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Environmental Learning Pathways to Pro-Environmental Intentions and Reported Behaviors Among Indigenous Youth in Thailand: A Mixed-Methods Study

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Abstract

Indigenous youth are increasingly recognized as important agents of sustainability; however, how environmental learning shapes pro-environmental intentions and behaviors remains insufficiently understood. This exploratory mixed-methods study integrates Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB) to examine behavioral transformation among indigenous youth participating in community-based environmental learning activities in northern Thailand. Twenty-five indigenous student participants engaged in a structured environmental learning program developed through Citizen Science, Critical Participatory Action Research, and Living Lab approaches. Quantitative data from 250 activity-level questionnaire responses and qualitative data from 200 reflective responses collected from 25 participants through eight reflection prompts were analyzed using PLS-SEM, mediation analysis, permutation-based MGA, and the Gioia methodology. The model explained 50.0% of the variance in pro-environmental behavioral intention. Communication quality significantly enhanced attention ($\beta = 0.452, p < 0.001$), and participation strongly predicted practical experience ($\beta = 0.660, p < 0.001$). Practical experience contributed to perceived value of information, which enhanced perceived behavioral control ($\beta = 0.691, p < 0.001$), a key mechanism influencing behavioral intention. Peripheral information processing showed a stronger effect than central processing, and MGA revealed differentiated learning pathways across activity categories. Qualitative findings indicated a progression from environmental practices to advocacy and environmental identity, supported by indigenous ecological knowledge and intergenerational learning. This study provides an exploratory framework for understanding culturally grounded environmental learning and offers implications for designing sustainability education programs with indigenous communities.

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1. Introduction

Environmental challenges such as climate change and biodiversity loss require substantial behavioral changes to achieve sustainability goals [1,2]. Understanding the determinants of pro-environmental behavior among youth is particularly important because

environmental values and behaviors developed during adolescence often persist into adulthood and influence long-term sustainability outcomes [3]. Indigenous youth are especially important actors in sustainability transitions because their communities maintain strong socio-ecological relationships and contribute significantly to biodiversity conservation and sustainable resource management [4,5]. As future stewards of ecological systems, they play a vital role in environmental sustainability and community resilience. Moreover, environmental learning among indigenous youth is often embedded within culturally situated practices, including place-based experiences, intergenerational knowledge transmission, collective stewardship, and direct engagement with local ecosystems [4,5]. These characteristics may shape how environmental information is acquired, interpreted, and transformed into action, potentially resulting in learning and decision-making pathways that differ from those commonly observed in more formalized or decontextualized educational settings.

Despite extensive research on environmental behavior, empirical evidence explaining how environmental learning shapes pro-environmental intentions and reported behaviors among indigenous youth remains limited. The Theory of Planned Behavior (TPB) has been widely applied to explain environmental behavior through attitudes, subjective norms, and perceived behavioral control [6,7]. However, TPB provides limited insight into how environmental learning experiences and information-processing mechanisms contribute to behavioral intentions [8]. Experiential Learning Theory (ELT) emphasizes learning through direct experience, reflection, conceptualization, and application [9], whereas the Elaboration Likelihood Model (ELM) explains how individuals process persuasive information through central and peripheral routes [10]. These perspectives are particularly relevant in indigenous contexts, where environmental knowledge is frequently developed through participation, observation, storytelling, cultural practices, and intergenerational interactions. Such learning processes may influence not only what environmental information is received but also how it is evaluated, internalized, and translated into behavioral intentions.

To address this gap, this study integrates ELT, ELM, and TPB into a unified framework to explain how environmental learning influences pro-environmental intentions and reported behaviors among indigenous youth. Complementing the quantitative analysis, the Gioia methodology [11] is employed to explore how environmental learning contributes to environmental stewardship, community engagement, environmental advocacy, and environmental identity formation. Accordingly, this study aims to: (1) examine the relationships among environmental learning, information processing, and pro-environmental intentions; (2) investigate differences in learning pathways across environmental activities; and (3) explore how environmental learning contributes to reported environmental behaviors and environmental identity formation among indigenous youth.

2. Literature Review and Hypothesis Development

2.1. Integrating Experiential Learning, Persuasion, and Behavioral Intention

Pro-environmental behavior is increasingly recognized as the outcome of interacting experiential, cognitive, and social processes rather than isolated psychological determinants [3]. Accordingly, understanding environmental behavior requires theoretical perspectives that explain how individuals learn from environmental experiences, process environmental information, and translate these processes into behavioral intentions.

Experiential Learning Theory (ELT) explains how direct experiences facilitate learning and behavioral change [9], whereas the Elaboration Likelihood Model (ELM) explains how attention and information processing influence cognitive evaluations and persuasion outcomes [10]. The Theory of Planned Behavior (TPB) provides a robust framework for explaining behavioral intentions through attitudes, subjective norms, and perceived

behavioral control [6]. However, TPB does not explicitly account for the experiential learning and information-processing mechanisms underlying behavioral formation.

Integrating ELT, ELM, and TPB therefore provides a comprehensive framework for explaining how environmental communication and experiential learning shape pro-environmental intentions and reported behaviors. Accordingly, this study proposes that communication quality and participation stimulate attention and practical experience, which subsequently influence information processing, perceived value of information, perceived behavioral control, and pro-environmental intentions among indigenous youth.

2.2. *Experiential Learning in Environmental Education*

Experiential Learning Theory (ELT) proposes that learning occurs through transforming experience into knowledge via reflection, conceptualization, and application [9]. In environmental education, ELT has been widely used to explain how authentic engagement with nature and community activities enhances environmental awareness and sustainable practices [3]. However, most ELT studies emphasize learning outcomes while offering limited explanation of how experiences are cognitively processed and translated into behavioral intentions. This limitation is particularly relevant in indigenous contexts, where experiential learning is embedded in place-based practices and community participation [4,5]. Accordingly, this study extends ELT by integrating ELM and TPB to explain how environmental experiences influence information evaluation and subsequent behavioral intention.

Communication quality facilitates experiential learning by attracting learners' attention to environmental issues [10,12].

H1. *Communication quality (CM) positively influences attention (ATT).*

Participation enables learners to acquire practical experience and increases the personal relevance of environmental issues [3].

H2. *Participation (PAR) positively influences practical experience (PE).*

H3. *Participation (PAR) positively influences attention (ATT).*

2.3. *Persuasion Processes and Information Evaluation*

The Elaboration Likelihood Model (ELM) explains persuasion through central processing, based on careful evaluation of message content, and peripheral processing, based on contextual cues such as credibility, emotions, or social influence [10]. Environmental communication studies have successfully applied ELM to explain message effectiveness, yet most focus on message characteristics rather than how experiential learning shapes information processing. Moreover, while central processing is often associated with durable behavioral change, peripheral processing may be equally influential in indigenous communities where trusted relationships and cultural contexts shape environmental learning.

Integrating ELM with ELT therefore explains how experiential learning influences both cognitive evaluation and contextual interpretation of environmental information.

Attention is required before information can be processed through either route.

H4. *Attention (ATT) positively influences central processing (CP).*

H5. *Attention (ATT) positively influences peripheral processing (PP).*

This study further proposes perceived value of information (PVI) as the mechanism linking information processing with behavioral determinants. While previous studies have examined central and peripheral processing separately, limited research has investigated their combined contribution to perceived information value in environmental education. Practical experience is also expected to strengthen information value by connecting knowledge with real-world application [9].

H6. *Central processing (CP) positively influences perceived value of information (PVI).*

H7. *Peripheral processing (PP) positively influences perceived value of information (PVI).*

H8. *Practical experience (PE) positively influences perceived value of information (PVI).*

2.4. From Information Value to Pro-Environmental Intention

The Theory of Planned Behavior (TPB) explains pro-environmental intentions through attitudes, subjective norms, and perceived behavioral control [6,7]. Although TPB consistently predicts environmental behavior, it provides limited explanation of how environmental experiences and information evaluation shape these behavioral determinants [8]. Integrating TPB with ELT and ELM addresses this limitation by connecting experiential learning and persuasion processes to behavioral intention.

Individuals who perceive environmental information as useful and actionable are expected to develop stronger perceived behavioral control [13].

H9. *Perceived value of information (PVI) positively influences perceived behavioral control (PBC).*

Perceived behavioral control has consistently been identified as a strong predictor of pro-environmental intention [7].

H10. *Perceived behavioral control (PBC) positively influences behavioral intention (BI).*

Subjective norms remain particularly important in indigenous communities, where family, community, and cultural expectations influence environmental behavior. Unlike conventional TPB applications that examine social norms independently, this study considers subjective norms alongside experiential learning and information-processing mechanisms [6].

H11. *Subjective norms (SN) positively influence behavioral intention (BI).*

Overall, this study extends existing environmental behavior theories by integrating experiential learning, persuasion processes, and behavioral intention mechanisms into a unified framework. In particular, it identifies perceived value of information as a key mechanism linking experiential learning and information processing to perceived behavioral control and pro-environmental intentions among indigenous youth, while reported behaviors and environmental identity formation are further explored through qualitative analysis.

3. Materials and Methods

3.1. Study Area

This study was conducted in two indigenous communities in Lampang Province, Thailand, where traditional rotational farming and community-based natural resource management remain important livelihood practices. The communities are located near the Mae Moh lignite mining and power generation area and have extensive experience in

environmental management, organic agriculture, and participatory environmental initiatives. Their strong environmental stewardship and community engagement provided an appropriate setting for examining environmental learning and pro-environmental behavior among indigenous youth.

3.2. Participants and Data Collection

Twenty-five indigenous students in Grades 4–6 were purposively selected through collaboration among researchers, teachers, community leaders, and parents. Participant selection was based on parental consent, students' voluntary willingness, and their readiness to participate throughout all stages of the research process. The study employed an integrated participatory approach combining Citizen Science (CS), Critical Participatory Action Research (CPAR), Living Labs (LLs), and behavioral interventions based on the EAST framework (Easy, Attractive, Social, and Timely). Figure 1 illustrates the overall research process.

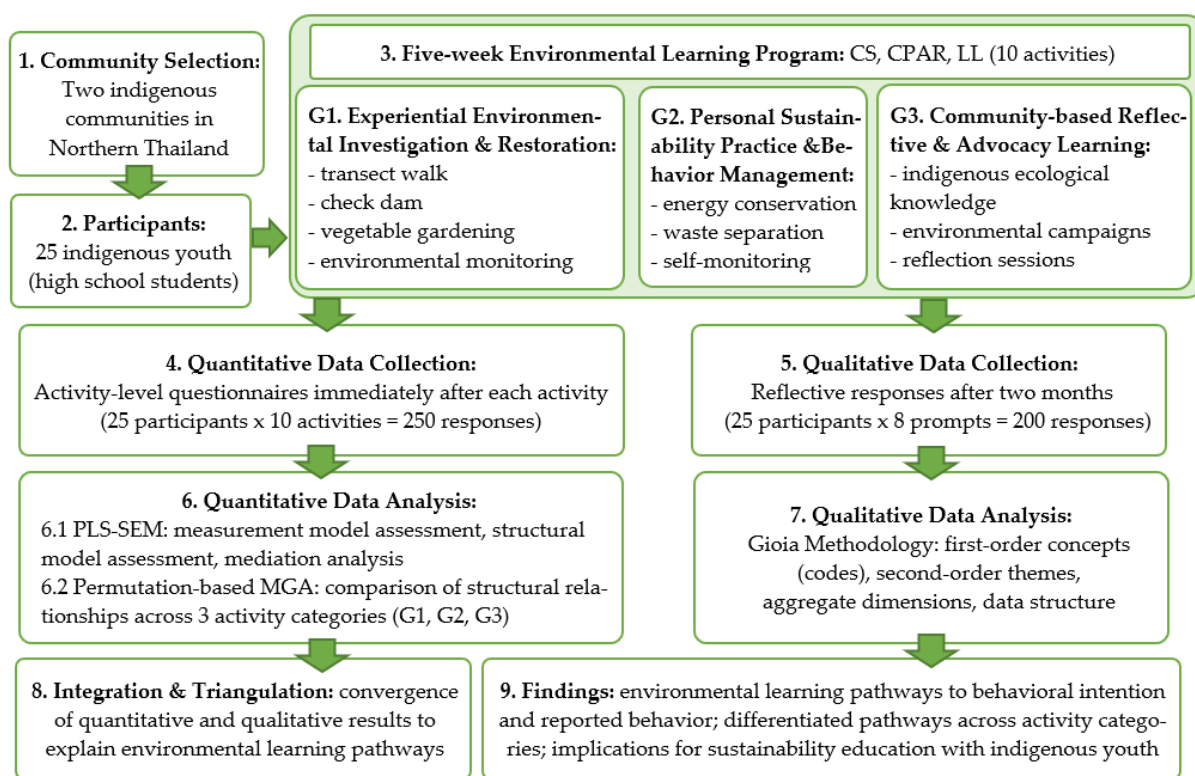


Figure 1. Overall research process.

The environmental learning program was implemented over 5 weeks. Participants completed ten environmental learning activities organized into three categories: (1) Experiential Environmental Investigation and Restoration, including transect walk, check dam, vegetable gardening, and environmental monitoring; (2) Personal Sustainability Practice and Behavior Management, including energy conservation, waste separation, and self-monitoring activities; and (3) Community-Based Reflective and Advocacy Learning, including indigenous ecological knowledge activities, environmental campaigns, and structured reflection sessions. Most activities lasted approximately 1–2 h, whereas some practice- and project-based activities, such as vegetable gardening and self-monitoring, were conducted continuously over 2–4 weeks.

Immediately following each activity, participants completed a structured questionnaire under the supervision of the research team and classroom teachers. Researchers explained the questionnaire using age-appropriate language and provided clarification

when needed without influencing participants' responses. The questionnaires were completed individually in the school setting and collected immediately after completion to ensure response completeness and minimize recall bias.

These three categories were designed to represent complementary stages of a developmental learning pathway rather than separate interventions (Table 1). The categorization was derived from the integration of Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB), illustrating how different types of learning experiences contribute to pro-environmental behavioral development.

The learning pathway begins with experiential investigation (G1), where students engage in authentic environmental activities that provide concrete learning experiences (ELT: Concrete Experience). These experiences encourage students to observe, interpret, and understand environmental issues through environmental engagement and information processing, thereby strengthening attitudes and perceived behavioral control. The second stage, personal sustainability practice (G2), emphasizes repeated behavioral practice and self-monitoring (ELT: Active Experimentation), reinforcing behavioral competence and perceived behavioral control. Finally, community-based reflective and advocacy learning (G3) extends learning through structured reflection, indigenous ecological knowledge, environmental communication, and community engagement, integrating reflective observation and conceptual understanding while strengthening subjective norms, behavioral intention, and environmental leadership.

Together, these three categories represent complementary educational functions that collectively support the progression from authentic environmental experience to sustained pro-environmental behavior.

The study protocol was approved by the Human Research Ethics Committee, as detailed in the Institutional Review Board Statement. Because the participants were minors, written informed consent was obtained from parents or legal guardians, and assent was obtained from all participating students before data collection. Participation was voluntary, participants could withdraw at any time without consequence, and all questionnaire responses and reflective narratives were anonymized to protect participants' privacy and confidentiality.

Although the study involved a relatively small number of participants, the repeated-measures design generated 250 activity-level questionnaire responses across the ten learning activities. As described in Section 3.4, the available observations exceeded the minimum sample size required for the PLS-SEM analyses and were considered adequate for the exploratory objectives of the study.

Table 1. Mapping of environmental learning categories and representative activities to the integrated ELT–ELM–TPB framework.

Group	Representative Activities	Primary Educational Function	ELT	ELM	TPB
G1. Experiential Environmental Investigation and Restoration	Transect walks, check dam construction, vegetable gardening, and environmental monitoring	Learning from nature through authentic environmental experiences	Concrete Experience	Central Processing	Attitude; Perceived Behavioral Control
G2. Personal Sustainability Practice and Behavior Management	Energy conservation, waste separation, and self-monitoring activities	Learning through repeated behavioral practice and self-regulation	Active Experimentation	Central Processing	Perceived Behavioral Control → Behavior
G3. Community-Based Reflective and Advocacy Learning	Indigenous ecological knowledge activities, environmental campaigns,	Learning with and for society through reflection, communication, and community engagement	Reflective Observation + Abstract Conceptualization	Central + Peripheral Processing	Subjective Norm; Attitude; Intention; Leadership

and structured reflection
sessions

For the quantitative component, participants completed the same structured questionnaire immediately after each environmental learning activity. Because each of the 25 participants responded following all ten activities, the quantitative dataset comprised 250 completed questionnaires (25 participants $\times$ 10 learning activities). These questionnaires represented repeated activity-level observations collected from the same participants, rather than responses from 250 independent individuals. The repeated observations were used to examine the relationships among the latent constructs of the integrated conceptual framework across multiple learning episodes using PLS-SEM.

Each completed questionnaire represented a distinct learning episode associated with a specific environmental learning activity rather than a repeated assessment of an unchanged participant characteristic. Accordingly, the analytical unit in the quantitative component was the activity-level learning experience, enabling the study to examine how different environmental learning contexts were associated with variation in experiential learning, information processing, and behavioral intention across the six-week intervention. This analytical perspective is consistent with the exploratory objective of understanding learning mechanisms operating within different educational activities rather than estimating stable individual differences.

Approximately two months after completing the environmental learning program, the same 25 participants voluntarily participated in the qualitative evaluation. Each participant responded to eight open-ended reflection questions, generating 200 reflective responses (25 participants $\times$ 8 questions). The questions explored changes in environmental behaviors, environmental stewardship activities, knowledge sharing, community participation, self-monitoring, indigenous ecological knowledge, environmental leadership, and environmental responsibility.

To preserve confidentiality while enabling participant-level analysis, each participant was assigned a unique anonymous identification code (P01–P25). All eight reflective responses from the same participant were linked using this identifier, allowing the research team to examine each participant's learning experiences across multiple reflection questions while maintaining anonymity. The linked responses were subsequently analyzed using the Gioia methodology to identify environmental learning pathways and complement the quantitative findings.

The eight reflection questions were developed based on the integrated conceptual framework combining Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB). Rather than measuring theoretical constructs quantitatively, the questions were designed to elicit participants' experiences of learning, cognitive processing, social interaction, behavioral intention, and reported environmental behavior following participation in the ten environmental learning activities. The sequence of questions reflected the causal logic of the integrated framework, whereby experiential learning activities (ELT) stimulate central and peripheral information processing through reflection and social interaction (ELM), ultimately influencing attitudes, subjective norms, perceived behavioral control, behavioral intentions, and reported environmental behaviors (TPB). Consequently, the qualitative findings served as a theory-informed process evaluation that explained how experiential learning and persuasive communication mechanisms contributed to the behavioral outcomes identified in the quantitative PLS-SEM analysis, thereby providing methodological triangulation within the mixed-methods research design.

The relationship between the questions and the integrated three theories are summarized in the following Table 2.

Table 2. Relationship between reflection questions and the integrated ELT–ELM–TPB framework.

Question	ELT	ELM	TPB
Q1. Behavioral changes	Active Experimentation	Behavioral outcome of persuasion	Reported Behavior
Q2. Caring for nature	Concrete Experience	Reinforcement of learning	Environmental Behavior
Q3. Sharing knowledge	Active Experimentation	Peripheral Route (social persuasion)	Subjective Norm
Q4. Community participation	Concrete Experience + Active Experimentation	Peripheral Route	Subjective Norm + Behavior
Q5. Self-monitoring	Reflective Observation	Central Route	Perceived Behavioral Control
Q6. Learning from elders	Abstract Conceptualization	Central Route	Attitude Formation
Q7. Organizing/leading	Active Experimentation	Peripheral Route (social influence)	Intention → Behavior
Q8. Changes in thinking	Abstract Conceptualization	Central Route	Attitude → Intention

Finally, because the quantitative dataset consisted of repeated observations from the same participants rather than independent respondents, this characteristic is acknowledged as a methodological limitation. Accordingly, the PLS-SEM analysis was intended to examine relationships among latent constructs across repeated learning experiences rather than estimate population parameters from statistically independent observations.

3.3. Measures

The research framework integrated Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB) into a unified explanatory model (Figure 2), comprising ten latent constructs (Table 3). Unlike previous studies that have generally applied these theories independently or in pairwise combinations, the present framework combines all three perspectives to explain how environmental learning translates into pro-environmental intention. Specifically, ELT explains how environmental experiences foster participation and practical learning, ELM explains how these experiences shape attention and central/peripheral information-processing pathways, and TPB explains how perceived information value strengthens perceived behavioral control and, ultimately, behavioral intention.

The ten latent constructs were measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Questionnaire items were adapted from validated scales and translated into Thai using a forward–backward translation procedure to ensure conceptual equivalence with the original instruments. The translated questionnaire was subsequently reviewed by environmental education experts, teachers, and community representatives to assess content validity, cultural appropriateness, and linguistic clarity for indigenous youth. Prior to the main survey, the questionnaire was pilot tested with a small group of students from a comparable educational context. Based on feedback from the pilot study, minor revisions were made to improve wording clarity and cultural relevance while retaining the original construct meanings.

To complement the quantitative framework, qualitative data were analyzed using the Gioia methodology. This mixed-methods design enabled the integration of quantitative evidence on cognitive mechanisms with qualitative insights into environmental behavioral transformation, providing a more comprehensive understanding of how environmental learning experiences influence pro-environmental intentions.

The qualitative component was designed to extend, rather than replicate, the SEM analysis by exploring participants' experiences and meaning-making processes beyond the predefined theoretical constructs. Accordingly, environmental identity and environmental agency were not specified as latent variables in the original ELT–ELM–TPB model.

Instead, they emerged inductively from participants' reflective narratives during the Gioia analysis and were interpreted as higher-order developmental outcomes of environmental learning. This integration of deductive theory testing with inductive qualitative analysis enabled the study to explain both the cognitive mechanisms underlying pro-environmental intentions and the broader developmental processes through which environmental learning fostered stewardship, agency, and identity formation.

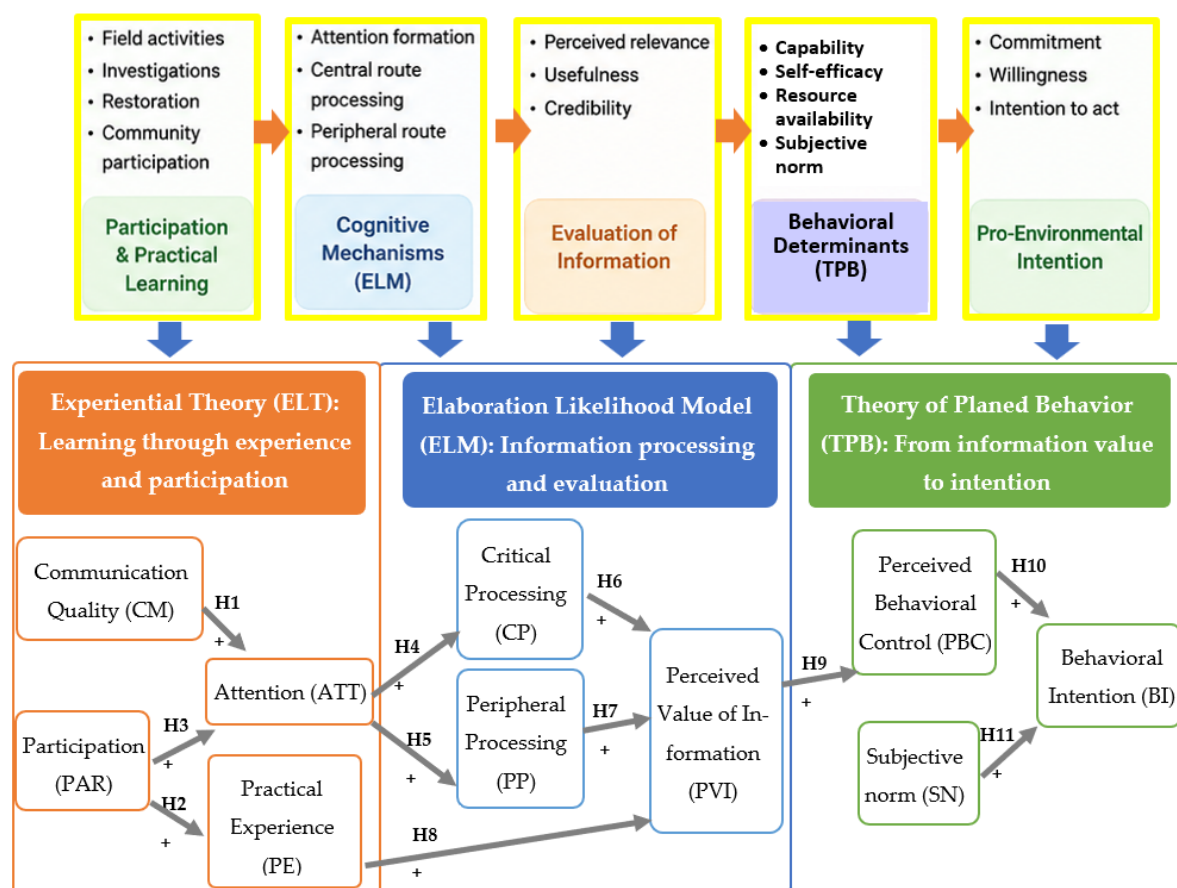


Figure 2. Conceptual Framework.

Table 3. Measurement items, theoretical foundations, and source references.

Construct	Code	Measurement Item	Theoretical Basis	Reference
Communication Quality (CM)	CM1	The communication explained the content clearly.	Communication clarity	McGuire [14]
	CM2	The communication used examples that helped me understand the content.	Message relevance	Witte [15]
	CM3	The communication was well organized.	Message design and structure	McGuire [14]
Participation (PAR)	PAR1	I actively participated in the activity.	Participatory engagement	Freire [16]
	PAR2	I had opportunities to exchange ideas with others.	Dialogic communication	Freire [16]
	PAR3	I contributed my thoughts or experiences during the activity.	Participatory learning	Kolb [9]
Attention (ATT)	ATT1	The activity immediately captured my attention.	Initial attention	Petty & Cacioppo [10]
	ATT2	I remained mentally focused during the activity.	Sustained attention	Kahneman [17]

Central Processing (CP)	CP1	The activity made me think deeply about the information.	Central-route elaboration	Petty & Cacioppo [10]
	CP2	I carefully interpreted and evaluated the meaning of the information.	Cognitive elaboration	Petty & Cacioppo [10]
Peripheral Processing (PP)	PP1	My impression was influenced by the presentation style.	Peripheral cues	Petty & Cacioppo [10]
	PP2	I relied on simple cues (e.g., visuals, attractiveness, speaker style) when judging the content.	Heuristic processing	Petty & Cacioppo [10]
Perceived Value of Information (PVI)	PVI1	The information provided was useful.	Information usefulness	DeLone & McLean [18]
	PVI2	The information was sufficiently comprehensive.	Information completeness	DeLone & McLean [18]
	PVI3	The information can be applied in real-life situations.	Perceived usefulness	Davis [19]
Practical Experience (PE)	PE1	I directly practiced the skills required in this activity.	Active experimentation	Kolb [9]
	PE2	This activity provided hands-on experience.	Concrete experience	Kolb [9]
Perceived Behavioral Control (PBC)	PBC1	I have sufficient knowledge to perform this behavior.	Self-efficacy	Ajzen [6]
	PBC2	Performing this behavior is under my control.	Controllability	Ajzen [6]
	PBC3	I have the resources needed to perform this behavior.	Resource control	Ajzen [6]
Subjective Norm (SN)	SN1	People who are important to me encourage me to perform this behavior.	Injunctive norm	Ajzen [6]
	SN2	People who are important to me think that I should perform this behavior.	Normative pressure	Ajzen [6]
	SN3	People who are important to me regularly perform these behaviors themselves.	Descriptive norm	Ajzen [6]
Behavioral Intention (BI)	BI1	I am committed to taking action related to this behavior.	Commitment	Ajzen [6]
	BI2	I will try to apply this behavior in my daily life.	Intention to act	Ajzen [6]

3.4. Quantitative Data Analysis

Quantitative data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4, following the methodological recommendations of Hair et al. [20]. PLS-SEM was selected because the primary objective of this study was theory development and prediction within a complex conceptual framework integrating Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB). This approach is appropriate for exploratory, prediction-oriented research involving multiple latent constructs and mediation pathways [20].

The quantitative dataset consisted of 250 activity-level questionnaire responses collected from 25 participants immediately after each of the ten environmental learning activities. The unit of analysis was therefore the individual learning activity rather than the participant. Each questionnaire captured participants' perceptions of a specific learning episode immediately following completion of an environmental activity and was intended to reflect contextual variation in learning experiences rather than stable individual characteristics.

Because the same participants completed all three categories of environmental learning activities, the observations across activity categories were not statistically independent. Accordingly, the permutation-based MGA should be interpreted as an exploratory comparison of activity-specific learning pathways rather than a formal between-group

analysis. Conventional PLS-SEM permutation procedures do not explicitly account for within-participant dependence, which may lead to underestimated standard errors. Therefore, the MGA findings are interpreted cautiously as hypothesis-generating evidence regarding differences in learning mechanisms across activity categories rather than definitive statistical inference.

Following the recommendations of Hair et al. [20], the adequacy of the sample was evaluated based on the minimum sample size requirements for PLS-SEM. This study demonstrates that the available activity-level observations exceeded the minimum sample size required to detect medium effect sizes ($f^2 = 0.15$) at a significance level of $\alpha = 0.05$ with a statistical power of 0.80. Consequently, the quantitative analyses were considered appropriate for the exploratory objectives of this study.

The measurement model was evaluated by examining indicator loadings, Cronbach's alpha, Composite Reliability (CR), Average Variance Extracted (AVE), and the Heterotrait–Monotrait Ratio (HTMT) to assess internal consistency, convergent validity, and discriminant validity [20,21]. The structural model was subsequently evaluated using path coefficients, coefficients of determination (R^2), effect sizes (f^2), predictive relevance (Q^2), and out-of-sample predictive performance (PLSpredict) [20]. Mediation effects were assessed using a bootstrapping procedure with 5000 bootstrap subsamples, and statistical significance was determined using bias-corrected confidence intervals that excluded zero [20].

To examine whether the structural relationships differed across the three categories of environmental learning activities, permutation-based Multi-Group Analysis (MGA) was conducted after establishing measurement invariance using the Measurement Invariance of Composite Models (MICOM) procedure [22]. Because all participants completed activities in each category, the MGA compared structural relationships across educational activity contexts rather than across independent participant groups.

As observations from the three activity categories were derived from the same participants, the repeated-measures design does not fully satisfy the assumption of independent observations underlying conventional permutation-based MGA. Consequently, the permutation results should be interpreted as exploratory comparisons of activity-specific structural relationships rather than confirmatory evidence of statistically independent group differences. The observed differences should therefore be regarded as hypothesis-generating findings that warrant confirmation in future studies using analytical approaches that explicitly account for within-participant dependence.

3.5. Qualitative Data Analysis

A total of 200 reflective responses (25 participants $\times$ 8 reflection questions) were analyzed using the Gioia methodology [11]. Because all responses from the same participant were linked through anonymous identification codes (P01–P25), the researchers were able to examine patterns of learning and behavioral transformation across multiple reflection questions while maintaining participant confidentiality.

Following the Gioia methodology, first-order concepts were derived directly from participants' narratives and remained close to the participants' own language. These concepts were subsequently grouped into second-order themes and synthesized into aggregate dimensions through iterative discussions among the research team. Linking multiple reflections to individual participants enabled the identification of recurring environmental learning pathways and behavioral transformation patterns rather than treating each reflection as an isolated response.

The resulting aggregate dimensions were then integrated with the quantitative findings from the PLS-SEM and Multi-Group Analysis (MGA) during the interpretation stage. This methodological triangulation strengthened the credibility of the findings by

explaining not only whether the proposed relationships were supported statistically but also how and why experiential learning and persuasive communication mechanisms contributed to pro-environmental behavioral development among indigenous youth.

3.6. Trustworthiness and Ethical Considerations

Qualitative rigor was enhanced through iterative coding, peer review of coding decisions, and continuous comparison between emerging themes and original narratives to ensure trustworthiness [23]. Quantitative and qualitative findings were integrated during interpretation to provide a comprehensive understanding of behavioral change processes [24].

4. Results

4.1. Measurement Model Assessment

Prior to evaluating the structural relationships, the measurement model was assessed for reliability and validity. All indicator loadings exceeded 0.70 (0.805–0.941), while Cronbach’s alpha (0.728–0.872), rho_A (0.745–0.874), and composite reliability (CR; 0.866–0.936) values confirmed internal consistency reliability (Table 4) [20]. Convergent validity was established, with all average variance extracted (AVE) values exceeding 0.50 (0.684–0.880). In addition, all variance inflation factor (VIF) values were below the recommended threshold, indicating no evidence of problematic multicollinearity among the indicators (Table S1). Discriminant validity was supported by both the HTMT criterion (Table S2) and the Fornell–Larcker criterion (Table S3), indicating that all constructs were empirically distinct. Overall, the measurement model demonstrated satisfactory reliability and validity, supporting subsequent structural model analysis.

Table 4. Measurement model assessment based on 250 activity-level questionnaire responses (25 participants).

	Measurement Item	Factor Loadings	Cronbach’s Alpha (More than 0.7)	rho_A (More than 0.7)	CR or rho_C (More than 0.7)	AVE (More than 0.5)
ATT	ATT1	0.941	0.864	0.865	0.936	0.880
	ATT2	0.936				
BI	BI1	0.906	0.742	0.750	0.885	0.794
	BI2	0.877				
CM	CM1	0.848	0.835	0.846	0.900	0.751
	CM2	0.866				
	CM3	0.885				
CP	CP1	0.913	0.825	0.832	0.919	0.851
	CP2	0.931				
PAR	PAR1	0.908	0.728	0.745	0.879	0.784
	PAR2	0.863				
	PAR3	0.908				
PBC	PBC1	0.868	0.834	0.864	0.898	0.747
	PBC2	0.902				
	PBC3	0.821				
PE	PE1	0.928	0.807	0.819	0.912	0.838
	PE2	0.902				
PP	PP1	0.920	0.821	0.821	0.918	0.848
	PP2	0.922				
PVI	PVI1	0.843	0.770	0.779	0.866	0.684
	PVI2	0.832				
	PVI3	0.805				

SN	SN1	0.879	0.872	0.874	0.921	0.796
	SN2	0.922				
	SN3	0.875				

4.2. Structural Model Results

The structural model integrated constructs from Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB), with Communication Quality (CM) and Participation (PAR) specified as antecedents of Attention (ATT) and Practical Experience (PE), which subsequently influenced information processing and Perceived Value of Information (PVI). PVI was hypothesized to enhance Perceived Behavioral Control (PBC), which in turn contributed to Behavioral Intention (BI), while Subjective Norms (SN) directly influenced BI.

The coefficient of determination (R^2) values (Table S4) indicated moderate-to-substantial explanatory power [20]. The model explained 54.6% of the variance in Attention, 43.6% in Practical Experience, 18.1% in Central Processing, 47.6% in Peripheral Processing, 44.3% in Perceived Value of Information, 47.8% in Perceived Behavioral Control, and 50.0% in Behavioral Intention. Furthermore, the f^2 effect size analysis (Table S5) showed that the exogenous constructs exerted small to large effects on their respective endogenous constructs, demonstrating meaningful contributions to the model's explanatory power. Overall, these results demonstrate that the integrated framework provides strong explanatory capability for the cognitive, experiential, and behavioral mechanisms underlying pro-environmental intentions among indigenous youth.

All hypothesized relationships were positive and statistically significant ($p < 0.001$), supporting H1–H11 (Table 5).

In the ELT stage, Communication Quality significantly influenced Attention ($\beta = 0.452$, $t = 8.440$), while Participation significantly affected both Attention ($\beta = 0.373$, $t = 7.503$) and Practical Experience ($\beta = 0.660$, $t = 18.095$), supporting H1–H3. These findings indicate that effective communication and active participation are key drivers of attentional engagement and experiential learning, with participation exerting the strongest influence on practical experience.

In the ELM stage, Attention significantly predicted both Peripheral Processing ($\beta = 0.690$, $t = 21.244$) and Central Processing ($\beta = 0.426$, $t = 7.830$), supporting H4–H5. The stronger effect on peripheral processing suggests that attention primarily facilitates heuristic and affective engagement, while also promoting deeper cognitive elaboration.

Regarding Perceived Value of Information (PVI), results show that it is jointly shaped by experiential and cognitive mechanisms. Practical Experience was the strongest predictor of PVI ($\beta = 0.369$, $t = 6.094$), followed by Peripheral Processing ($\beta = 0.269$, $t = 3.743$) and Central Processing ($\beta = 0.185$, $t = 3.497$), supporting H6–H8. These findings suggest that information is perceived as more valuable when grounded in direct experience and reinforced through both heuristic and systematic processing, with experiential learning playing the dominant role.

Within the TPB framework, PVI significantly influenced Perceived Behavioral Control ($\beta = 0.691$, $t = 21.328$), supporting H9 and representing the strongest relationship in the model. This indicates that perceived informational value substantially enhances individuals' confidence in their ability to perform pro-environmental behaviors. In turn, Behavioral Intention was significantly affected by both Perceived Behavioral Control ($\beta = 0.401$, $t = 6.577$) and Subjective Norms ($\beta = 0.356$, $t = 5.406$), supporting H10–H11. Among these predictors, Perceived Behavioral Control exerted the stronger effect, highlighting its central role in shaping behavioral intention.

Overall, the findings support a sequential mechanism in which Communication Quality and Participation enhance Attention and Practical Experience, Attention activates

central and peripheral processing routes, these processes together with experiential learning enhance Perceived Value of Information, which strengthens Perceived Behavioral Control, and ultimately leads to Pro-Environmental Behavioral Intention. This integrated pattern provides strong empirical support for the combined application of ELT, ELM, and TPB in explaining pro-environmental intentions among indigenous youth.

Table 5. Structural model results and hypothesis testing.

	Path Co-Efficient	Std. Dev.	t-Value	Confidence Interval		f ²	VIF	p Values	Hypotheses (Supported)
				2.5%	97.5%				
PVI → PBC	0.691	0.032	21.328	0.652	1.332	0.000	1.877	0.000	H9
ATT → PP	0.690	0.032	21.244	0.635	1.289	0.000	1.000	0.000	H5
PAR → PE	0.660	0.036	18.095	0.518	1.122	0.000	1.000	0.000	H2
CM → ATT	0.452	0.054	8.440	0.155	0.497	0.001	1.565	0.000	H1
ATT → CP	0.426	0.054	7.830	0.112	0.388	0.002	1.000	0.000	H4
PBC → BI	0.401	0.061	6.577	0.068	0.270	0.005	2.216	0.000	H10
PAR → ATT	0.373	0.050	7.503	0.105	0.323	0.001	1.565	0.000	H3
PE → PVI	0.369	0.061	6.094	0.061	0.266	0.007	1.724	0.000	H8
SN → BI	0.356	0.066	5.406	0.043	0.239	0.021	2.216	0.000	H11
PP → PVI	0.269	0.072	3.743	0.015	0.168	0.084	1.877	0.000	H7
CP → PVI	0.185	0.053	3.497	0.009	0.135	0.105	1.162	0.000	H6

4.3. Predictive Assessment Using PLSpredict

To assess the out-of-sample predictive performance of the proposed model, a PLSpredict analysis was conducted (Table 6). The results revealed positive Q²predict values for all endogenous latent variables, indicating predictive relevance. Specifically, ATT (Q²predict = 0.539), PE (0.431), PP (0.449), PVI (0.358), and BI (0.410) demonstrated strong predictive relevance, whereas CP (0.203) and PBC (0.293) exhibited moderate predictive relevance. Furthermore, the RMSE values ranged from 0.685 to 0.901 and the MAE values ranged from 0.531 to 0.737, suggesting acceptable prediction errors across all constructs. Overall, these findings indicate that the proposed model demonstrates moderate-to-high out-of-sample predictive performance.

Table 6. PLSpredict LV summary.

Construct	Q ² predict	RMSE	MAE	Interpretation (Predictive Relevance)
ATT	0.539	0.685	0.531	Very strong
CP	0.203	0.901	0.737	Moderate
PE	0.431	0.762	0.590	Strong
PP	0.449	0.750	0.583	Strong
PVI	0.358	0.809	0.639	Strong
PBC	0.293	0.849	0.712	Moderate to strong
BI	0.410	0.775	0.653	Strong

4.4. Mediation Analysis Results

The mediation analysis used bootstrapping to examine the indirect mechanisms through which experiential learning, communication, and information processing influenced pro-environmental behavioral intention. All indirect effects were positive and significant ($p < 0.05$) (Table S6), supporting multiple sequential mediation pathways across the integrated Experiential Learning Theory (ELT), Elaboration Likelihood Model (ELM), and Theory of Planned Behavior (TPB).

The strongest indirect effect was PVI → PBC → BI ($\beta = 0.277$, $t = 6.361$, $p < 0.001$), indicating that the influence of perceived information value on behavioral intention

operates primarily by strengthening perceived behavioral control. Practical Experience (PE) also showed substantial indirect effects through $PE \rightarrow PVI \rightarrow PBC$ ($\beta = 0.255$, $t = 5.677$, $p < 0.001$), with the full sequential pathway $PE \rightarrow PVI \rightarrow PBC \rightarrow BI$ remaining significant ($\beta = 0.102$, $t = 4.377$, $p < 0.001$). These findings suggest that hands-on environmental experiences enhance the perceived value of environmental information, which subsequently increases behavioral control and intention.

Attention (ATT) influenced behavioral intention through both central and peripheral information-processing routes. The indirect pathway $ATT \rightarrow CP \rightarrow PVI$ was significant ($\beta = 0.079$, $t = 3.049$, $p = 0.002$), as were its subsequent effects through PBC ($\beta = 0.055$, $t = 3.106$, $p = 0.002$) and BI ($\beta = 0.022$, $t = 2.763$, $p = 0.006$). However, the peripheral pathway $ATT \rightarrow PP \rightarrow PVI$ produced stronger effects ($\beta = 0.186$, $t = 3.601$, $p < 0.001$), which remained significant through PBC ($\beta = 0.128$, $t = 3.377$, $p = 0.001$) and BI ($\beta = 0.051$, $t = 3.022$, $p = 0.003$). Likewise, both Central Processing (CP) and Peripheral Processing (PP) significantly affected BI through PVI and PBC, with consistently larger indirect effects observed for the peripheral route, suggesting that heuristic and affective processing plays a greater role than deep cognitive elaboration among indigenous youth.

Communication Quality (CM) indirectly influenced downstream constructs through attention and information processing. Significant mediation effects were found for both the central ($CM \rightarrow ATT \rightarrow CP$, $\beta = 0.192$, $t = 5.216$, $p < 0.001$) and peripheral ($CM \rightarrow ATT \rightarrow PP$, $\beta = 0.312$, $t = 7.478$, $p < 0.001$) routes, with the peripheral pathway producing stronger sequential effects on BI ($\beta = 0.023$ vs. $\beta = 0.010$). Similarly, Participation (PAR) enhanced both information-processing pathways through attention and an experiential-learning pathway through $PAR \rightarrow PE \rightarrow PVI$ ($\beta = 0.244$, $t = 5.435$, $p < 0.001$), which remained significant through PBC ($\beta = 0.168$, $t = 5.095$, $p < 0.001$) and BI ($\beta = 0.068$, $t = 4.125$, $p < 0.001$). This experiential pathway generated stronger indirect effects than either attention-based pathway.

Overall, the mediation analysis supports the sequential mechanisms proposed by the integrated ELT–ELM–TPB framework. Participation and Communication Quality enhance Practical Experience and Attention; Attention activates both Central and Peripheral Processing; these processes, together with Practical Experience, increase Perceived Value of Information, which strengthens Perceived Behavioral Control and ultimately promotes Behavioral Intention. Overall, the findings indicate that (1) PVI and PBC are the primary mediators linking environmental learning to behavioral intention, (2) experiential-learning pathways exert stronger indirect effects than communication-only pathways, and (3) peripheral processing consistently produces larger indirect effects than central processing, providing empirical support for the integrated theoretical framework.

4.5. Multi-Group Analysis (MGA) Results

Participant groups were defined based on the conceptual classification of the ten environmental learning activities into three educational categories, rather than representing different participant populations. All students participated in all ten activities; however, the activities were organized into G1 (Experiential Environmental Investigation and Restoration), G2 (Personal Sustainability Practice and Behavior Management), and G3 (Community-Based Reflective and Advocacy Learning) to reflect their primary educational functions within the integrated ELT–ELM–TPB framework. MGA revealed significant heterogeneity across these categories, suggesting that different educational functions activated distinct learning pathways. Accordingly, the findings reflect differences in learning mechanisms rather than participant characteristics (Table 7).

Table 7. Summary of MGA Results: Distinct Environmental Learning Mechanisms Across Educational Activity Types.

Comparison	Stronger Group	Key Significant Relationships	Interpretation of Learning Mechanism
Group 1 (Experiential Environmental Investigation & Restoration) vs. Group 2 (Personal Sustainability Practice & Behavior Management)	1	CM → ATT (0.619 vs. 0.131); PP → PVI (0.850 vs. 0.288); PVI → PBC (0.782 vs. 0.416)	Learning was primarily communication-driven and cue-based, with attention and peripheral processing transforming environmental observations into information value and behavioral confidence.
	2	PAR → ATT (0.648 vs. 0.232); ATT → CP (0.591 vs. 0.251); PAR → CP (0.383 vs. 0.058)	Learning was primarily participation-driven, whereby active engagement stimulated attention and deeper cognitive processing.
Overall Comparison	—	Group 1: CM → ATT → PP → PVI → PBC; Group 2: PAR → ATT → CP → PVI	Investigation and restoration activities emphasized environmental cues and communication, whereas sustainability practice activities promoted active participation and cognitive elaboration.
Group 1 (Experiential Environmental Investigation & Restoration) vs. Group 3 (Community-Based Reflective & Advocacy Learning)	1	ATT → PP (0.769 vs. 0.576); PP → PVI (0.850 vs. 0.019)	Learning followed an experience-driven and heuristic pathway, where environmental cues and direct observation strongly shaped information value.
	3	ATT → CP (0.770 vs. 0.251); CP → PVI (0.531 vs. −0.076); PAR → CP (0.307 vs. 0.058); CP → PBC (0.419 vs. −0.059)	Learning followed a reflection-driven and cognitively elaborated pathway, where participation and reflection promoted knowledge integration, behavioral capability, and intention.
Overall Comparison	—	Group 1: ATT → PP → PVI; Group 3: ATT → CP → PVI → PBC → BI	Investigation and restoration activities relied on experiential and peripheral processing, whereas reflective and advocacy activities emphasized central processing, meaning-making, and behavioral transformation.

4.5.1. Comparison Between Group 1 and Group 2 (Table S7)

Multi-Group Analysis (MGA) revealed significant differences between experiential environmental investigation and restoration activities (Group 1) and personal sustainability practice and behavior-management activities (Group 2), particularly in communication processes, attention formation, and information-processing pathways. Group 1 exhibited a stronger communication-driven learning mechanism, with communication quality exerting a substantially greater effect on attention ($\beta = 0.619$ vs. 0.131 , $p = 0.001$), and peripheral processing showing a much stronger influence on perceived information value ($\beta = 0.850$ vs. 0.288 , $p = 0.004$). The pathway from perceived information value to perceived behavioral control was also stronger in Group 1 ($\beta = 0.782$ vs. 0.416 , $p < 0.001$), suggesting that experiential investigation activities relied heavily on communication cues, attention, and heuristic information processing.

In contrast, Group 2 demonstrated a stronger participation-driven learning mechanism. Participation exerted a greater effect on attention ($\beta = 0.648$ vs. 0.232 , $p = 0.001$), while attention more strongly stimulated central processing ($\beta = 0.591$ vs. 0.251 , $p = 0.021$). The indirect effect of participation on central processing was also significantly greater in Group 2 ($\beta = 0.383$ vs. 0.058 , $p < 0.001$), indicating that sustainability practice activities promoted deeper cognitive engagement through active participation.

Overall, the findings suggest that experiential investigation and restoration activities primarily operated through communication-driven and peripheral-processing pathways,

whereas sustainability practice activities promoted learning through participation and greater cognitive elaboration.

4.5.2. Comparison Between Group 1 and Group 3 (Table S8)

MGA further revealed substantial differences between experiential environmental investigation and restoration activities (Group 1) and community-based reflective and advocacy learning activities (Group 3), particularly in information-processing mechanisms. Group 3 exhibited significantly stronger central-route processing, with attention exerting a much greater effect on central processing ($\beta = 0.770$ vs. 0.251 , $p < 0.001$), and central processing strongly influencing perceived information value ($\beta = 0.531$ vs. -0.076 , $p < 0.001$). Practical experience also contributed positively to perceived information value in Group 3 but not in Group 1 ($\beta = 0.394$ vs. -0.037 , $p < 0.001$), suggesting that reflective and advocacy activities promoted meaning-making through cognitive elaboration and reflection.

In contrast, Group 1 demonstrated a stronger peripheral-processing pathway. Peripheral processing exerted a substantially greater effect on perceived information value ($\beta = 0.850$ vs. 0.019 , $p < 0.001$), representing the largest observed difference between the two groups. Attention also more strongly influenced peripheral processing in Group 1 ($\beta = 0.769$ vs. 0.576 , $p = 0.008$), indicating that experiential investigation activities relied primarily on direct environmental cues and experiential learning.

Additionally, participation-driven and central-processing pathways were significantly stronger in Group 3, leading to greater perceived information value, behavioral control, and behavioral intention. These findings suggest that experiential investigation activities primarily operate through experiential and heuristic mechanisms, whereas reflective and advocacy activities promote deeper cognitive processing, knowledge integration, and environmental meaning-making (Table 7).

4.6. Qualitative Findings on Environmental Behavioral Transformation Among Indigenous Youth

4.6.1. Overview of Qualitative Findings

Qualitative analysis using the Gioia methodology revealed a multi-stage process through which environmental learning experiences contributed to behavioral change, social engagement, environmental agency, and identity formation among indigenous youth. First-order concepts were organized into second-order themes and synthesized into five aggregate dimensions, illustrating how experiential learning, communication processes, and socio-cognitive factors interacted to facilitate environmental behavioral transformation (Table 8).

Table 8. Gioia Data Structure Illustrating Environmental Behavioral Transformation among indigenous youth.

Interview Topic	First-Order Concepts	Representative Quote	Second-Order Theme	Aggregate Dimension
Changes in environmental behaviors	Waste separation; plastic reduction; reusable bottles and bags; recycling and material reuse; composting; energy conservation; water conservation; sustainable transportation; food waste reduction; responsible consumption; pollution prevention; chemical-use reduction; personal environmental responsibility	"I now separate waste before throwing it away every time at home." "I carry my own tumbler to reduce plastic waste." "I turn off the lights whenever I leave a room."	Development of daily sustainable practices	Behavioral Adoption

Environmental stewardship activities	Tree planting; ecosystem restoration; watershed conservation; river and stream clean-up; mangrove restoration; biodiversity conservation; soil conservation; forest fire prevention; habitat restoration; nursery maintenance; environmental monitoring; school eco-projects; community restoration	"I planted more trees around my home." "I help care for the stream near our village." "I participate in water restoration activities."	Environmental stewardship behaviors	Behavioral Adoption
Community participation	Teamwork; volunteerism; cooperation; collective responsibility; peer encouragement; family engagement; community collaboration; intergenerational cooperation; conflict resolution; communication skills; shared resource management; community mobilization	"I encourage my parents to separate waste at home." "I teach my younger siblings about recycling." "I try to be a good role model."	Collective environmental participation	Social Learning
Indigenous ecological knowledge	Learning from elders; traditional ecological knowledge; indigenous conservation practices; sacred forest stewardship; traditional water management; sustainable farming; biodiversity knowledge; seasonal ecological knowledge; cultural values toward nature; environmental ethics; sustainable resource use; local ecological wisdom	"I joined a tree-planting activity with the community." "I learned teamwork skills." "I learned that change requires cooperation."	Indigenous ecological knowledge integration	Social Learning
Environmental communication	Sharing environmental knowledge; peer education; family education; environmental awareness campaigns; environmental discussions; social media communication; role modelling; environmental persuasion; community outreach; knowledge transfer; promoting sustainable behaviors	"I keep a record of my resource-use behaviors." "I review my behavior before going to bed." "I set goals to reduce waste each day."	Environmental social influence	Agency and Influence
Leadership and advocacy	Organizing environmental activities; environmental leadership; campaign coordination; advocacy; motivating participation; facilitating group activities; mentoring younger students; coordinating restoration projects; public speaking; community mobilization; environmental decision-making	"I learned about forests from village elders." "I understand the relationship between people and forests." "I believe local wisdom helps protect the environment."	Environmental advocacy and leadership	Agency and Influence
Self-regulation	Self-monitoring; behavioral reflection; goal setting; habit tracking; self-evaluation; environmental checklists; feedback seeking; behavioral adjustment; continuous improvement; responsibility for personal actions; monitoring environmental impact	"I organized a small clean-up activity at school." "I posted environmental messages on social media." "I feel more confident as a leader."	Self-regulated environmental action	Agency and Influence
Environmental identity	Environmental responsibility; stewardship identity; connection to nature; sense of belonging to nature; environmental ethics; intergenerational responsibility; sustainability commitment; environmental citizenship; pride in conservation; intrinsic motivation; biodiversity appreciation; seeing oneself as a protector of nature	"Nature is part of my life." "Conservation is part of who I am." "I want to be someone who protects nature." "I want to pass on a healthy environment to future generations."	Environmental identity transformation	Identity Internalization

4.6.2. Experiential Environmental Practice and Behavioral Internalization

Participants reported adopting a range of pro-environmental behaviors, including waste separation, reduced plastic consumption, composting, and water and energy conservation. These practices became integrated into daily routines, suggesting that repeated environmental experiences facilitated behavioral internalization and strengthened confidence in performing sustainable behaviors.

4.6.3. Community-Based Environmental Participation and Social Learning

Environmental learning was reinforced through participation in collective activities, such as tree planting, watershed conservation, ecological restoration, and community clean-up initiatives. Participants also emphasized learning from elders regarding traditional ecological knowledge, indicating that environmental understanding was shaped through social interaction, cultural values, and community engagement.

4.6.4. Environmental Communication, Persuasion, and Behavioral Influence

Participants actively disseminated environmental knowledge through interpersonal communication, school activities, and social media. Many described encouraging peers and family members to adopt environmentally responsible behaviors, demonstrating that environmental communication functioned as an important mechanism for behavioral influence and norm reinforcement.

4.6.5. Environmental Agency, Leadership, and Self-Regulated Action

Many participants reported assuming leadership roles in environmental activities, including organizing sustainability campaigns, coordinating community actions, and encouraging peer participation. Participants also described monitoring their own environmental behaviors and setting personal sustainability goals, indicating increased environmental agency and self-regulatory capacity.

4.6.6. Environmental Identity Formation and Intergenerational Responsibility

Participants expressed a growing sense of environmental identity characterized by feelings of interconnectedness with nature, environmental responsibility, and concern for future generations. These findings suggest that environmental learning extended beyond behavioral change to encompass value internalization, ethical responsibility, and long-term environmental stewardship.

4.6.7. Integrated Interpretation: A Multi-Mechanism Transformation Model

Overall, the qualitative findings revealed four interconnected stages of environmental behavioral transformation among indigenous youth: (1) Behavioral Adoption—engagement in sustainable daily practices; (2) Social Learning—participation in community-based activities and knowledge exchange; (3) Agency and Influence—development of leadership, communication, and environmental advocacy; and (4) Identity Internalization—formation of environmental identity and intergenerational responsibility.

Together, these findings suggest that environmental behavioral transformation emerged through the interaction of experiential learning, social participation, communication processes, and cognitive-behavioral mechanisms.

5. Discussion

The findings demonstrate that pro-environmental intentions among indigenous youth emerge through multiple complementary learning mechanisms rather than a single behavioral pathway (Figure 3). The following discussion integrates the quantitative and

qualitative evidence to explain how experiential learning, communication, cognitive evaluation, and behavioral capability collectively translate environmental learning into pro-environmental intentions and environmental stewardship within the integrated ELT–ELM–TPB framework.

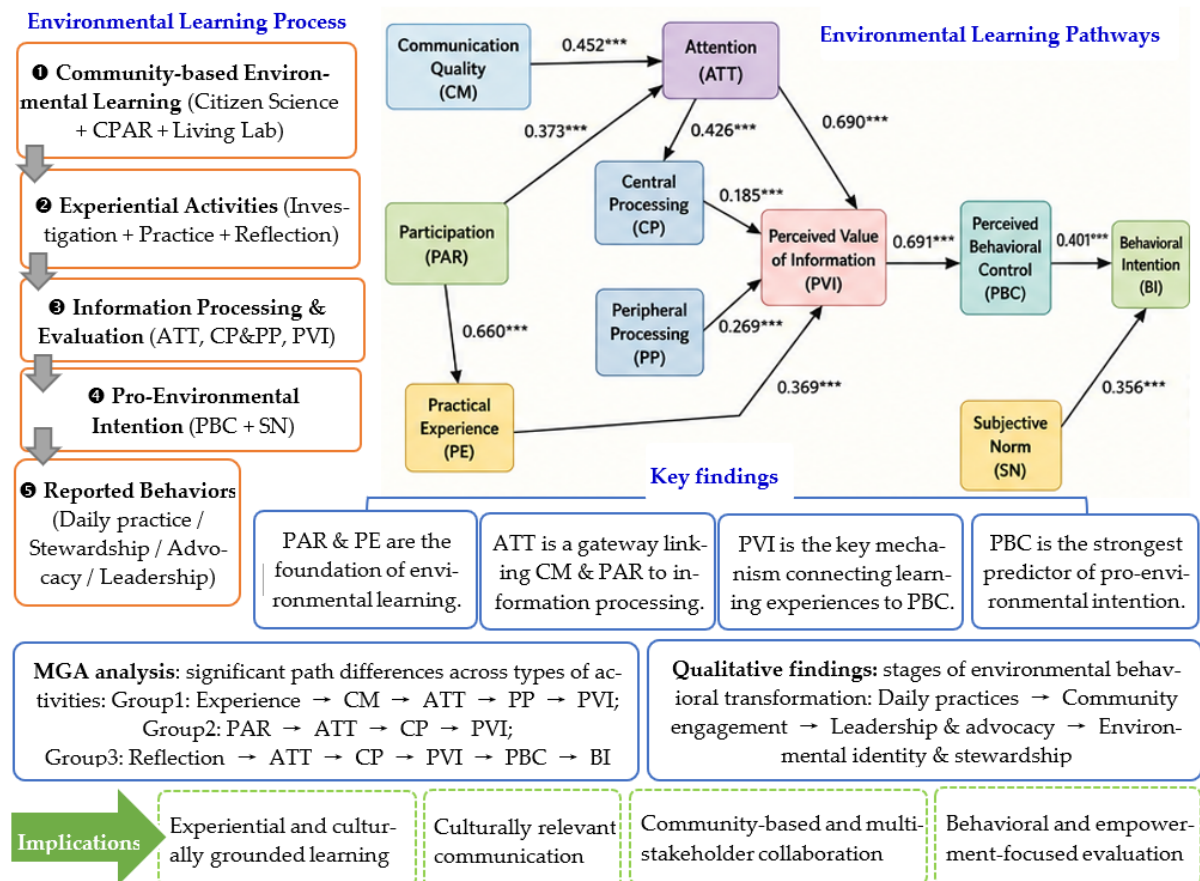


Figure 3. Environmental Learning Process and Pathways to Implications. (***) indicates statistical significance at $p < 0.001$.

5.1. Experiential Learning as the Foundation of Pro-Environmental Intentions

The findings demonstrate that participation and practical experience form the foundation of pro-environmental learning among indigenous youth. The structural model showed that participation strengthened practical experience, while the mediation analysis indicated that experiential-learning pathways generated stronger downstream effects on behavioral intention than communication-only pathways (Section 4.4). Participants' reflections further revealed changes in daily environmental practices, ecosystem restoration, and learning through direct interaction with nature and indigenous ecological knowledge. Together, these findings suggest that concrete environmental experiences enhance the perceived value of environmental information while fostering environmental stewardship.

These findings support ELT, which proposes that knowledge develops through concrete experience and reflective engagement rather than passive information transmission [9,25]. Experiential activities enabled participants to connect environmental knowledge with everyday life, consistent with research showing that direct engagement with nature strengthens environmental knowledge, emotional connection, and pro-environmental behavior [3,12]. The qualitative findings further suggest that experiential learning promotes

environmental stewardship identities and long-term responsibility toward nature, consistent with place-based and indigenous environmental education [26,27].

Accordingly, environmental education programs for indigenous youth should prioritize authentic, culturally grounded environmental experiences over classroom-based knowledge transfer alone, consistent with sustainability education emphasizing experiential and action-oriented learning [28,29].

5.2. Attention as the Gateway to Environmental Learning

The findings indicate that attention serves as the critical gateway connecting communication quality and participation with subsequent information processing. While the structural model identified communication quality as the strongest predictor of attention, the qualitative findings help explain this relationship. Participants frequently described learning through discussions with peers, guidance from community elders, storytelling, collaborative activities, and culturally grounded environmental communication, suggesting that meaningful communication first captures learners' attention before stimulating deeper cognitive engagement, consistent with previous environmental communication research [30,31].

This interpretation aligns with the Elaboration Likelihood Model, which proposes that attention is a prerequisite for both central and peripheral information processing [10,32]. However, attention alone is insufficient to promote behavioral change; rather, it initiates the cognitive processes through which environmental information becomes personally relevant and behaviorally meaningful, consistent with ELM research on information evaluation and internalization [33].

These findings extend previous environmental communication research by demonstrating that culturally grounded communication not only attracts attention but also enables learners to connect environmental messages with indigenous knowledge, lived experiences, and collective responsibility.

5.3. Perceived Information Value as the Critical Cognitive Mechanism

One of the most important findings is the central role of Perceived Information Value (PVI) as the cognitive mechanism linking environmental learning experiences to behavioral capability. The structural model demonstrated that practical experience together with both information-processing routes contributed to PVI, while the mediation analysis identified PVI as the principal mechanism connecting learning experiences with perceived behavioral control and behavioral intention (Section 4.4).

The qualitative findings complement this mechanism by illustrating how participants evaluated environmental knowledge according to its practical usefulness in daily life. Rather than emphasizing information acquisition alone, participants described applying environmental knowledge through waste reduction, ecosystem restoration, sustainable farming, and community conservation activities. These narratives suggest that environmental information becomes influential only when learners perceive it as locally relevant, culturally meaningful, and directly applicable, consistent with environmental communication research [34,35].

This interpretation is consistent with information-value and information adoption theories, which argue that individuals are more likely to adopt information perceived as useful for solving practical problems [36,37]. The present findings therefore extend previous environmental education research by suggesting that educational effectiveness depends less on the amount of information delivered than on learners' perceptions of its relevance and applicability within their own communities.

Accordingly, environmental education should emphasize culturally meaningful, action-oriented learning experiences that enhance the perceived value of environmental knowledge rather than focusing solely on information transmission.

5.4. Behavioral Control as the Primary Driver of Intention

Consistent with the Theory of Planned Behavior (TPB), perceived behavioral control emerged as the strongest determinant of pro-environmental intention [6,38]. The qualitative findings provide important contextual support for this relationship. Participants frequently described increased confidence in organizing environmental activities, monitoring their own behaviors, leading community initiatives, and encouraging others to adopt environmentally responsible practices. These experiences illustrate how experiential learning strengthened participants' confidence in their ability to perform environmental behaviors, reinforcing previous evidence that perceived behavioral control and self-efficacy are key predictors of environmental action [39,40]. They also reflect Bandura's concept of self-efficacy, whereby mastery experiences strengthen confidence to perform desired behaviors [41].

The findings also highlight the importance of subjective norms within indigenous communities. Participants consistently emphasized collective responsibility, intergenerational cooperation, and learning from elders, suggesting that social expectations and cultural values reinforce individual confidence and commitment to environmental action, consistent with research on indigenous environmental stewardship and community-based learning [42,43].

Together, the quantitative and qualitative findings suggest that environmental education should move beyond knowledge acquisition toward developing learners' confidence, agency, and practical competence within supportive community environments.

5.5. Complementary Environmental Learning Pathways

The MGA findings demonstrate that environmental learning pathways differ according to the educational characteristics of each activity rather than representing a single universal learning process. The qualitative findings provide additional insight into these differences. Participants involved in restoration activities emphasized direct engagement with ecosystems and environmental stewardship, whereas sustainability practice activities promoted behavioral experimentation and routine environmental practices. Reflective and advocacy-oriented activities, in contrast, generated narratives emphasizing leadership, environmental identity, self-regulation, and community influence.

These complementary findings suggest that different educational activities activate distinct learning mechanisms. Experiential activities promote environmental awareness through direct interaction with nature, consistent with experiential and inquiry-based learning approaches [3,9]. Participatory activities strengthen behavioral competence through active involvement, supporting theories of learning-by-doing and participatory education [28]. Reflective and advocacy-oriented activities facilitate deeper cognitive elaboration, environmental agency, and identity formation, consistent with the Elaboration Likelihood Model, which proposes that central-route processing promotes more enduring attitudinal and behavioral change [10,32].

This interpretation extends ELT, ELM, and TPB by demonstrating that environmental learning should be conceptualized as a dynamic, activity-dependent process rather than a single linear pathway. Accordingly, effective environmental education programs should integrate experiential, participatory, reflective, and advocacy-oriented pedagogies to promote complementary dimensions of environmental learning. Such an integrated approach is consistent with contemporary sustainability education frameworks that emphasize transformative, participatory, and action-oriented learning [29,44].

5.6. Environmental Identity and Intergenerational Stewardship

An important contribution emerging from the qualitative findings is the identification of environmental identity and intergenerational stewardship as outcomes extending beyond the quantitative model. Participants increasingly described environmental protection as part of their personal identity, their cultural responsibility, and their commitment to future generations. These narratives suggest that environmental learning was not limited to developing behavioral intention but also fostered enduring environmental values and a stronger sense of belonging to both community and nature.

Although environmental identity was not explicitly included in the structural model, the qualitative findings indicate that it may represent an important mechanism through which experiential learning contributes to sustained environmental engagement. This interpretation is consistent with previous studies emphasizing the role of environmental identity, place attachment, and indigenous knowledge systems in promoting long-term pro-environmental behavior [13,28,45].

Future research should therefore examine environmental identity and environmental agency as latent constructs within expanded ELT–ELM–TPB models to better understand how environmental learning contributes to sustained environmental stewardship over time.

6. Conclusions

This study investigated the mechanisms underlying pro-environmental intentions and reported behaviors among indigenous youth by integrating Experiential Learning Theory (ELT), the Elaboration Likelihood Model (ELM), and the Theory of Planned Behavior (TPB). Using a mixed-methods approach combining Partial Least Squares Structural Equation Modeling (PLS-SEM), Multi-Group Analysis (MGA), and Gioia qualitative analysis, the findings demonstrate that environmental behavioral change emerges through the interaction of experiential learning, information-processing mechanisms, perceived information value, and socio-cognitive determinants of behavior.

The quantitative findings revealed that participation and practical experience form the foundation of environmental learning, while attention functions as a critical gateway linking communication quality and participation to information processing. Perceived value of information emerged as the most important cognitive mechanism translating environmental experiences into behavioral capability and intention, whereas perceived behavioral control was identified as the strongest direct predictor of pro-environmental intention. The qualitative findings further demonstrated that environmental learning among indigenous youth extends beyond behavioral intention to encompass environmental stewardship, leadership, environmental agency, environmental identity, and intergenerational responsibility.

A major contribution of this study is the demonstration that environmental learning pathways are activity-dependent rather than universal. Multi-Group Analysis revealed that experiential environmental investigation and restoration activities primarily activated communication-driven and peripheral-processing pathways, sustainability practice activities emphasized participation and central cognitive processing, and reflective and advocacy-oriented activities promoted deeper cognitive elaboration, environmental agency, and behavioral transformation. These findings extend existing applications of ELT, ELM, and TPB by suggesting that different environmental learning activities activate distinct but complementary mechanisms of environmental behavioral change.

The findings have important implications for environmental education and sustainability practice. Environmental education programs for indigenous youth should move beyond conventional classroom-based knowledge transfer and adopt experiential, participatory, reflective, and culturally grounded learning approaches. Activities such as

ecological restoration, citizen science, environmental stewardship, reflection, advocacy, and youth leadership development may strengthen environmental knowledge, behavioral capability, environmental identity, and long-term environmental commitment. In addition, environmental communication strategies should incorporate indigenous ecological knowledge, local environmental contexts, and culturally relevant messages to enhance attention, perceived information value, and environmental engagement.

From a policy perspective, the findings support increased investment in community-based and participatory environmental education programs that foster collaboration among schools, indigenous communities, local governments, and civil society organizations. Evaluation frameworks should move beyond knowledge acquisition and include indicators of behavioral change, environmental agency, leadership, and community participation.

Finally, future research should extend the integrated ELT–ELM–TPB framework by incorporating additional constructs, such as environmental identity, environmental self-efficacy, moral norms, place attachment, environmental agency, and indigenous cultural values. In particular, environmental identity and environmental agency, which emerged inductively from participants' reflective narratives in this study, should be further conceptualized and empirically examined as potential latent constructs within expanded SEM frameworks using larger samples. Future studies should also investigate whether cultural identity functions as a moderating mechanism influencing how environmental experiences are interpreted, how environmental information is processed, and how behavioral intentions are developed. Because the present findings are analytically rather than statistically transferable, multi-site and cross-cultural studies involving diverse indigenous communities are needed to examine the broader applicability of the proposed framework across different cultural, educational, and ecological contexts. Longitudinal research is also recommended to examine the persistence of environmental behavioral change over time and to explore how indigenous worldviews, community connectedness, and culturally grounded learning processes contribute to sustained environmental stewardship and collective environmental action.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/su18158010/s1>, Table S1: Collinearity statistics (VIF); Table S2: Discriminant validity of the measurement model based on the heterotrait–monotrait ratio (HTMT); Table S3: Fornell–Larcker criterion; Table S4: The R-square; Table S5: F-square; Table S6: Mediation Analysis; Table S7: Multi-Group Analysis (Comparison between Group 1 and Group 2); Table S8: Multi-Group Analysis (Comparison between Group 1 and Group 3).

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References

1. United Nations. *The Sustainable Development Goals Report 2023*; United Nations: New York, NY, USA, 2023. Available online: <https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf> (accessed on 27 June 2026).
2. Steg, L.; Vlek, C. Encouraging pro-environmental behaviour: An integrative review and research agenda. *J. Environ. Psychol.* **2009**, *29*, 309–317. <https://doi.org/10.1016/j.jenvp.2008.10.004>.
3. Ardoin, N.M.; Bowers, A.W.; Gaillard, E. Environmental education outcomes for conservation: A systematic review. *Biol. Conserv.* **2020**, *241*, 108224. <https://doi.org/10.1016/j.biocon.2019.108224>.
4. Berkes, F. *Sacred Ecology*, 4th ed.; Routledge: New York, NY, USA, 2018.
5. IPBES. Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; Version 1. *Zenodo* **2019**, 1148. <https://doi.org/10.5281/zenodo.6417333>.
6. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T).
7. Yuriev, A.; Boiral, O.; Francoeur, V.; Paillé, P. Overcoming the barriers to pro-environmental behaviors in the workplace: A systematic review. *J. Clean. Prod.* **2018**, *182*, 379–394. <https://doi.org/10.1016/j.jclepro.2018.02.041>.
8. Kollmuss, A.; Agyeman, J. Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* **2002**, *8*, 239–260. <https://doi.org/10.1080/13504620220145401>.
9. Kolb, D.A. *Experiential Learning: Experience as the Source of Learning and Development*; Prentice Hall: Englewood Cliffs, NJ, USA, 1984.
10. Petty, R.E.; Cacioppo, J.T. *Communication and Persuasion: Central and Peripheral Routes to Attitude Change* New York, NY, USA, 1986; Springer: Berlin/Heidelberg, Germany. Available online: <https://richardpetty.com/wp-content/uploads/2019/01/1986-jpsp-cacioppopettykaorodriguez.pdf> (accessed on 27 June 2026).
11. Gioia, D.A.; Corley, K.G.; Hamilton, A.L. Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organ. Res. Methods* **2013**, *16*, 15–31.
12. Monroe, M.C.; Plate, R.R.; Oxarart, A.; Bowers, A.; Chaves, W.A. Identifying effective climate change education strategies: A systematic review of the research. *Environ. Educ. Res.* **2019**, *25*, 791–812. <https://doi.org/10.1080/13504622.2017.1360842>.
13. Tabernero, C.; Hernández, B. Self-efficacy and intrinsic motivation guiding environmental behavior. *Environ. Behav.* **2011**, *43*, 658–675. <https://doi.org/10.1177/0013916510379759>.
14. McGuire, W. Input and output variables currently promising for constructing persuasive communications. In *Public Communication Campaigns*, 3rd ed.; Rice, R.E., Atkin, C.K., Eds.; Sage: Thousand Oaks, CA, USA, 2001; pp. 22–48.
15. Witte, K. Putting the fear back into fear appeals: The extended parallel process model. *Commun. Monogr.* **1992**, *59*, 329–349. <https://doi.org/10.1080/03637759209376276>.
16. Freire, P. *Pedagogy of the Oppressed*; Continuum: New York, NY, USA, 1970.
17. Kahneman, D. *Attention and Effort*; Prentice-Hall: Englewood Cliffs, NJ, USA, 1973.
18. DeLone, W.H.; McLean, E.R. The DeLone and McLean model of information systems success: A ten-year update. *J. Manag. Inf. Syst.* **2003**, *19*, 9–30. <https://doi.org/10.1080/07421222.2003.11045748>.
19. Davis, F.D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* **1989**, *13*, 319–340. <https://doi.org/10.2307/249008>.
20. Hair, J.F.; Hult, G.T.M.; Ringle, C.M.; Sarstedt, M. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 3rd ed.; Sage: Thousand Oaks, CA, USA, 2022.
21. Henseler, J.; Ringle, C.M.; Sarstedt, M. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *J. Acad. Mark. Sci.* **2015**, *43*, 115–135.
22. Henseler, J.; Ringle, C.M.; Sarstedt, M. Testing measurement invariance of composites using partial least squares. *Int. Mark. Rev.* **2016**, *33*, 405–431.
23. Lincoln, Y.S.; Guba, E.G. *Naturalistic Inquiry*; Sage: Beverly Hills, CA, USA, 1985.
24. Creswell, J.W.; Plano Clark, V.L. *Designing and Conducting Mixed Methods Research*, 3rd ed.; Sage: Thousand Oaks, CA, USA, 2018.

25. Kolb, D.A. Learning styles and learning spaces: A review of the multidisciplinary application of experiential learning theory in higher education. In *Learning Styles and Learning: A Key to Meeting the Accountability Demands in Education*; Sims, R.R., Sims, S.J., Eds.; Nova Science Publishers: New York, NY, USA, 2005; pp. 45–91.
26. Kimmerer, R.W. *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*; Milkweed Editions: Minneapolis, MN, USA, 2013.
27. McGregor, D. Traditional knowledge and water governance: The ethic of responsibility. *AlterNative* **2014**, *10*, 493–507. <https://doi.org/10.1177/117718011401000505>.
28. Wals, A.E.J.; Brody, M.; Dillon, J.; Stevenson, R.B. Convergence between science and environmental education. *J. Environ. Educ.* **2014**, *45*, 71–76. <https://doi.org/10.1126/science.1250515>.
29. UNESCO. *Education for Sustainable Development: A Roadmap*; UNESCO: Paris, France, 2020. Available online: <https://ocm.icrom.org/documents/education-sustainable-development-roadmap-esd-2030-roadmap> (accessed on 27 June 2026).
30. Moezzi, M.; Janda, K.B.; Rotmann, S. Using stories and storytelling in energy and climate change research. *Energy Res. Soc. Sci.* **2017**, *31*, 1–10. <https://doi.org/10.1016/j.erss.2017.06.034>.
31. Fernández-Llamazares, Á.; Cabeza, M. Rediscovering the potential of Indigenous storytelling for conservation practice. *Conserv. Lett.* **2018**, *11*, e12398. <https://doi.org/10.1111/conl.12398>.
32. Petty, R.E.; Briñol, P.; Priester, J.R. Mass media attitude change: Implications of the elaboration likelihood model of persuasion. In *Media Effects: Advances in Theory and Research*, 3rd ed.; Bryant, J., Oliver, M.B., Eds.; Routledge: New York, NY, USA, 2009; pp. 125–164.
33. Petty, R.E.; Briñol, P. The elaboration likelihood model. In *Handbook of Theories of Social Psychology*; Van Lange, P.A.M., Kruglanski, A.W., Higgins, E.T., Eds.; Sage: London, UK, 2012; pp. 224–245.
34. Nisbet, M.C. Communicating climate change: Why frames matter for public engagement. *Environment* **2009**, *51*, 12–23. <https://doi.org/10.3200/ENVT.51.2.12-23>.
35. Corner, A.; Markowitz, E.; Pidgeon, N. Public engagement with climate change: The role of human values. *WIREs Clim. Change* **2014**, *5*, 411–422.
36. Sussman, S.W.; Siegal, W.S. Informational influence in organizations: An integrated approach to knowledge adoption. *Inf. Syst. Res.* **2003**, *14*, 47–65. <https://doi.org/10.1287/isre.14.1.47.14767>.
37. Erkan, I.; Evans, C. The influence of eWOM in social media on consumers' purchase intentions. *J. Res. Interact. Mark.* **2016**, *10*, 47–65. <https://doi.org/10.1108/JRIM-01-2015-0004>.
38. Ajzen, I. The theory of planned behavior: Frequently asked questions. *Hum. Behav. Emerg. Technol.* **2020**, *2*, 314–324.
39. Bamberg, S.; Möser, G. Twenty years after Hines, Hungerford, and Tomera: A meta-analysis of psycho-social determinants of pro-environmental behaviour. *J. Environ. Psychol.* **2007**, *27*, 14–25. <https://doi.org/10.1016/j.jenvp.2006.12.002>.
40. Han, H. Travelers' pro-environmental behavior in a green lodging context: Converging value-belief-norm theory and the theory of planned behavior. *Tour. Manag.* **2015**, *47*, 164–177. <https://doi.org/10.1016/j.tourman.2014.09.014>.
41. Bandura, A. *Self-Efficacy: The Exercise of Control*; Freeman: New York, NY, USA, 1997.
42. Whyte, K.P. Indigenous climate change studies: Indigenizing futures, decolonizing the Anthropocene. *Engl. Lang. Notes* **2017**, *55*, 153–162.
43. Reo, N.J.; Whyte, K.P.; McGregor, D.; Smith, M.; Jenkins, J.F. Factors that support Indigenous involvement in multi-actor environmental stewardship. *AlterNative* **2017**, *13*, 58–68. <https://doi.org/10.1177/1177180117701028>.
44. Brundiers, K.; Wiek, A.; Redman, C.L. Real-world learning opportunities in sustainability education. *Int. J. Sustain. High. Educ.* **2010**, *11*, 308–324. <https://doi.org/10.1108/14676371011077540>.
45. Clayton, S. (Ed.) *The Oxford Handbook of Environmental and Conservation Psychology*; Oxford University Press: Oxford, UK, 2012.

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