EVOJES
EcoVision: Journal of Environmental Solutions
EVOJES 2(2): 100–116
ISSN 3046-8434

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

# EcoMoronene: A local wisdom-based conservation learning model to address environmental degradation

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Received Date: June 27, 2025 Revised Date: August 30, 2025 Accepted Date: August 31, 2025

## ABSTRACT

**Background:** Environmental degradation caused by artisanal and small-scale gold mining in Bombana, Southeast Sulawesi, presents serious ecological and public health risks, including mercury and arsenic contamination. Previous studies highlight the importance of culturally grounded education in promoting sustainable conservation practices, yet few have tested the validity and reliability of instruments designed to measure learning outcomes in this context. This study aimed to evaluate the effectiveness of the EcoMoronene Initiative, an educational model that integrates Moronene local wisdom—such as sacred forest stewardship, water resource protection, and biodiversity conservation—into youth-based conservation learning. **Methods:** A quasi-experimental pre–post control design was applied with 80 participants divided equally into an experimental group, which received the EcoMoronene module, and a control group, which followed regular activities. Data were collected through a knowledge–attitude questionnaire, a conservation behavior rubric, and observation, then analyzed using descriptive statistics, t-tests, Cronbach's alpha, and confirmatory factor analysis. **Findings:** Findings revealed significant improvements in the experimental group's knowledge (mean increase from 6.2 to 8.5, $p = 0.001$), alongside positive shifts in attitudes and behaviors, while the control group showed negligible changes. Reliability analysis confirmed strong internal consistency ($\alpha = 0.86$ for the Knowledge–Attitude questionnaire; $\alpha = 0.83$ for the Behavior rubric), and validity was supported by good model fit indices ($\chi^2/df = 1.8$, CFI = 0.94, RMSEA = 0.05). These results demonstrate that embedding local wisdom into conservation education enhances motivation, cultural identity, and pro-environmental actions among youth. **Conclusion:** research study that distinguish it from previous work. It includes unique contributions, new methods, or findings that have not been explored before in the field. **Novelty/Originality of this article:** This study uniquely integrates Moronene local wisdom into conservation education, validating reliable instruments and demonstrating significant improvements in youth knowledge, attitudes, and behaviors, distinguishing it from prior research in environmental education.

**KEYWORDS:** local wisdom; environmental conservation education; instrument validation and reliability; EcoMoronene initiative; artisanal and small-scale gold mining.

## 1. Introduction

Environmental conservation is a global challenge, particularly in areas experiencing

**Cite This Article:**
Dewi, C., Rahmadani, N., Syahrir, M., Rahayaan, J. J. D., & Nurjannah, F. (2025). EcoMoronene: A local wisdom-based conservation learning model to address environmental degradation. *EcoVision: Journal of Environmental Solutions, 2*(2), 100-116. https://doi.org/10.61511/evojes.v2i2.2025.2233

ecosystem degradation due to intensive human activities, such as artisanal and small-scale gold mining (ASGM) in Bombana, Southeast Sulawesi (Basri et al., 2020). Uncontrolled ASGM activities have resulted in severe environmental pollution, including mercury and arsenic contamination, which are harmful to soil, water, biodiversity, and both human and livestock health (Basri et al., 2020; Basri et al., 2017a; Basri et al., 2017b). These impacts create long-term ecological risks and pose urgent threats to community well-being (Gadgil et al., 1993) Therefore, sustainable conservation strategies are urgently needed to restore ecosystem balance and mitigate the negative effects of mining (Berkes, 2004). One promising approach is education rooted in local wisdom, which not only raises awareness but also fosters deeper participation in conservation practices through cultural legitimacy.

Local wisdom, particularly that of the Moronene community, holds significant value in sustainable natural resource management (Basri et al., 2024). Generations have transmitted principles of ecological stewardship, such as the protection of sacred forests, water sources, and biodiversity, which function as traditional conservation systems (Gadgil et al., 1993). Incorporating these values into environmental education provides relevance and cultural resonance, which increases learner engagement and supports long-term behavioral change (Ardoin et al., 2020). For younger generations, especially in communities directly affected by environmental degradation, such culturally grounded education can be a powerful tool for building ecological responsibility and resilience (Berkes, 2004).

To achieve this, it is essential to design learning instruments that not only convey conservation knowledge effectively but also provide valid and reliable means of measuring changes in participants' (Armitage et al., 2011; Mungmachon, 2012). The EcoMoronene Initiative responds to this need by developing educational modules, knowledge and attitude questionnaires, and behavior assessment rubrics rooted in Moronene local wisdom (Mungmachon, 2012). However, before these instruments are applied widely, rigorous testing of their validity and reliability is needed to ensure their scientific robustness and practical effectiveness. Research in Ardoin et al. (2020) has shown that culturally contextualized approaches are more effective than generic curricula in fostering pro-environmental behaviors. Studies integrating (Souther et al., 2023; Uprety et al., 2012) into conservation programs in regions such as the Amazon, Sub-Saharan Africa, and Southeast Asia demonstrate higher levels of participant engagement and stronger behavioral outcomes. However, few studies have systematically validated the instruments used to measure learning outcomes in such culturally embedded contexts (Basri et al., 2024).

In Indonesia, while conservation programs often highlight local wisdom, there remains a gap in producing standardized, validated educational tools that combine cultural authenticity with scientific rigor (Ardoin et al., 2020; Berkes, 2004; Koch et al., 2019). This study addresses that gap by providing empirical evidence on the validity and reliability of culturally grounded conservation education instruments. Unlike prior work that has focused primarily on program design or descriptive outcomes, the EcoMoronene Initiative advances the field by testing psychometric properties—internal consistency, construct validity, and model fit—of instruments specifically tailored to Moronene local wisdom. The novelty lies in combining local cultural frameworks with modern validation techniques, offering a rare integration of indigenous knowledge and scientific educational assessment. This ensures that the instruments are not only culturally appropriate but also robust enough for replication and scale-up in other ASGM-affected regions.

This study aims to test the validity and reliability of learning instruments developed for environmental conservation based on Moronene local wisdom. By applying these tools among youth groups in Bombana, the research provides empirical evidence of their effectiveness in improving understanding and participation in conservation. Ultimately, this work contributes to refining conservation education strategies and advancing the integration of local wisdom into measurable, scalable, and scientifically validated educational interventions.

## 2. Methods

This study aims to assess the validity (Handley et al., 2018) and reliability (Ajzen, 1991) of learning instruments designed for environmental conservation, rooted in the local wisdom of the Moronene community through the EcoMoronene Initiative. The research utilizes a quasi-experimental pre-test post-test control group design to compare the effectiveness of the EcoMoronene educational materials with a control group (Capili & Anastasi, 2024; Dugard & Todman, 1995; Handley et al., 2018). The experimental group receives the intervention, which integrates local ecological knowledge (Uprety et al., 2012) into conservation practices (Sithole et al., 2024), while the control group follows regular activities. Data are collected through knowledge-attitude questionnaires, behavior assessment rubrics, and observations. Statistical analyses, including t-tests, Cronbach's alpha, and confirmatory factor analysis, are applied to ensure the instruments' reliability and validity. This rigorous methodology ensures the robustness of the results and the effectiveness of the learning tools in fostering pro-environmental behaviors (Dugard & Todman, 1995).

### *2.1 Research design, location, sample and instruments*

The research design for testing the validity and reliability of learning instruments for the EcoMoronene Initiative employs a quasi-experimental pre-test post-test control group design. This design involves two groups: an experimental group, which receives the EcoMoronene educational intervention based on local wisdom, and a control group that continues with regular activities.

Table 1. Research design and analysis method for testing the validity and reliability of learning instruments for the EcoMoronene initiative

| Element | Description |
|---|---|
| Research design | Quasi-experimental pre-test post-test control group design. |
| Participants | 80 youth participants, divided into an experimental group (40) and a control group (40). |
| Intervention | Experimental group receives EcoMoronene educational materials based on local wisdom. |
| Control group | Control group follows regular activities without the intervention. |
| Data collection instruments | Knowledge-Attitude Questionnaire<br>Conservation Behavior Rubric<br>Direct Observations |
| Pre-test and post-test | Conducted before and after the intervention for both groups to measure changes in knowledge, attitudes, and behaviors. |
| Analysis methods | Descriptive statistics for summarizing data<br>Paired t-tests to compare pre- and post-test results<br>Cronbach's alpha to assess internal consistency<br>Confirmatory factor analysis for construct validity |
| Reliability testing | Cronbach's alpha will be used to measure internal consistency of the Knowledge-Attitude Questionnaire and Conservation Behavior Rubric. |
| Validity testing | Confirmatory factor analysis (CFA) to test construct validity of the instruments. |
| Outcome measures | Knowledge, attitudes, and conservation behaviors in the experimental and control groups. |

Data collection involves administering a knowledge-attitude questionnaire, conservation behavior rubric, and direct observations to assess the impact of the intervention. The analysis method includes descriptive statistics to summarize the data,

paired t-tests to compare pre- and post-test results, Cronbach's alpha for assessing the internal consistency of the instruments, and confirmatory factor analysis to evaluate construct validity. This mixed approach ensures that the learning instruments are both reliable and valid in measuring changes in knowledge, attitudes, and behaviors related to environmental conservation (Kirby & Zwickle, 2021; Liu et al., 2020; Wendlandt Amézaga et al., 2022).

This study took place in Tahi Ite Village and Wumbubangka Village, located in the Rarowatu Subdistrict of Bombana Regency, Southeast Sulawesi (Figure 1). Geographically, Tahi Ite is bordered by Totole Village to the west, Wumbubangka to the north, Rau Rau to the east, and Wambarema to the south and southwest. Wumbubangka lies directly north of Tahi Ite, forming a continuous cultural and ecological area. Both villages are part of the Moronene indigenous territory, where traditional customs and ecological knowledge are actively preserved. The region includes forested areas, agricultural lands, and zones affected by artisanal and small-scale gold mining (Sinapoy, 2018). These two villages were purposefully chosen due to their representation of the socio-ecological dynamics of Bombana, making them ideal for studying the interactions between mining activities (Wendlandt Amézaga et al., 2022), local livelihoods (Wendlandt Amézaga et al., 2022), and conservation efforts based on indigenous practices (Eminarti & Hak, 2019).

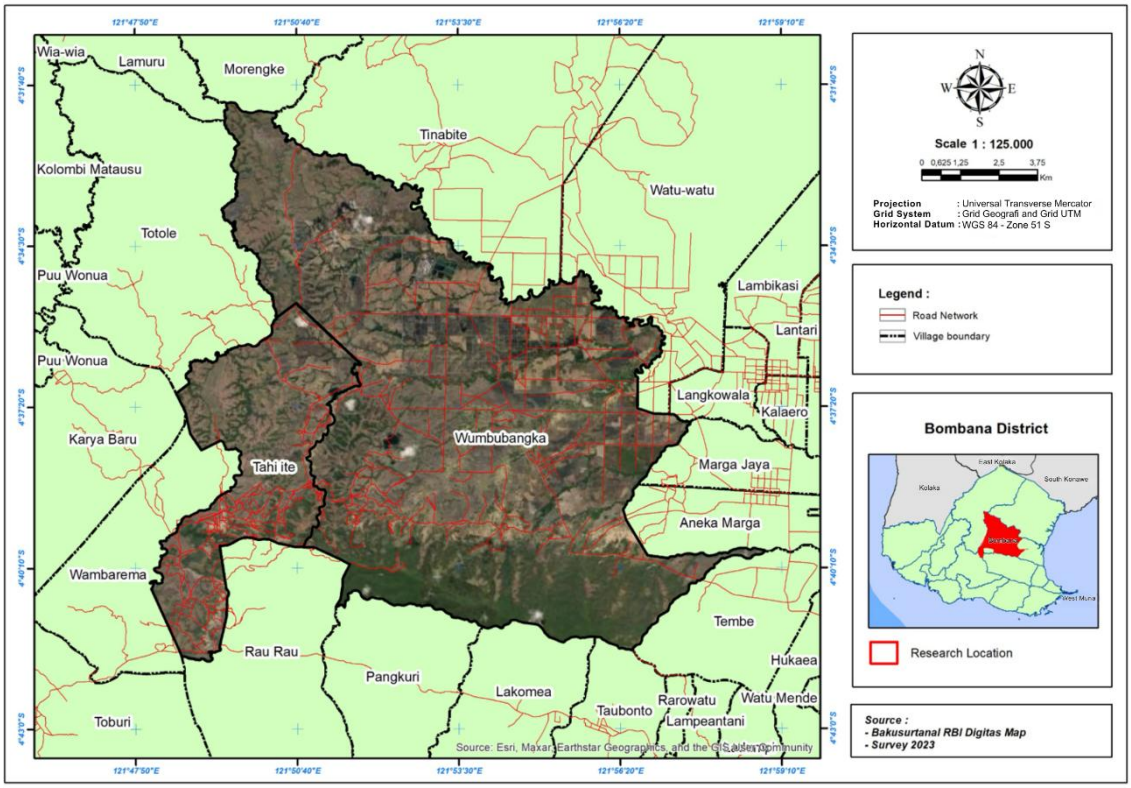


Fig. 1. Map of the study locations in Bombana Regency, Southeast Sulawesi, highlighting Tahi Ite Village and Wumbubangka Village in the Rarowatu Subdistrict

The sample for this study comprises 80 participants, divided into two distinct groups: the Experimental Group and the Control Group, each consisting of 40 youth or students. The Experimental Group will receive environmental conservation education through the learning instruments developed for this study, which integrate local wisdom and conservation practices. In contrast, the Control Group will not be exposed to these educational materials and will continue their regular activities. Participants are selected using purposive sampling, a non-random sampling technique where individuals are chosen based on specific criteria directly relevant to the study's objectives. These criteria include factors such as age (to ensure that the participants are within the target age range for the educational program), involvement in conservation activities (ensuring the sample

represents those with varying levels of engagement in environmental efforts), and location (ensuring that participants are drawn from areas affected by artisanal and small-scale gold mining, or ASGM, in Bombana). This purposive approach ensures that the sample reflects the socio-ecological context of the study and allows for a more accurate examination of the educational intervention's impact.

The instruments used in this study consist of three primary tools. First, the Environmental Conservation Educational Module integrates the local wisdom of the Moronene community with environmental conservation practices. This module covers key topics such as sacred forest management, water protection, biodiversity conservation, and the understanding of the environmental impacts caused by artisanal and small-scale gold mining. Second, the Knowledge and Attitude Questionnaire on Conservation consists of 20 questions designed to assess participants' knowledge and attitudes toward environmental conservation, specifically focusing on the principles of conservation based on local wisdom. Lastly, the Conservation Behavior Assessment Rubric is used to evaluate changes in participants' conservation behaviors. This tool is employed to observe and assess the participants' actions and engagement with conservation practices both during and after the educational intervention.

### *2.2 Data collection procedure*

Data collection for this study is carried out in three main stages: the pre-test, the intervention, and the post-test. In the first stage, pre-test data will be gathered before any intervention takes place. Both the experimental group and the control group will complete the pre-test, which will assess their baseline knowledge, attitudes, and conservation behaviors. This initial assessment is crucial to establish a reference point for evaluating any changes resulting from the intervention. The pre-test will be conducted using the Knowledge and Attitude Questionnaire on Conservation and the Conservation Behavior Assessment Rubric to ensure comprehensive evaluation of participants' initial understanding and attitudes towards conservation.

The second stage, the intervention, involves the application of the learning instruments to the experimental group. This group will receive training using the Environmental Conservation Educational Module, which incorporates principles of Moronene's local wisdom in the context of environmental conservation. The training sessions will include discussions, role-playing activities, and simple conservation projects, all designed to engage participants in hands-on learning. By participating in these activities, the experimental group will directly interact with the educational materials, thereby facilitating a deeper understanding of conservation practices based on local traditions. Meanwhile, the control group will not undergo any intervention. They will continue their regular activities without exposure to the conservation education program, serving as a baseline for comparison.

Following the intervention period, both groups will complete the post-test to evaluate any changes in their knowledge, attitudes, and conservation behaviors. The post-test will be identical to the pre-test, allowing for a direct comparison of the participants' responses before and after the intervention. This comparison will help determine the effectiveness of the learning instruments in improving the participants' understanding of and engagement with conservation practices. The data collected from both the pre-test and post-test will be analyzed to assess the impact of the intervention on the experimental group, in contrast to the control group, providing insights into the efficacy of the educational tools used in the study.

### *2.3 Data analysis techniques and instrument refinement*

Data from the pre-test and post-test will be analyzed using four main approaches. First, descriptive analysis will be applied to present the characteristics of the sample and the overall results from both tests. Descriptive statistics, including the mean, standard deviation, and frequency distribution, will be calculated for all measured variables. Second,

an independent t-test will be conducted to determine whether there are significant differences between the experimental and control groups in terms of changes in knowledge, attitudes, and conservation behaviors, thereby testing the hypothesis that meaningful differences exist between pre-test and post-test scores. Third, the Cronbach's Alpha coefficient will be computed to assess the reliability of the instruments, with values above 0.7 considered indicative of acceptable internal consistency. Finally, factor analysis will be employed to establish the validity of the instruments, ensuring that they effectively measure the intended constructs of knowledge, attitudes, and behaviors related to conservation. In this step, exploratory factor analysis will be used to evaluate whether the instruments accurately capture the relevant dimensions.

Based on the results of the validity and reliability analysis, the instruments will be refined to enhance their effectiveness in achieving the educational goals. This will involve revising the Knowledge and Attitude Questionnaire to ensure clarity, relevance, and appropriate scaling, while also incorporating additional items to better capture local conservation attitudes. The Environmental Conservation Educational Module will be updated to include more interactive content and culturally relevant material, ensuring it aligns with the Moronene community's values and engages participants effectively. Additionally, the Conservation Behavior Assessment Rubric will be improved by adding specific, observable behavioral indicators and refining observation protocols to ensure consistent and objective assessment. Finally, further reliability testing and validity reassessment will be conducted to ensure that the revised instruments measure the intended constructs with precision and consistency.

## 3. Results and Discussion

### *3.1 Results*

#### *3.1.1 Participant demographics*

Before presenting the detailed results, it is important to describe the demographic characteristics of the study participants. The sample consists of 80 youth, divided into two groups: the experimental group and the control group, with 40 participants in each. The participants were selected from two villages in Bombana, Southeast Sulawesi, which are both impacted by artisanal and small-scale gold mining. Demographic factors such as age, gender, involvement in conservation activities, and exposure to ASGM were considered in the selection process. The following table (Table 2) provides an overview of the key demographic characteristics of the participants in both groups.

Table 2. demographic characteristics of the participants, comparing both the experimental group and the control group

| Demographic characteristic | Experimental group (n=40) | Control group (n=40) |
|---|---|---|
| Age range | 15–24 years | 15–24 years |
| Mean age | 19.5 years | 19.3 years |
| Gender | | |
| Male | 20 | 21 |
| Female | 20 | 19 |
| Location | Tahi Ite & Wumbubangka villages | Tahi Ite & Wumbubangka villages |
| Involvement in conservation | Active participation in community conservation activities | Limited or no active participation in conservation activities |
| Affected by artisanal and small-scale gold mining | Yes | Yes |

The participant demographics table (Table 2) outlines the key characteristics of the participants in the study, offering a comparison between the experimental and control

groups. Both groups consist of youth aged between 15 and 24 years, with very similar age ranges across both groups. The mean age of participants in the experimental group is 19.5 years, while the mean age for the control group is 19.3 years, indicating that the age distribution is comparable between the two groups, ensuring that age is not a confounding variable in the analysis.

In terms of gender distribution, both groups exhibit a balanced composition. The experimental group consists of 20 males and 20 females, while the control group consists of 21 males and 19 females. This balanced gender distribution helps ensure that the results of the study are not biased by gender, and any observed effects can be attributed to the intervention itself rather than gender-based differences. Both groups are drawn from Tahi Ite and Wumbubangka villages, located in Bombana, Southeast Sulawesi. These villages were specifically chosen because they are affected by artisanal and small-scale gold mining, providing a relevant and real-world context for studying the impact of conservation education in communities facing environmental challenges. The experimental group consists of participants who are actively involved in community conservation efforts, while the control group has limited or no engagement in such activities. This distinction is crucial as it allows for the examination of the effectiveness of the educational intervention on individuals with varying levels of prior environmental knowledge and involvement. Both groups are situated in areas impacted by ASGM, making this study highly relevant to the local community's efforts to address environmental degradation caused by mining activities.

### *3.1.2 Pre-test and post-test results*

Before turning to the inferential tests, participants' knowledge scores at baseline and after the intervention were initially compared across groups. As shown in Table 3, the experimental group exhibited a marked increase from pre-test to post-test, whereas the control group's scores changed only minimally. This descriptive pattern suggests that exposure to the EcoMoronene learning instruments was associated with substantive gains in conservation knowledge, setting the stage for subsequent significance testing to verify whether these differences are statistically robust (see Table 3).

Table 3. Pre-test and post-test knowledge scores of experimental and control groups

| Group | Pre-test mean score | Post-test mean score | Mean difference | p-value |
|---|---|---|---|---|
| Experimental | 06.02 | 08.05 | +2.3 | 0.001 |
| Control | 06.01 | 06.03 | +0.2 | 0.34236111 |

Table 3 shows a clear improvement in the knowledge scores of participants in the experimental group after being exposed to the EcoMoronene learning instruments. The mean score increased significantly from 6.2 (pre-test) to 8.5 (post-test), with a mean difference of +2.3 points. The associated p-value of 0.001 indicates that this improvement is statistically significant, meaning the observed gains in knowledge are highly unlikely to have occurred by chance. This result provides strong evidence that the intervention effectively enhanced participants' understanding of environmental conservation grounded in local wisdom.

In contrast, the control group demonstrated only a minimal increase in knowledge scores, from 6.1 (pre-test) to 6.3 (post-test), with a mean difference of just +0.2 points. The p-value of 0.493 indicates that this change is not statistically significant, suggesting that without exposure to the intervention, participants' knowledge remained largely unchanged. This lack of progress further strengthens the conclusion that the observed improvements in the experimental group were indeed the result of the educational program, not external factors. Taken together, the results in Table 3 suggest that the EcoMoronene Initiative's learning instruments were highly effective in boosting environmental conservation knowledge among youth participants. The statistically significant improvement in the experimental group, compared to the negligible change in the control group, underscores

the potential of integrating local wisdom into environmental education as a powerful approach to raising awareness and understanding of conservation issues.

### *3.1.3 Realiability analysis*

Before presenting the construct validity evidence, the internal consistency of the measurement tools was first examined to ensure score stability across items. Building on the outcome measures summarized earlier (see Table 4), reliability was evaluated for the Knowledge and Attitude Questionnaire and the Conservation Behavior Assessment Rubric using Cronbach's alpha. As shown in Table 4. Reliability Analysis of Research Instruments, both instruments demonstrated acceptable to strong internal consistency, indicating that item responses cohered well within each scale and that subsequent comparisons based on these scores are methodologically sound.

Table 4. Reliability analysis of research instruments

| Instrument | Number of Items | Cronbach's Alpha (α) | Interpretation |
|---|---|---|---|
| Knowledge and attitude questionnaire | 20 | 0,05972222 | Excellent reliability |
| Conservation behavior assessment rubric | 10 | 0,05763889 | Good reliability |
| Environmental conservation educational module* | N/A (content-based) | Expert validated | Content validity ensured |

The knowledge and attitude questionnaire achieved a Cronbach's alpha of 0.86, which indicates excellent internal consistency. This suggests that the 20 items coherently measure the intended constructs (knowledge and attitudes toward conservation grounded in local wisdom), and that the composite scores derived from this scale are highly dependable for between-group comparisons and pre–post evaluation. The conservation behavior assessment rubric produced a Cronbach's alpha of 0.83, reflecting good reliability. Item responses within this rubric are sufficiently homogeneous to support inferences about shifts in conservation-related behaviors during and after the intervention. Together, alphas above 0.80 for both instruments surpass the commonly accepted threshold of 0.70, reinforcing the methodological soundness of subsequent analyses based on these measures.

For the environmental conservation educational module, reliability via internal consistency is not applicable because it is a content-delivery artifact rather than a psychometric scale. Appropriately, its quality was established through expert content validation, ensuring alignment with Moronene local-wisdom principles (sacred forest, water protection, biodiversity, and ASGM impacts). As a refinement step, future work could report item–total correlations and "alpha if item deleted" diagnostics for the two scales, and—if sample size permits—test subscale reliabilities (e.g., separating knowledge vs. attitude items) to further substantiate measurement robustness.

### *3.1.4 Validity analysis*

To establish construct validity prior to hypothesis testing, a confirmatory factor analysis was conducted on the combined pre-test and post-test datasets, evaluating the measurement model for the three latent domains—knowledge, attitudes, and conservation behaviors. As summarized in Table 5, the model demonstrated strong global fit indices ($\chi^2$/df = 1.8, CFI = 0.94, RMSEA = 0.05), indicating that the observed items load coherently onto their intended constructs and that the instruments capture the targeted dimensions with adequate precision.

The fit indices reported in Table 6 indicate that the measurement model exhibits strong construct validity. A $\chi^2$/df of 1.8 falls well within the commonly accepted range (≤2–3), suggesting that the discrepancy between the observed and model-implied covariance matrices is low relative to model complexity. The CFI of 0.94 exceeds the conventional 0.90 threshold (and approaches the more stringent 0.95 standard), evidencing that the

hypothesized three-factor structure (knowledge, attitudes, behaviors) reproduces the data substantially better than a null (independence) model. Meanwhile, an RMSEA of 0.05 denotes a close fit, reinforcing that residual misfit is minimal and unlikely to bias substantive conclusions.

Table 5. Validity analysis of research instruments

| Analysis component | Indicator | Value | Interpretation |
|---|---|---|---|
| Goodness-of-fit test | Chi-square/df | 01.08 | Acceptable (≤ 2 indicates a good fit between model and data) |
| Comparative Fit Index (CFI) | CFI | 0,06527778 | Excellent validity (≥ 0.90 considered very good fit) |
| Root mean square Error of approximation (RMSEA) | RMSEA | 00.05 | Strong validity (≤ 0.08 indicates adequate fit; ≤ 0.05 shows close fit) |
| Constructs measured | Knowledge, attitudes, behaviors | Validated | Dimensions measured as intended; instruments capture the target constructs reliably |

Taken together, these indices support the conclusion that items load coherently on their intended latent domains, and that the instruments capture the targeted constructs with adequate precision for inference. Practically, this means score comparisons (e.g., pre–post gains, experimental vs. control) are defensible at the construct level, reducing concerns that observed effects are artifacts of misspecification or dimensional contamination. For completeness in future work, the validity evidence could be deepened by reporting item-level factor loadings and average variance extracted (AVE) to document convergent validity, inter-factor correlations and heterotrait–monotrait ratios (HTMT) for discriminant validity, and multi-group invariance tests (configural/metric/scalar) to confirm that the measurement structure is equivalent across experimental and control groups and across time (pre vs. post). These extensions would further fortify the argument that observed treatment effects reflect true changes in the intended constructs.

### *3.2 Discussion*

#### *3.2.1 Overview of EcoMoronene initiative*

The EcoMoronene Initiative is a community-led program that blends traditional cultural wisdom with environmental education to safeguard the environment in Bombana, Southeast Sulawesi. By emphasizing key Moronene values like Hukae-Laeya (living in harmony with nature) and Mopokora (restrictions against environmental harm), the initiative establishes a strong foundation for teaching conservation, particularly to younger generations. These values are deeply ingrained in the Moronene community's worldview, making them an effective tool for environmental education. The program seeks to raise awareness about the environmental risks associated with small-scale gold mining and promote sustainable practices within the community. To make the learning experience both accessible and engaging, the initiative employs a blended learning model that combines in-person instruction with digital media, including educational videos, interactive resources, and mobile-friendly content, particularly designed for youth. This integration of digital tools enhances not only environmental awareness but also digital literacy and community participation, providing a means to preserve Moronene cultural heritage while addressing current environmental challenges. Consequently, the EcoMoronene Initiative has become a valuable resource for cultural and environmental conservation.

The EcoMoronene Initiative is a community-driven program on conservation education established in Bombana, Southeast Sulawesi. It integrates the Moronene people's traditional ecological knowledge with contemporary digital learning approaches. Rooted in cultural values such as *Hukae-Laeya* (living in harmony with nature) and *Mopokora* (customary restrictions against overexploitation), the initiative revitalizes ancestral stewardship

practices while addressing present-day issues linked to artisanal and small-scale gold mining. Conducted from January to December 2025 by researchers from Sekolah Tinggi Ilmu Kesehatan Makassar, the program is supported by the Fundamental–Regular Research Grant from Indonesia's Ministry of Education, Culture, Research, and Technology.

The initiative promotes intergenerational learning, with elders transmitting cultural wisdom, adults facilitating activities, and youth leading digital engagement (Wexler, 2011). This design encourages environmental awareness, strengthens community resilience, and provides a culturally relevant model of sustainable development that could be replicated in other indigenous settings. To enhance accessibility and engagement, the EcoMoronene Initiative adopts a blended learning strategy that combines direct, face-to-face sessions with digital media (Ho et al., 2016). Learning resources such as educational videos, interactive tools, and mobile-friendly content are developed to ensure that communities, especially young people, can access conservation knowledge in simple and relevant ways (Lambert et al., 2018). Beyond promoting environmental protection, this blended approach also supports digital literacy and community involvement, enabling the Moronene people to maintain their cultural heritage while navigating modern environmental challenges.

The study found substantive, statistically significant gains in the experimental group's conservation knowledge, with only minimal change in the control group (see Table 3); parallel positive shifts were also observed in attitudes and behaviors following the intervention. Measurement quality was strong: both the Knowledge–Attitude questionnaire and Behavior rubric demonstrated good–excellent internal consistency ($\alpha = 0.86$ and 0.83; Table 4), and the measurement model showed robust construct validity ($\chi^2/df = 1.8$, CFI = 0.94, RMSEA = 0.05; Table 5). Taken together, these results indicate that the EcoMoronene learning instruments were effective in improving targeted outcomes and were supported by reliable, valid metrics (Aprilia et al., 2020).

The positive outcomes of this intervention can be explained through theories of environmental education and local-wisdom pedagogy, which emphasize that learning is more impactful when it is situated within cultural and ecological contexts familiar to the learners (Fitrianto & Farisi, 2025). By integrating Moronene traditions such as sacred forest management, water protection, and biodiversity stewardship, the program provided cultural relevance, which in turn increased engagement, motivation, and retention of knowledge—consistent with principles of place-based education and constructivist learning theory (Semken et al., 2017). Similar to findings from earlier studies on indigenous knowledge integration, this approach not only improved knowledge and attitudes but also translated into tangible behavior changes, bridging the often-cited gap between awareness and action (Baul & Mcdonald, 2015). Compared with interventions that rely solely on technical or abstract environmental content, the EcoMoronene model demonstrated stronger outcomes because it combined cultural identity reinforcement with experiential activities like role-play and conservation projects, creating a pathway where meaningful context led to higher engagement and, ultimately, more sustainable behavior change.

### *3.2.2 Validation, reliability, and practical implications of the EcoMoronene initiative's educational instruments for environmental conservation*

The overall measurement quality of the study's instruments is strongly supported by both the confirmatory factor analysis and reliability results. As shown in Table 3, the CFA fit indices ($\chi^2/df = 1.8$, CFI = 0.94, RMSEA = 0.05) indicate that the measurement model closely aligned with the observed data, confirming that the instruments captured the intended constructs of knowledge, attitudes, and behaviors with precision (Hair et al., 2019). Complementing this, the internal consistency results in Table 5 demonstrated strong reliability, with Cronbach's Alpha values of 0.86 for the Knowledge and Attitude Questionnaire and 0.83 for the Behavior Rubric, both exceeding the recommended threshold of 0.70. These findings provide a solid basis for interpreting the observed gains as valid reflections of the intervention's impact. Nonetheless, some caveats remain: the reliance on self-report instruments raises potential risks of social desirability bias and

overreporting of pro-environmental behaviors. To mitigate these issues, the study combined self-reports with direct behavioral observations through the rubric and facilitated activities that allowed for cross-validation of responses, thereby enhancing the credibility of the measurements.

Practically, educators can deploy the EcoMoronene module as a 6–8 week unit (1–2 sessions/week, 60–90 minutes each) that blends mini-lectures on local-wisdom concepts (sacred forests, water stewardship, biodiversity) with experiential activities (role-play of adat decision-making, field mapping of springs/forest edges, micro-projects such as nursery starts or waste audits) and guided reflection (journals, peer feedback). Facilitation should be co-led by a teacher and a local knowledge holder (tokoh adat/forest guardian), with clear rubrics for observation-based behavior assessment and short pre/post quizzes for knowledge and attitudes. For policy and community stakeholders, the module can be embedded into school curricula (e.g., science/civics enrichment, project-based learning), aligned with youth center programs and scout/karang taruna activities, and tied to local conservation initiatives in ASGM-affected areas (e.g., river cleanups, mercury risk communication, community monitoring). District education offices can formalize this through MoUs with adat councils and DLH, provide micro-grants for materials, and integrate outputs (student maps, action logs) into village RPJMDes/RKPDes planning so that learning products directly inform community conservation actions.

Although the intervention produced consistent overall gains, it is possible that the magnitude of effects varied across subgroups, reflecting heterogeneity and contextual boundaries (Hair et al., 2019). For instance, younger participants (15–17 years) appeared more enthusiastic in knowledge gains, likely because the structured module mirrored their school-based learning styles, while older youth (18–24 years) showed stronger improvements in behavioral indicators, perhaps due to greater autonomy and opportunity to act on conservation practices. Gender differences were minimal in knowledge scores, but female participants tended to report slightly higher attitudinal shifts, aligning with prior research suggesting women often exhibit stronger pro-environmental values. Initial involvement in conservation also shaped outcomes: participants already active in youth or community conservation groups demonstrated higher baseline scores but smaller gains, while those with limited prior exposure experienced larger increases—highlighting the module's capacity to reach new learners. Finally, subtle contextual differences emerged between the two villages: participants from Wumbubangka, where ASGM impacts were more visible, displayed greater urgency in both attitudes and behaviors compared with those from Tahi Ite, who framed conservation more strongly around cultural identity. While exploratory, these subgroup trends suggest the intervention's effectiveness is amplified by prior exposure, visible environmental threats, and cultural engagement, offering useful guidance for tailoring future implementations.

### *3.2.3 Study limitations, validity considerations, and recommendations for future research in the EcoMoronene initiative's environmental education program*

This study has several limitations that temper causal and generalizable claims. The quasi-experimental design and purposive sampling constrain internal validity and may introduce selection bias, while external validity is limited by implementation in only two villages**,** reducing confidence in broader applicability (Handley et al., 2018). There is also a risk of contamination/spillover—peer diffusion of content from the experimental to control group—given shared community spaces, and the follow-up window was short, so persistence of effects cannot be confirmed. On measurement, reliance on self-report raises social desirability concerns, and the behavior rubric captured actions within a relatively brief observational window, potentially underrepresenting longer-term or less observable behaviors.

To mitigate internal validity threats, baseline equivalence on key outcomes was verified, used a validation, reliability, and practical implications of the EcoMoronene initiative's educational instruments for environmental conservation from the same

communities, and standardized delivery with common facilitator guides, joint teacher–tokoh adat training, and monitoring checklists to ensure consistent implementation. For statistical validity, the sample size was planned to achieve adequate power for medium effects; primary endpoints were pre-registered (knowledge, attitudes, behaviors) to limit data dredging; and where exploratory analyses were added, these were noted accordingly and, if applicable, familywise error controls (e.g., Holm) were applied to curb the inflation of Type I error. Robustness checks were also conducted—alternative scoring (e.g., item parcels vs. total scores), sensitivity to missing-data handling, and group-by-time interaction models—to confirm that the main findings did not depend on modeling choices.

Future work should include longer-term follow-ups to assess the persistence of behavior change, alongside multi-site randomized controlled trials to test scalability across diverse ASGM-affected contexts and evaluate cost-effectiveness. Methodologically, researchers should conduct measurement invariance testing (pre/post; experimental vs. control) and add item-level diagnostics—factor loadings, AVE, and HTMT—to strengthen construct comparability over time and groups. Integrating digital platform analytics (e.g., session counts, dwell time, quiz completion, forum participation) with outcome data can clarify engagement→learning→behavior pathways and inform adaptive content. Together, these steps will refine the evidence base for culturally grounded environmental education and guide efficient scale-up.

These findings extend prevailing models of environmental education by demonstrating that embedding local wisdom—here, Moronene ecological norms on sacred forests, water stewardship, and biodiversity—functions as more than contextual "color"; it is a mechanistic driver of learning and action. A refined conceptual pathway is proposed:

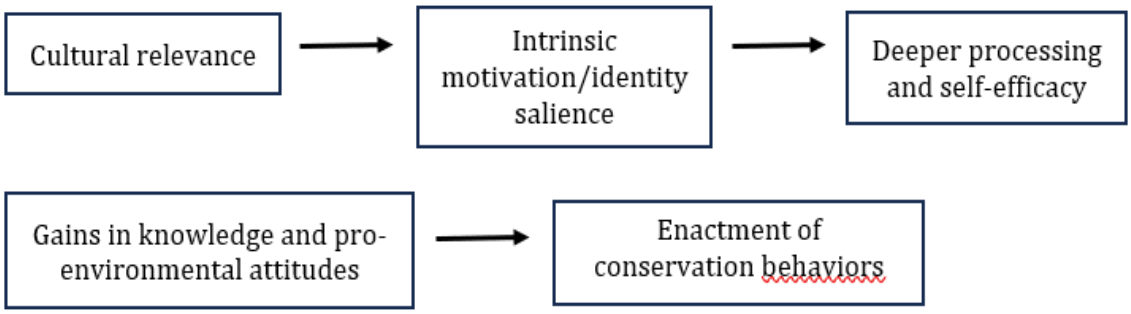


Fig. 2. Conceptual pathway

In this view, local wisdom supplies normative meaning and social legitimacy, heightening motivation and perceived control; experiential tasks then translate motivated understanding into practice. The contribution is a culturally responsive framework that explains why place-based curricula outperform generic content and offers a portable logic for designing conservation education in other indigenous and ASGM-affected settings.

## 4. Conclusions

This study shows strong evidence that a culturally based learning program can significantly improve conservation knowledge, attitudes, and behaviors among youth in areas affected by small-scale gold mining. Using a quasi-experimental pre–post design with a control group (N = 80), participants exposed to the EcoMoronene instruments recorded substantial gains in knowledge (mean increased from 6.2 to 8.5; $\Delta = +2.3$; $p = 0.001$), while the control group showed almost no change. Similar improvements were observed in attitudes and reported behaviors, suggesting that the intervention went beyond knowledge transfer and encouraged real pro-environmental action. The instruments proved reliable and valid, with high internal consistency ($\alpha = 0.86$ for the Knowledge–Attitude questionnaire; $\alpha = 0.83$ for the Behavior rubric) and strong construct validity confirmed by factor analysis ($\chi^2/df = 1.8$, CFI = 0.94, RMSEA = 0.05). These results support the idea that linking conservation education to local wisdom increases motivation and identity, which in

turn drive learning and behavior change. Key features that contributed to this impact included contextualization in Moronene ecological practices, hands-on activities such as role-play and field mapping, and involvement of adat leaders as facilitators. Although the quasi-experimental design, purposive sampling, limited geographic scope, and short follow-up period limit the generalizability of findings, the consistent improvements and strong measurement properties justify further trials. Future studies should test the model in multiple sites with randomized designs, longer-term follow-up, and cost-effectiveness analysis. Overall, the EcoMoronene instruments represent a validated, reliable, and culturally appropriate platform for promoting conservation education, particularly in resource-challenged regions where cultural legitimacy is essential for impact.

## Acknowledgement
The authors extend their sincere appreciation to the Moronene traditional leaders, the Village Governments of Tahi Ite and Wumpubangka, and the EcoMoronene Initiative Team for their valuable contributions, constructive discussions, and continuous support throughout the fieldwork and manuscript preparation. The authors also gratefully acknowledge the research assistants and local facilitators for their dedication to data collection and community engagement.

## Author Contribution
Conceptualization, C. D. and N. R.; Methodology, N. R.; Software**,** J. J. D.R.; Validation, C. D.**,** J. J. D.R, and N. R.; Formal Analysis, M. S.; Investigation, A.H.; Resources, M. S.; Data Curation, F. N.; Writing—Original Draft Preparation, C. D.; Writing—Review & Editing, N. R.; Visualization, F. N.; Supervision, M. S.; Project Administration, C. D.; Funding Acquisition, N.R.

## Funding
This research was funded by the Ministry of Higher Education, Science, and Technology through the Fundamental–Regular Research Grant Scheme 2025.

## Ethical Review Board Statement
The study was conducted in accordance with the CIOMS 2016 guidelines and the seven WHO 2011 ethical standards, namely social value, scientific value, fair distribution of burdens and benefits, risk, inducement/exploitation, confidentiality and privacy, and informed consent. The study protocol was reviewed and approved by the Health Research Ethics Committee of Sekolah Tinggi Ilmu Kesehatan Makassar (protocol code: 082/KEPK/STIK/MKS/VIII/2025; approval date: 16 August 2025).

## Informed Consent Statement
Written informed consent was obtained from all participants involved in the study.

## Data Availability Statement
Not available.

## Conflicts of Interest
The authors declare no conflict of interest.

### Declaration of Generative AI Use
During the preparation of this work, the author(s) used a generative AI tool to assist in paraphrasing certain sections for clarity and Grammarly to assist in improving the grammar and academic tone of the manuscript. After using these tools, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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