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Education for Sustainable Development in Morocco: Psychosocial Determinants and Didactic Implications

Asma ID BABOU[1,2]

[1]Laboratory of Research in Sciences and Techniques, Higher School of Education and Training, Ibn Zohr University, Agadir, Morocco

[2]Regional Center for Education and Training Professions of Souss-Massa, Morocco

Email: asmaidbabou@gmail.com

ORCID ID: https://orcid.org/0009-0005-4472-3360

Abstract

Contemporary educational systems play a strategic role in raising environmental awareness and fostering pro-environmental behaviors from an early age. Grounded in science didactics, this study explores at the micro-systemic level the structural relationships between students' representations of biodiversity, their individual behaviors, the behaviors of their social entourage, and their effective contribution to Education for Sustainable Development. A confirmatory quantitative survey was conducted among 202 high school students across six qualifying secondary schools in Morocco. Factor analyses and partial least squares structural equation modeling (PLS-SEM via SmartPLS v4) confirm high psychometric reliability across all constructs (Cronbach's α between 0.828 and 0.931; rho_A between 0.913 and 0.922; CR between 0.918 and 0.932) and demonstrate that students' individual behaviors ($\beta = 0.338$; $t = 2.966$; $p = 0.003$) as well as social modeling by their entourage ($\beta = 0.411$; $t = 4.049$; $p < 0.001$) exert a highly significant positive influence on Education for Sustainable Development, jointly explaining nearly half of its variance ($R^2 = 0.499$; $Q^2 = 0.458$). These findings underscore the decisive role of cognitive and relational dynamics in shaping eco-citizen attitudes and call for participatory, experiential, and place-based didactic approaches linking schools, families, and local communities.

Keywords

Pro-environmental behaviors; Social representations; Education for Sustainable Development; Social learning; Science didactics; Moroccan high schools

1. Introduction

On both global and national scales, natural ecosystems face mounting anthropogenic pressures resulting from pollution, rapid urbanization, habitat fragmentation, and climate change. In Morocco, and particularly in vulnerable pre-Saharan and semi-arid territories such as the province of Guelmim,

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the erosion of oasis, steppe, and coastal biodiversity poses a vital challenge directly affecting water, food, and socio-economic security. Faced with this ecological urgency, Education for Sustainable Development (ESD) serves as a key strategic lever to promote responsible conduct and foster critical environmental awareness from adolescence.

However, from the standpoint of science didactics, biodiversity education cannot be reduced to a mere top-down transmission of biological, taxonomic, or ecological facts. Its primary aim is to cultivate lasting attitudes, ethical values, and action competencies in favor of preserving living systems (Lange & Martinand, 2014). Extensive international literature in environmental psychology and didactics emphasizes that mastering theoretical scientific knowledge alone does not automatically translate into virtuous ecological practices, a discrepancy widely recognized as the "knowledge-action gap" (Kollmuss & Agyeman, 2002; Hungerford & Volk, 1990). This behavioral inertia directly questions the effectiveness of traditional schooling models, which often prioritize cognitive assessment over civic engagement.

In this context, the mental and social representations that students construct regarding biodiversity play a pivotal role. Shaped by direct sensory experiences, socio-cultural heritage, and everyday interactions, these representations act as interpretive frameworks guiding attitudes, value judgments, and environmental practices (Id Babou et al., 2023; Moscovici, 1961; Vygotsky, 1978). Furthermore, adolescents never act in isolation: the influence of their immediate entourage-parents, teachers, and peer groups, proves decisive (Steg et al., 2014), as young people draw heavily upon behavioral patterns observed and legitimized within their family and school environments (Bandura, 1977; Bruner, 1986).

This research aims to empirically analyze the structural links between Moroccan high school students' representations of biodiversity, their individual pro-environmental behaviors, and those of their social entourage, in order to assess how these psychosocial dynamics, contribute to effective ESD. To guide this explanatory investigation, two core hypotheses were formulated:

- Hypothesis 1(H1): Students' pro-environmental behaviors (CCE) reflect their representations of biodiversity and exert a direct, positive, and significant influence on their contribution to Education for Sustainable Development (ESD);
- Hypothesis 2 (H2): The pro-environmental behaviors of students' social entourage (CCEE) are closely linked to their representations of biodiversity and exert a significant positive effect on anchoring Education for Sustainable Development (ESD).

2. Theoretical Framework: Representations, Behaviors and Social Mediation

2.1. From Social Representations to "Education to": Epistemological Issues in Didactics

In the didactics of life and earth sciences, the concept of representation — inherited from both Piagetian genetic psychology and the theory of social representations of Moscovici (1961) and Jodelet (1989), refers to a form of knowledge that is socially elaborated and shared, with a practical aim and contributing to the construction of a reality common to a social whole. When they relate to biodiversity, these representations are not simple "errors" or "erroneous conceptions" that would simply need to be rectified by a masterful contribution of scholarly knowledge; they constitute systems of interpretation rooted in the cultural values, affects and daily uses of the territory (Id-Babou et al., 2023).

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The integration of biodiversity within "education to" (environmental education, education for sustainable development, citizenship education) further complicates the didactic task. Unlike traditional school disciplines structured around stabilized knowledge, ESD addresses Socially Lively Questions (QSV) crossed by scientific uncertainties, economic conflicts of interest and ethical choices (Legarde & Simonneaux, 2006; Lange & Martinand, 2014). Therefore, understanding how students' representations are articulated with their actual behaviors and with the norms of their surroundings becomes an essential condition for designing pedagogical devices capable of going beyond ecological verbalism.

2.2. The multidimensional and contextual nature of pro-environmental behaviour

Human behaviour is a central object of study at the crossroads of psychology, educational sciences and environmental sciences. It is defined as an observable and measurable action reflecting the dynamic interaction between an individual and his or her physical and social environment (Bandura, 1986). In the school context, behaviours related to biodiversity are embodied in tangible practices: participation in conservation or reforestation projects, responsible consumption, rational management of water and waste, or involvement in citizen awareness-raising initiatives.

According to Ajzen (1991), individual behaviours are governed by the interaction between internal stimuli (attitudes, belief systems, personal values) and external stimuli (subjective social norms, reference models, institutional context). This perspective highlights the psychosocial dimension of ecological action: behaviour is fundamentally contextual. Immersive educational experiences in high school (such as ecological field trips or science club projects) can stimulate and consolidate favourable attitudes, while the lack of support or coherence in the family environment can weaken them.

2.3. The four operational dimensions of biodiversity behaviour

The rigorous evaluation of high school students' behaviors with regard to biodiversity requires taking into account four interconnected behavioral and cognitive dimensions (Hungerford & Volk, 1990; Steg et al., 2014):

- Direct pro-environmental behaviours: these correspond to active engagement in concrete actions to preserve, protect or restore local ecosystems;
- Responsible consumption behaviours: these are reflected in the adoption of sustainable daily habits, such as reducing plastic waste, saving water and energy, and the reasoned choice of environmentally friendly products;
- Participation in educational and awareness-raising activities: this includes voluntary involvement in school ESD programmes, hands-on workshops, environmental clubs and community campaigns;
- Self-directed learning and self-inquiry: this dimension reflects the autonomous process of seeking scientific information and the voluntary deepening of knowledge about biodiversity.

2.4. Explanatory theories of behaviour: from individual intention to social learning

Four complementary theoretical frameworks shed light on the psychological and relational mechanisms that underlie these behaviours:

- The theory of reasoned action and planned behaviour (Ajzen, 1991): it postulates that voluntary behaviours are preceded by behavioural intentions, which are themselves

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determined by personal attitudes towards the act, the subjective norms perceived by those around them and the feeling of behavioural control;

- The theory of cognitive dissonance (Festinger, 1957): it explains that individuals seek to reduce the psychological tension resulting from a gap between their ecological convictions and their daily actions, thus shedding light on certain inconsistencies observed in environmental practices;
- Social Learning Theory (Bandura, 1977): it emphasizes the central role of observation, imitation and vicarious modelling: students tend to adopt and reproduce behaviours valued and practiced by their teachers, parents or peers;
- Socioconstructivist theory (Vygotsky, 1978; Bruner, 1986): it emphasizes that learning and value systems are constructed through social interaction, with the environment acting as an essential mediator in the development of representations relating to the living.

2.5. Values associated with biodiversity: the contribution of Kellert's typology

The representations that students have towards biodiversity are rooted in a set of values that guide their attitudes and behaviour. Stephen Kellert's typology (1993, 1996, 2002) proposes a heuristic classification of these values according to eight fundamental dimensions (Table 1).

Table 1: Typology of values associated with biodiversity and nature (adapted from Kellert, 1996)

Category	Synthetic definition	Dominant function
Utilitarian	The instrumental value of nature to satisfy human material needs.	Hardware, cost-effective and secure support
Naturalist	Pleasure of exploration and curiosity linked to direct contact with nature.	Cognitive and emotional development
Aesthetics	Appreciation of the physical beauty and harmony of natural environments.	Inspiration and well-being
Humanist	Deep emotional and affective attachment to living beings.	Empathy and social cohesion
Moralist	Ethical concern and sense of duty for the protection of living things.	Moral responsibility and respect
Eco-friendly	Scientific understanding of the systemic interdependencies of ecosystems.	Knowledge and rational observation
Symbolism	Use of nature as a vehicle for cultural expression and meaning.	Communication and cultural identity
Dominant / Negativist	A relationship of domination, control or fear in the face of nature.	Control, avoidance or rejection

This typology is particularly fruitful for our research: it allows us to decipher the diversity of relationships with nature among Moroccan high school students. These registers of values (whether cognitive, affective, utilitarian or moral) directly condition the nature and intensity of pro-environmental behaviors, thus offering a valuable analytical framework for understanding how representations, shaped by school and social environment, translate into actions in favor of sustainable development.

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3. Research Methodology and Empirical Protocol

3.1. Type of research and justification for the confirmatory quantitative approach

This study adopts a confirmatory quantitative approach aimed at modeling and testing the causal relationships between representations of biodiversity, the individual behaviors of students, the behaviors of those around them and their contribution to Education for Sustainable Development. After a rigorous stage of cultural and didactic contextualization of the theoretical model in the Moroccan context, a structured questionnaire was designed based on scales validated in the international scientific literature (Ajzen, 1991; Kellert, 1996; Steg et al., 2014). Each statement was evaluated according to a five-level Likert scale (from 1 = "Strongly disagree" to 5 = "Strongly agree").

3.2. Study field, population and characteristics of the sample

The survey was administered to a sample of 202 students enrolled in six secondary schools in the province of Guelmim (southern Morocco). This pre-Saharan territory, characterized by the fragility of its oasis ecosystems and a high vulnerability to water stress and desertification, is a privileged observatory for analyzing the ecological representations and practices of young people in the face of tangible environmental issues.

Participants were selected through purposive sampling to ensure a balanced representation of schools (urban and rural) and scientific fields. The sociodemographic and academic characteristics of the sample are distributed as follows:

- Gender: 71% boys and 29% girls;
- School environment: 53% of pupils attend school in urban areas and 47% in rural areas;
- Level and course of study: 71% of students in the second year of the Baccalaureate, Physical Sciences (PC) option, and 29% in the second year of the Baccalaureate, Life and Earth Sciences (SVT) option.

These proportions ensure a satisfactory representativeness of the target population and fully comply with the sample size requirements required for confirmatory factor analyses and structural equation modelling (Hair et al., 2011).

3.3. Tools for measurement, operationalization and psychometric validation

The questionnaire includes three measurement scales covering the key dimensions of the conceptual model: (1) students' behavior towards biodiversity (CCE, 13 items); (2) the behavior of the student's social environment, parents, teachers and peers (CCEE, 9 items); and (3) the contribution to Education for Sustainable Development (ESD, 13 items). Table 2 illustrates the operationalization of these three constructs through examples of representative items.

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Table 2: Operationalization of latent constructs and examples of questionnaire items

Latent Construct (Code)	Number of items	Examples of representative items measured on the Likert scale (1 to 5)
Student Behaviour (CCE)	13 items	• I voluntarily participate in tree planting or cleaning activities within my high school. • I adopt daily actions to save water and reduce plastic waste. • I inform myself independently about the protection of species local animal and plants.
Behaviour of the entourage (CCEE)	9 items	• My parents encourage and practice gestures of preservation of natural resources at home. • My teachers concretely integrate the issues of protection of the biodiversity in their courses. • My classmates' value ecological initiatives and respect for nature in high school.
Education for Sustainable Development (ESD)	13 items	• Educational activities on biodiversity allow me to understand the challenges of sustainable development. • The school helps me develop civic skills to act in favor of the environment. • I feel able to raise awareness of the preservation of ecosystems.

The factor validity and internal reliability of the scales were first assessed under SPSS using principal component analysis (PCA) and Cronbach's alpha test (Table 3).

Table 3: Factor Adequacy Tests (KMO) and Exploratory Internal Consistency Tests (SPSS)

Latent variable	KMO Index	Explained variance (%)	Cronbach's Alpha (SPSS)
Student Behaviour (CCE)	0,821	45,21 %	0,898
Behaviour of the entourage (CCEE)	0,890	64,52 %	0,931
Education for Sustainable Development (ESD)	0,749	33,97 %	0,828

The indices obtained confirm the excellent psychometric quality of the instruments: for student behaviour (CCE), the KMO index of 0.821 indicates a very satisfactory inter-item correlation, a coherent explained variance of 45.21% and excellent internal reliability (α = 0.898). For entourage behaviour (CCEE), the KMO index reaches 0.890 with an explained variance of 64.52% and a very high internal consistency (α = 0.931). Finally, for Education for Sustainable Development (ESD), the KMO index of 0.749 and the Cronbach alpha of 0.828 attest to a completely satisfactory homogeneity for a multidimensional construct.

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4. Results Analysis and Structural Modeling

The confirmatory empirical analysis was conducted using the partial least squares approach (PLS-SEM) using the SmartPLS v4 software. The choice of this method is justified by its robustness in the estimation of complex predictive models mobilizing latent psychosocial variables without strict constraints of multivariate normality (Hair et al., 2011). In accordance with the reference methodological recommendations, the approach was articulated in two stages: the evaluation of the validity and reliability of the external measurement model, followed by the evaluation of the internal structural model and the testing of the hypotheses.

4.1. Validation of the measurement model: reliability and convergent validity

The internal reliability and convergent validity criteria in SmartPLS v4 were verified through four complementary indicators presented in Table 4: Cronbach's alpha (α), the Dijkstra-Henseler reliability coefficient (rho_A), Composite Reliability (CR) and Average Variance Extracted (AVE).

Table 4: Construct reliability and convergent validity of the measurement model (SmartPLS v4 outputs)

Latent Construct	Cronbach's Alpha (α)	rho_A	Composite Reliability (CR)	AVE
Student Behaviour (CCE)	0,916	0,922	0,930	0,597
Behaviour of the entourage (CCEE)	0,900	0,913	0,918	0,585
Education for Sustainable Development (ESD)	0,909	0,915	0,932	0,732

As shown by the SmartPLS v4 outputs (Table 4), all the internal consistency indices — both Cronbach's alpha (between 0.900 and 0.916) and the rho_A coefficient (between 0.913 and 0.922) and the composite CR reliability (between 0.918 and 0.932), far exceed the critical threshold of 0.70, attesting to the remarkable reliability of the three constructs. In addition, all extracted mean variance (AVE) values are well above the minimum threshold of 0.50 (0.597 for CCE; 0.585 for CCEE; 0.732 for EDD), thus confirming a fully satisfactory convergent validity (Hair et al., 2011).

4.2. Evaluation of the structural model: explanatory power, effect size and predictive capacity

The overall quality of the structural model was assessed using three key indicators (Table 5): the coefficient of determination (R^2), the effect size (f^2) and the Stone-Geisser predictive relevance index (Q^2).

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Table 5: Evaluation of the explanatory and predictive quality of the structural model (SmartPLS v4 outputs)

Structural indicator	Value Achieved	Methodological interpretation
R^2 (Coefficient of determination — EDD)	0,499	Substantial explanatory power (49.9% explained variance)
f^2 (Effect Size: CCE → EDD)	0,169	Direct effect of moderate intensity
f^2 (Effect Size: CCEE → EDD)	0,267	Direct effect of moderate to strong intensity
Q^2 (Predictive Ability — Blindfolding)	0,458	Strong predictive relevance of the model ($Q^2 > 0.35$)

The results of the structural model indicate that the behaviours of pupils and those of their entourage jointly explain nearly 50% of the variance observed in Education for Sustainable Development ($R^2 = 0.499$). The analysis of the effect size (f^2) shows a moderate influence of the pupil's own behaviour ($f^2 = 0.169$) and a significantly more marked influence of the behaviour of his or her social environment ($f^2 = 0.267$), underlining the preponderant weight of social interactions in the genesis of eco-citizen attitudes. Finally, the value $Q^2 = 0.458$ attests to the excellent predictive capacity of the model, confirming its statistical robustness.

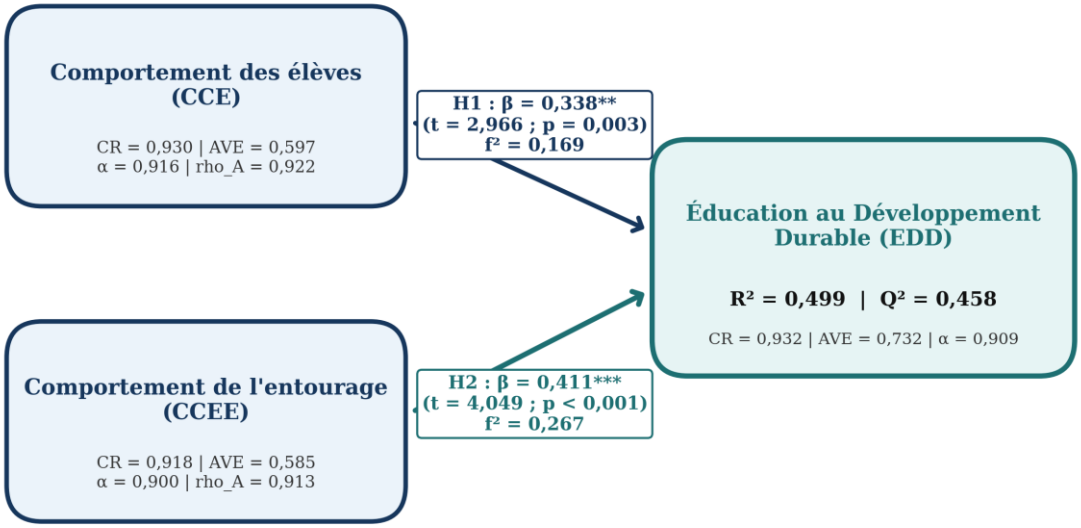
4.3. Testing of research hypotheses and representation of the structural model

The examination of the causal relationships between the latent variables allowed us to test our two research hypotheses using standardized tracking coefficients (β), values of the Student's T statistic and significance thresholds (P-values) from a bootstrapping procedure (Table 6 and Figure 1).

Table 6: Structural Assumption Test Results (SmartPLS v4 Outputs)

Hypothesized relationship	Coefficient (β)	Statistic T	P-Value	Empirical decision
H1: CEC → ESD	0,338	2,966	0,003	Validated
H2: CCEE → ESD	0,411	4,049	< 0.001	Validated

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*Source : Modélisation structurelle PLS-SEM (SmartPLS v4, N = 202, Bootstrapping 5 000 sous-échantillons). ** p < 0,01 ; *** p < 0,001.*

Figure 1: Validated structural model of the behavioural and social determinants of Education for Sustainable Development (PLS-SEM).

The two structural relationships were statistically significant at the 1% level ($p < 0.01$; $T > 1.96$), thus confirming:

- On the one hand (H1), that students' pro-environmental behaviors positively and directly influence their engagement in Education for Sustainable Development ($\beta = 0.338$; $T = 2.966$; $p = 0.003$);
- On the other hand (H2), that the pro-environmental behaviours of those around them have an even more pronounced positive effect on this same dynamic ($\beta = 0.411$; $T = 4.049$; $p < 0.001$).

5. Discussion and Didactic Issues for Education for Sustainable Development in Morocco

5.1. Discussion of empirical results with regard to theoretical frameworks

The results obtained confirm our two research hypotheses and highlight the central role of behaviors, representations and social mediation in biodiversity education:

First, the significant link between students' behaviour and their contribution to ESD ($\beta = 0.338$; $p = 0.003$) supports the idea that pro-environmental behaviours are the direct extension of internalised representations and attitudes (Ajzen, 1991; Kollmuss & Agyeman, 2002). In other words, high school students who perceive biodiversity as an essential and not purely instrumental value exhibit more responsible behaviours, such as reducing waste, participating in ecological projects or raising awareness among their peers. These results support the theory of biophilia (Kellert & Wilson, 1993) as

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well as the work of Kellert (1996, 2002), according to which affective and cognitive interactions with living organisms shape ecological attitudes in the long term.

Secondly, the preponderant influence of the behaviour of those around them ($\beta = 0.411$; $p < 0.001$; $f^2 = 0.267$) confirms the decisive weight of the social and relational context in the formation of environmental attitudes. This result is fully in line with the postulates of Bandura's (1977) theory of social learning, which emphasizes the importance of imitating and modelling observed behaviours. Students appropriate the pro-environmental practices valued and embodied by their teachers, parents or peers, thus demonstrating the power of social dynamics in the construction of representations of biodiversity (Steg et al., 2014). In the Moroccan context studied, the coherence between the values transmitted at school and those experienced in the family sphere appears to be decisive for consolidating a true environmental culture (Lange & Martinand, 2014).

5.2. Articulation between the analysis of school curricula and psychosocial dynamics

An examination of official prescriptions reveals that biodiversity education is often confined to a disciplinary, descriptive and naturalistic approach within the Life and Earth Sciences, leaving little room for societal problematization and citizen action (Id babou, 2023). However, our PLS-SEM modelling shows that the anchoring of ESD is not only a matter of cognitive compliance with programmatic content, but depends massively on the behavioural mobilisation of the student and the normative congruence of his or her social environment. The effectiveness of a curricular reform in ESD therefore requires reconciling the logic of disciplinary knowledge with the consideration of learners' social representations and life contexts.

5.3. Pedagogical and didactic implications for the Moroccan education system

From an educational and didactic point of view, this research underlines the urgency of promoting integrated, participatory and experiential biodiversity education, which goes beyond the simple masterful transmission of knowledge to engage students in concrete practices. Three priority levers for action emerge:

- Develop field activities and experiential learning: promote direct observation of local ecosystems (oases, wetlands, coastline), ecological restoration projects and territorial surveys in order to activate the naturalistic, aesthetic and humanistic dimensions of representations (Kellert, 2002);
- Promote interdisciplinary approaches around Socially Alive-Thinking Questions (QSV): decompartmentalize disciplines by articulating experimental sciences (SVT, physics-chemistry), human sciences (geography, philosophy, civic education) and languages to deal with the socio-ecological complexity of biodiversity and develop students' critical thinking;

Strengthening school-family-community collaboration (Whole-School Approach): taking advantage of the leverage effect of the environment by closely involving parents, environmental clubs, local

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associations and local authorities in school projects, thus guaranteeing the coherence of the educational models offered to young people (Lange & Martinand, 2014).

Table 6: Results of structural hypothesis testing (Bootstrapping SmartPLS v4)

Hypothesized Path	Path Coefficient (β)	T-Statistic	P-Value	Empirical Decision
H1: CCE → ESD	0.338	2.966	0.003	Validated
H2: CCEE → ESD	0.411	4.049	< 0.001	Validated

6. Conclusion

This research highlights the decisive role of psychosocial and relational dynamics in the appropriation of Education for Sustainable Development and the preservation of biodiversity in secondary education in Morocco. The lessons learned from this study show that the eco-citizen commitment of high school students results from a close synergy between their internalized representations, their own daily practices and, just as decisively, the exemplary behaviors observed within their family, school and community environment.

From a didactic point of view, these results highlight the limits of an academic transmission exclusively focused on the acquisition of abstract disciplinary knowledge. To bridge the gap between theoretical knowledge and concrete action in the long term, schools are called upon to renew their pedagogical approaches by favoring experiential, interdisciplinary approaches rooted in the ecological realities of the territories. By promoting educational continuity between the classroom, the family and the local community, the education system will be able to train critical, responsible citizens who are fully involved in the ecological transition.

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