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Science Education and Environmental Identity: An Integrative Approach to Fostering Sustainability Practices in Primary School Students

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Abstract

The research investigated how science education through integrated sustainability practices helps primary school students develop environmental identity while studying sustainability practices in their daily schoolwork. The research investigated methods to incorporate sustainability principles into regular school operations, which would lead students toward environmentally responsible conduct. The research used qualitative methods to achieve its goals. The research team conducted 60 sessions of semi-structured interviews and school observations in private schools located in Riyadh and Al-Ahsa regions of Saudi Arabia. The Grounded Theory method enabled researchers to generate concepts that directly stem from the collected data. The research results demonstrated that schools need to implement sustainability practices to teach students about nature-human connections and develop environmental values and sustainable practices and improve daily environmental practices and establish sustainable practices as school examples. The study demonstrated that students developed stronger environmental identity through daily school activities that incorporated sustainability education. Furthermore, students' environmental behaviors improved through participation in activities such as waste sorting and tree planting. Based on these findings, the study recommends strengthening the role of science education in promoting sustainability through practical activities, training teachers in integrative environmental education strategies, developing curricula that emphasize sustainable practices, and involving parents in raising environmental awareness within the school community.

Keywords: science education; environmental identity; sustainability; environmental practices; environmental education integration; environmental awareness

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1. Introduction

Because of how quickly environmental devastation is happening, humanity is confronted with multiple ecological problems of growing complexity that increasingly endanger environmental and social order at the same time. The Earth faces an existential

threat because of climate change and pollution in air and water and ecosystem destruction and biodiversity decline [1–5]. The situation has evolved from scientific and technical aspects to affect moral and ethical and cultural domains as major crises. The world needs an urgent transformation of human-nature connections throughout all regions. The current situation demands more than traditional knowledge production and legislative approaches because they prove insufficient for addressing this problem. People need to undergo a complete transformation in their mental outlook and natural behavior patterns, and actions. Educational institutions need to transform their mental and future orientation approaches because they serve as essential sites for developing these perspectives [3–6].

Pedagogy at every level attempts to do more than just give information and explain ideas. Each educational level is capable of transmutation of thinking processes and forming essential values and attitudes to sustain the environment. The lower primary class introduces pupils to basics of life, which highlights the importance of science education. Students need to learn the relationship between man and nature as well as the intricacies of the environment in order to make responsible choices [7–10]. Science education needs an integrative method to achieve its full potential because this method connects scientific explanations to students' real-life experiences and their everyday environment. Students need to learn outside traditional classroom boundaries because their everyday experiences should become the foundation for sustainability education [9,11,12].

The early stages of education require this method because students develop their intellectual and emotional and behavioral identities at this time. The values and attitudes that students will maintain throughout their lives exist in a state of flexibility during this developmental stage [13]. This offers the best opportunity for nurturing a responsibility to the environment and a sense of the self as part of nature [13,14]. Environmental education at this stage should go beyond the imparting of information and should include the nurturing of the learners to the point where they can encounter, experience, and find personal meaning in the complex environmental issues and challenges. This is the reason for the need to nurture the environmental identity of learners: as a fundamental element in constituting a generation that feels that they belong to, and are not separated from, the environment [15–18].

Essence of identity with the environment transcends to the mere understanding of worrying about it as it goes further to portray an emotional connection to it as well as an anchor to the intrinsic feeling of the responsibility of protecting it [15,19–21]. Such an identity is not acquired through teaching, yet it is through experience and engagement in substantial activities that an individual to the environment derives its utmost satisfaction. Students whose science education is complemented with activities such as school gardening, nature observation and other similar activities, develop the ability to deeply, emotionally, and persistently understand the concept of sustainability [20]. Such activities empower students to have more responsibility at school and in the community, and more importantly, to construct their understanding of the environment from observation and everyday life, which enhances their environmental responsibility [19,22,23].

The worldwide educational assessment indicates that science education should serve as a tool to help students in elementary school develop their environmental awareness [3–5,24,25]. The initiative supports an integrative system that uses science education to help students develop deep environmental understanding. The educational objective focuses on developing students who understand environmental issues rather than teaching them basic environmental knowledge. The educational goal focuses on developing environmental stewards who understand their planet deeply while showing genuine care and taking active steps for its protection.

1.1. Literature Review

Educators begin exposing learners to science during the formative years in the hope that they will begin to appreciate the environment and develop critical thinking skills. The stage is crucial in the students' life as it shapes how they will learn, appreciate and practice the relevant skills, and adopt the desired attitudes. For this reason, science education is an important tool that fosters the necessary integration between science and environment [22,23]. Students are thus able to assimilate environment-related issues and concepts in a logical manner [7,11,26–28].

Generally, to retain a curriculum, one must focus on the environment, pollution, and conservation. Such topics aid the learner in making coherent and practical associations about the environment and their day-to-day activities, which fosters an understanding of environmental issues at an early age [8–10,20,21,29]. The study of ecosystem equilibrium helps students develop appreciation for all ecosystem elements while showing them how single removals trigger a chain reaction. The combination of knowledge about deforestation and water pollution, and fossil fuel usage creates environmental awareness in students [3,6].

Students at this level start to develop basic knowledge, which enables them to recognize their deep connection with nature as an environment that extends beyond abstract distant systems. The combination of knowledge enables students to solve environmental problems by understanding complex feedback systems and finding solutions through enhanced critical thinking [30,31]. The teaching approach develops critical thinking abilities, which include analysis and evaluation, and creation skills that match the educational standards of the twenty-first century [32–35].

The teaching approach integrates outdoor and practical learning to foster energy and related values alongside cognitive skill development. Rather than being passive spectators to their ecosystems, students participate in proactive activities such as tree planting, air and water observation and recording, and waste cleanup [5,25].

Constructivism identifies learning as a process of adapting one's psycho-physical system to the outside world. This illustrates the effectiveness of learning made through direct contact with nature rather than through narration [30,36]. The study of ecosystem equilibrium helps students develop appreciation for all ecosystem elements while teaching them about the basic chain reactions that occur when one component disappears. The acquisition of knowledge about deforestation and water pollution, and fossil fuel usage enables students to develop environmental awareness [3,6].

Students at this level start to develop essential knowledge that enables them to recognize nature as their environment through deep connections and relational bonds that extend past distant abstract systems. The combination of knowledge enables students to solve environmental problems by understanding complex feedback systems and finding solutions through enhanced critical thinking abilities [30,31]. The teaching approach develops essential higher-order thinking abilities, which include analysis and evaluation and creation because they form the base of twenty-first-century education standards [32–35].

The teaching of science through direct instruction with practical and outdoor activities develops both cognitive abilities and the value of energy in students. These emotional benefits enhance the motivation of students to learn and engage in pro-environmental behaviors [37]. Thus, it is crucial to integrate direct and prolonged sensory interactions with the natural world into the curriculum in order to prepare students who, in addition to being knowledgeable about the environment, are emotionally committed to its preservation.

Research highlights a growing concern about the disconnect between holistic, deep, and transformational learning and nature. Learning in the real world, particularly with nature, achieves deeper and longer-lasting changes than learning that is abstract and content-heavy [3,18,31]. The educational approach to science must be based on a new

paradigm that situates practice as active inquiry into phenomena of the world that can be connected to within the learners' daily context. This new philosophy promotes independent, responsible thought and citizenship as the learners begin to grapple with the intricate web of relationships in their environment.

The program results in active civic participation as community knowledge defenders. Horizontal knowledge integration is supported by emotional and psychological frames that support higher-order and transformational thinking. Action and self-sustaining systems alongside deep empathy and understanding prepare candidates for global sustainability challenges.

Most recent science education frameworks emphasize that the core of science teaching is sustaining education within contextualized, personalized, and life-oriented approaches [36,38]. These models argue for reframing the outcomes, content, and pedagogy of environmental education as the primary focus of a unit, rather than as a supplementary finishing component, for greater relevance and efficacy [20].

Research shows that incorporating sustainability into the Science courses enhanced students' environmental consciousness and led to stronger emotional responses toward the subjects [21,31,39]. Moreover, studies show that student participation in local projects has a positive impact on their academic performance, teamwork competencies, and the scope of environmental protection measures [3,40]. Global learning Encouragement of environmental and citizenship competencies is higher when the environment is integrated, in contrast to gained in isolation [25].

The educational approach follows the current educational trends in teaching methods. The social–constructivist theory of Vygotsky demonstrates how students learn best through social interactions while working within their "zone of proximal development." The learning environment of cooperative learning enables students to share their thoughts while working together to solve environmental problems. Students participate in knowledge construction by actively developing their own answers and ideas during this learning process [21,29,39].

Learning and development, according to Bronfenbrenner's ecological systems theory, take place within an established system. The system begins with family and school before expanding to encompass broader community and societal elements. This indicates that students who experience hands-on learning with their natural environment show more behavioral changes than students who learn theory, demonstrating that environmental education value increases when students learn outside their classrooms through family and community involvement. Research through theoretical instruction [13,15–18].

The discovery learning approach of Bruner supports teaching methods that use real-world experiences and inquiry-based learning. Students develop environmental enthusiasm and long-term commitment through direct environmental experiences such as biodiversity observation and pollution analysis, and sustainability project work [24,28].

The science curriculum needs to evolve from knowledge transmission to develop "environmental competence", which combines knowledge with skills and values and responsible actions according to the theoretical foundations. The assessment of students should focus on their ability to solve real-world problems and self-assess their work, and perform community-based tasks that demonstrate their ability to apply classroom learning beyond traditional exams.

Research from Al-4 et al. [23], Lanza et al. [28], Tal [41] and Torsdottir et al. [42] shows that students who engage in interactive environmental education demonstrate better skill assessment and show reduced destructive behavior such as resource waste. The research supports the need for an educational system that positions teachers as environmental advocates while transforming schools into green learning centers.

The educational transformation extends beyond classroom teaching methods because it affects how schools operate within their community and their physical environment. The combination of institutional recycling programs and waste reduction strategies and school gardens and environmental education initiatives at schools helps students develop purposeful environmental identities [25,43–45].

Environmental identity development remains essential for modern environmental education to progress. The educational goal surpasses environmental knowledge acquisition because it aims to develop emotional bonds and behavioral connections between students and nature [14,19,40]. Students need to participate in environmental-focused activities to develop their sense of purpose and personal identity. Students develop environmental awareness through activities that include resource conservation and collaborative work on projects and other initiatives [3,6]. Students need specific educational experiences to develop environmental identity because this identity requires active construction through purposeful educational approaches that help them recognize their environmental duties. Students need their school activities and community involvement to match their curriculum content for developing environmental identity. The works of Güler Yıldız et al. [4], Hadjichambis et al. [5,25] and Kahn & Weiss, [46] demonstrate that small educational practices at the smallest level, including resource selection and learning space design and school ground maintenance, influence student adoption of sustainable values.

A fundamental requirement exists to base civic engagement activities on personal environmental identities. The solution of interdisciplinary problems demonstrates the importance of addressing climate change and biodiversity loss at their catastrophic levels. The development of environmental identity creates an essential foundation that enables people to adopt responsible ecological behavior and solve problems at individual and worldwide levels [22,23,47].

Advocacy and active environmental education, along with environmental education, can realize the Sustainable Development Goals (SDGs) based on the research of Ertz et al. [21]. Schools and universities can develop socially responsible citizens through their interdisciplinary programs, which teach students 21st-century skills. A curriculum on environmental ethics can help students integrate their skills in teamwork, collaborative problem solving, and critical reflection on the problem to develop creative solutions needed to address environmental issues.

1.2. Statement of the Study

Science pedagogy plays a vital role in teaching students about environmental responsibility, yet numerous educational systems maintain their traditional approach to science education by teaching abstract theoretical concepts that fail to connect with students and their surroundings [44,48]. The gap between the acquired scientific knowledge and the mode of application in actual life tends to sour and dilute the contributions that science education is capable of offering in triggering actionable change.

Field observations through classroom visits and semi-structured interviews with students and teachers vividly illustrate a persistent discrepancy between the scientific ideas being taught and the surrounding ecological realities of the students. The prevailing curriculum is content-heavy; the lack of experiential learning leads to passive, rather than active, engagement with the material being studied. Instruction from a transmission model of teaching is less likely to enable deep learning to occur and, as such, fails to develop a love for, or even a concern, towards the environment.

Environmental identity stands as a crucial factor for developing sustainable conduct in this specific situation. Environmental identity exists beyond theoretical boundaries. People develop environmental identity through meaningful encounters with the physical

world and emotional experiences and active participation [24,25]. Students need educational settings to experience and interact with their local systems so they can build their environmental identity through direct experiences rather than memorizing abstract scientific facts.

The research shows that interactive science education methods help primary school students develop a robust environmental identity. The educational stage of primary school students is crucial because it matches their developmental period when they actively form their personal identity and remain highly receptive to new information. Students acquire new knowledge while building their future behavioral framework through this developmental stage.

The research uses environmental competence as its theoretical base to explain how people solve environmental issues through responsible decision-making and problem-solving abilities. Science education shows promise for developing critical thinking skills and student environmental participation in sustainability practice when teachers use participatory and context-specific teaching methods.

The research develops an educational framework that unites cognitive aspects with emotional elements and motor skills in science education. The research advocates for three active educational methods, which include project-based learning and cooperative learning and solution-centered learning, that enable students to study their environment directly and create practical solutions for identified problems. The research shows teachers should evolve from knowledge distributors to purposeful learning architects who lead students through inquiry-based educational experiences.

The research focuses on science education's broader mission to develop practical skills through environmental learning, which enables students to handle modern ecological challenges and become future environmental guardians. The research investigates how well current educational programs achieve this goal while identifying methods to enhance environmental education through science education. Thus, this study answers the core question of the research: how does environmental science education influence the development of students' environmental identity and foster their engagement in sustainability practices?

2. Methodology

2.1. Research Design

The research investigates how students develop their environmental identity and acquire sustainable practices through science education forms the main subject of this investigation. The research used qualitative methods to unite scientific knowledge with environmental education through an interdisciplinary framework. The qualitative research method studies complex educational practices through contextual analysis to reveal how teachers experience their work environment and the meaning behind their teaching methods.

The research data collection methods consisted of semi-structured interviews and classroom observation sessions. The researcher conducted interviews to engage with science educators about their educational beliefs regarding science education and environmental identity development and sustainable practice implementation. The research method produced detailed unstructured data which captured both teacher perspectives and their operational teaching environment.

The researcher gained direct access to observe teaching methods in real classrooms to evaluate teaching methods and study student-teacher interactions when students learned about environmental topics or practiced sustainable activities. The integration of these two tools enabled a better and more in-depth understanding of the role of science educa-

tion in fostering students' awareness of environmental issues and encouraging sustainable practices.

2.2. Participants

To select participants for this study, the researcher used purposive convenience sampling. Participants in the study included 60 elementary science teachers from two areas in the Kingdom of Saudi Arabia: Riyadh (the capital), as well as the Al-Ahsa region. Participants were chosen because of the fit of their profiles with the aims of the study, especially their educational qualifications, teaching methodologies, and the nature of their schools. For this study, participation was restricted to male teachers only because of the cultural and sociological factors in Saudi Arabia that shield boys and men from entering schools for girls. The lack of female responders should, therefore, be viewed as a contextual issue and not the result of gender bias in the study's design.

All the participants worked in private schools with fairly similar professional and sociocultural surroundings in terms of the resources available, the number of students per class, and the level of freedom in curriculum and pedagogy. Both the default state school curriculum or alternative curricula, which offer further teaching opportunities for environmental education integrated into the sciences, are present in schools. The research scheme made it possible to scrutinize science education's impact on pupils' formation of environmental identity and its effect on students' sustainable behavior.

The data distribution regarding participant teaching experiences showed equal representation. The teaching experience of eight teachers (13.3%) spanned from 2 to less than 5 years, while 24 teachers (40%) worked for between 5 and less than 10 years. The majority of teachers (46.7%) had spent more than ten years teaching, which made them the largest group in the study. The participant distribution provided an optimal mix of new teacher creativity and experienced teacher reflection because novice teachers brought fresh ideas while veteran teachers contributed their accumulated knowledge.

The participants demonstrated suitable qualifications for studying the research topic because they all possessed science education degrees. Specifically, 31 teachers (51.7%) were bachelor holders in a scientific field (biology or chemistry), accompanied by a teaching diploma. Further, 15 teachers (25%) were bachelor graduates in education majoring in the teaching of science. At the postgraduate level, 10 teachers (16.7%) had a master's degree in science education or in curriculum and instruction, while 4 of them (6.6%) were doctorate holders in higher education pertaining to the teaching of science or the curriculum development of science.

2.3. Data Collection Tools

The research employed qualitative methods through multiple data collection tools to study how learning spaces help students develop environmental awareness and school-based sustainability practices. To do this, two primary qualitative tools were structured classroom observation and semi-structured interviews. Each of these tools was carefully designed and developed along the parameters of expert validation, field piloting, real use, and thorough validation and reliability analysis.

2.3.1. Structured Observations

While coming up with new drafts with new sentences, we knew this section would be difficult. I Hesitated Further. I Observed All the Science Lessons in the Upper Primary Classes (4, 5, 6) With the Aim of Assessing the Integration of Environment and Sustainability Concepts in Teaching. Lessons that Taught or Touched upon the Themes of Ecology and Nature, Renewable Energy, and the Human-Nature Relationship Were the Focal Points in the Lesson.

I took 45 min for each observation session, including all aspects of the classroom, which included teacher-student interactions, use of instructional materials, types of questions asked, environmental and critical thinking, student participation in environmental conversations, and the ways in which the ecosystem is taught, and focused on the entire classroom and school. These observations also included the school's extra-curricular activities, environmental amenities, and awareness posters.

The principals of the classroom, the school, and the amenities are documented in a separate observation guide that is designed in accordance with the aims of the study. The checklist was subjected to scientific validation by ten experts from various relevant fields, including science curricula, environmental education, teaching methods, environmental psychology, and educational supervision, along with experienced teachers and supervisors from the Saudi educational context. Their feedback ensured both face and content validity, with indicators revised and refined for clarity and comprehensive coverage of cognitive and behavioral aspects related to environmental identity.

The observations were carried out independently by two researchers specialized in science education, using the same observation checklist. After each session, comparative analytical meetings were held to assess the degree of agreement between their assessments. To measure inter-rater reliability, Cooper's formula (1981) was applied as follows:

$$\text{Agreement percentage} = (\text{Number of agreements})/(\text{Number of agreements} + \text{Number of disagreements}) \times 100$$

According to this formula, the inter-rater agreement for classroom observations reached 97%, a very high rate that confirms the tool's consistency and reliability in interpreting environmentally related teaching behaviors. These observations were further supported by contextual field notes taken immediately after each session, adding depth to the analysis of classroom dynamics and implicit or indirect meanings.

2.3.2. Semi-Structured Interviews

To complement the field data and deepen the understanding derived from observations, semi-structured interviews were conducted with the same teachers observed in the classrooms. Interviews took place in quiet areas within the school environment and lasted between 40 and 60 min, with participants providing informed written consent for audio recording.

The interview guide was carefully developed based on the theoretical framework of the study and the literature on science education and environmental education. It included several open-ended questions that encouraged participants to freely express their views and experiences. Key topics covered were:

- How do you understand the concept of sustainability in the context of teaching science?
- What relationship do you see between science and environmental identity?
- How do you integrate environmental awareness into your lessons?
- Do you implement any extracurricular activities related to the environment?
- What challenges do you face in promoting environmental behavior among students?
- How do you assess the school's role in building environmental values?

The interview guide was validated by the same multidisciplinary panel of ten experts, whose reviews helped ensure content validity, clarity, and relevance to the study's aims and context. A pilot study was also conducted with seven teachers outside the main sample to test question effectiveness, evaluate participant responses, and adjust the language to suit the local educational culture.

Interviews were analyzed independently by the two researchers, followed by discussion sessions to interpret the textual content and determine the degree of agreement

between analyses. Using Cooper's formula to calculate inter-rater agreement in interview analysis, the percentage reached 95%, indicating a very good level of consistency and shared objective interpretation.

2.4. Data Analysis

This particular research is qualitative in nature. The literature on classroom observations and semi-structured interviews concerning the impact of science instruction on students' environmental identity and sustainability actions. To fully grasp the phenomena at hand, the grounded theory approach, which works with data from the bottom up, defining and organizing categories and concepts is applicable in this case.

Over time, engaged analysis of the interview documents and observation records resulted in the open coding of chaos. The open codes were then given axis coding to generate gap as axis codes, which led to four predominant themes that appear in both observation and interview data.

1. The value of the interrelationship of humans and their environment enhances understanding of the concept. It came from the way teachers and classroom practices focused on the value of human and nature interaction.
2. Through their instruction, teachers strive to foster in students environmental ethics and practices of sustainability.
3. The promotion of environmental behavior and practices among learners: This focused on learners developing sustainable practices both in the classroom and the school environment.
4. The educational institution actively promotes sustainable practices by creating an educational environment that supports learning and sustainability through its policies and activities.

Research data included observations that revealed the practices students used when relating to one another and the teaching materials used, as well as the development of their critical thinking abilities with regard to environmental problems. They focused on particular aspects of problem-based and local surrounding environmental examples because they wanted to quantify their presence in the data.

From the analysis of interviews with teachers, the research focused on their 'environmental identity and sustainability in teaching and learning' while balancing the spoken and unspoken words that added a qualitative depth to the analysis in the specific social setting. The second coder conducted an independent analysis of all ten interviews to verify that the results were accurate and dependable. Interview participants were also invited to validate the results of the research in a cooperative effort to enhance researcher validation by signing the transcripts of their interpretations.

The research obtained higher credibility by integrating thorough qualitative evaluations with large-scale quantitative outlines. This was an example of triangulation where multiple pieces of evidence were used to bolster the data. The research articulates the role of science education in fostering students' environmental identity and the practice of sustainability at the primary level.

Based on the above, the process of qualitative data analysis can be represented in Figure 1.

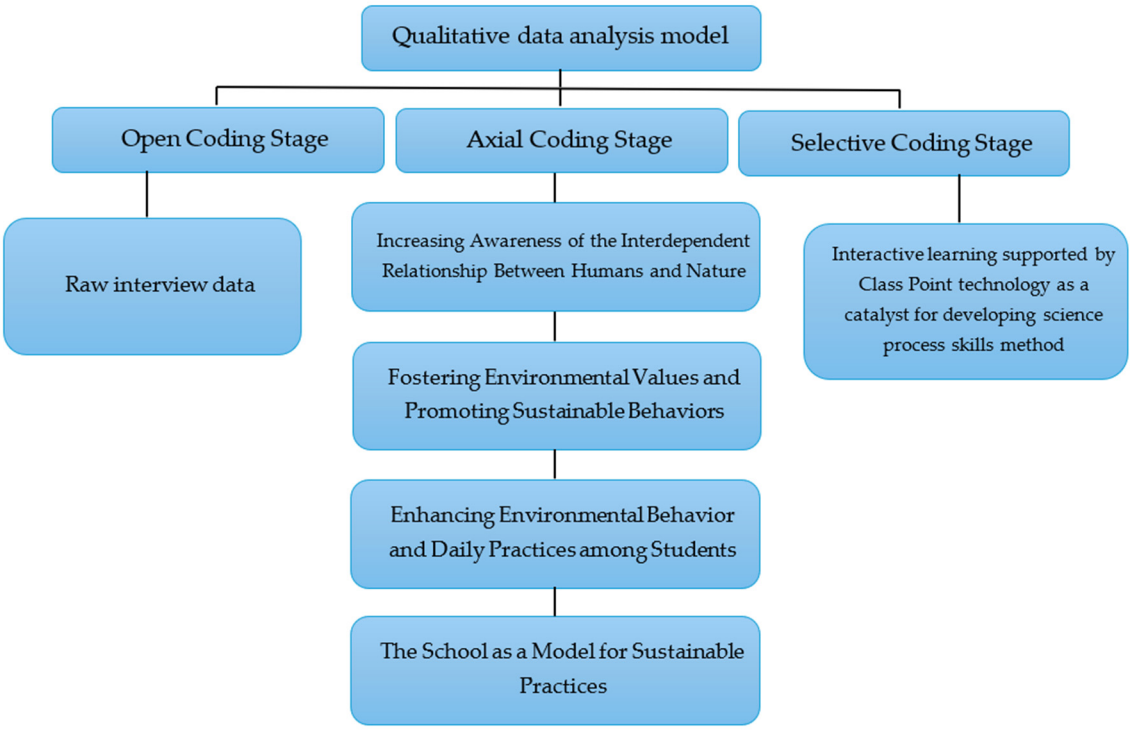

Figure 1. Semi-structured Analysis Model.

2.5. Ethical Considerations

To conduct the research within the parameters of the laid ethical framework of research was given priority as part of the study's focus. The ethics of the study was under the jurisdiction of the King Faisal University in Al-Ahsa, which also granted the study's ethics approval. Subsequently, line of sight was developed with the administrative offices of private schools in Riyadh and Al-Ahsa, which, after comprehensively analyzing the study's aims and methodology, granted approval, thus allowing for the orderly setting of data collection.

Subjects were given a comprehensive overview of the purpose of the study and the Relinquishment of their responsiveness. The researchers obtained complete participant rights abandonment through informed consent forms, which allowed participants to withdraw their active data contributions at any time without facing any adverse effects.

The scholars prevented participants' identity disclosure by removing all elements of personal data and reports and replacing real names with pseudonyms. Only the original principal investigators could access the original data, which was stored in high security. Due to the ethics maintained, which enabled the respondents and the researcher to build rapport, the data was found to be credible and therefore useful for the study. It enhanced the trustworthiness of the study. The participants only abandoned their rights through the informed consent processes, which allow them to withdraw their data unconditionally and at any time, as decided by the participants. The study underscored the fact that ethical research, which has its roots in respect, transparency and professional conduct is the foundation of responsible science.

3. Study Findings

The research examined how school science education supports students in developing their environmental identity and sustainability involvement. The research involved 60 observations and interviews with primary science teachers to achieve its goals. The research findings produced four categories, which demonstrate the various aspects of

science education and student environmental identity development. The following section explains these categories in detail.

3.1. Category One Results: Increasing Awareness of the Interdependent Relationship Between Humans and Nature

Science education enables students to understand the fundamental connection between humans and nature while teaching them to view the biosphere as an interconnected system where human actions affect all life forms and abiotic elements and ecosystems and human existence depends heavily on these ecosystems. Analysis of classroom observations revealed that 57% of educational situations included clear indications of students' engagement with environmental concepts by linking them to their real-life behaviors, reflecting the early formation of genuine environmental awareness. This awareness extends beyond theoretical knowledge to encompass behavioral and value-based understanding.

Classroom practices varied and included group discussions, experimental activities, role-playing scenarios, and spontaneous questions from students, all illustrating their growing comprehension of the dynamic relationship between humans and the environment. Table 1 presents these findings in detail.

Table 1. Frequencies and Percentages of Classroom Practices that Increase Awareness of the Interdependent Relationship between Humans and Nature.

No.	Observed Educational Practice	No.	%	Illustrative Examples
1	Linking resource consumption to environmental impact	57	95.00%	Water conservation at home, turning off lights, energy use discussions, avoiding plastic bags.
2	Discussing the human role in causing environmental imbalance	53	88.3%	Random construction, overgrazing, air pollution from vehicles, tree cutting in urban areas.
3	Analyzing environmental phenomena as outcomes of human actions	49	81.6%	Global warming, local species disappearance due to urban expansion, worsening sandstorms.
4	Using local examples to illustrate ecological interconnection	45	75.00%	Coastal pollution, neighborhood waste, nearby agricultural projects, environmental changes in the city.
5	Classroom applications highlighting ecosystem-human link	44	73.30%	Water recycling experiments, plant life cycle role-play, interactive models showing human intervention in nature.

Table 1 highlights the key educational practices associated with this category, along with their frequency and percentage from the 60 classroom observations, and examples illustrating how these practices manifested in real classroom interactions. These results indicate that science education is not delivered as isolated or purely theoretical content, but rather as an integrated approach embedded within daily classroom dynamics, fostering authentic interaction between students and their environment.

It is notable from Table 1 that linking resource consumption to environmental impacts was the most common educational practice, occurring in 95% of observations. This reflects that teachers connect scientific concepts to students' daily behaviors, such as turning off faucets after use, avoiding plastic, or conserving electricity, thereby grounding students' understanding in tangible environmental consequences. Here, information is not merely presented as abstract facts but is transformed into a tool for self and environmental awareness, strengthening a sense of both individual and collective responsibility.

Discussions about the human role in environmental disruption appeared in 88.3% of cases, indicating increased student awareness that humans are not passive observers of the environment but active agents responsible for many of its changes. These discussions often revolved around overgrazing, construction in green areas, and excessive reliance on cars—issues close to the students' realities—contributing to the formation of an environmental identity infused with a moral sense of responsibility.

Students demonstrate advanced causal reasoning through their 81.6% agreement that environmental phenomena stem from human activities. Students now understand that natural events do not exist independently because they recognize how human activities create environmental effects through deforestation, leading to sand and windstorms and urbanization, causing species extinction. The advanced level of understanding represents a key indicator of successful inquiry-based and constructive learning approaches.

Students who use local case studies amount to 75% because they want to base their knowledge on direct observations rather than textbook information. Students experience environmental engagement through their discussions about local bay pollution and waste management issues in their neighborhoods, which creates a more dynamic connection to their surroundings than their usual approach. The practice of critical local geographies develops into a fundamental aspect of environmental identity through this approach.

The results showed that 73.3% of classroom activities involved environmental projects and role-plays and model-based solutions to study human-organism relationships and organism-organism connections. The educational practices demonstrate how students move from receiving information passively to becoming active participants in learning. Since they now actively engage in their education, the students have transcended their previous role as consumers of environmental information. Students gain knowledge through firsthand encounters with the environment, which arouse their senses and cognitive processes. The practices show how teaching about sustainability should move from abstract ideas to real-world application strategies.

From the perspective of the classroom, the descriptive information gleaned from the interviews seems to support the increased environmental consciousness. 98% of the teachers said that teaching science helped the students' understanding to go from being superficial to being more integrated with their everyday behavior and attitude. They claimed that this change was not limited to the classroom but also occurred during recess, in relationships with peers, and even at home, demonstrating the emergence of an environmental identity that is deeply ingrained in the child's thoughts and behavior.

The teacher said, illustrating how the students' environmental awareness grew:

> *"The students became interested in plastic waste in the ocean after I explained the food chain because they wanted to know what happens to fish when people discard plastic in the sea. The students then asked about the impact on people who consume fish as their food source?"*

Students beginning to years about the food chain and subsequently beginning to ask these kinds of questions demonstrate a transformation from abstract and linear thought to complex and relational thought. Students are able to recognize a human action, in this case throwing plastic, and understand the consequences of this action on the ecosystem and the people in it. It is also worth noting that students are beginning to understand the environment as a complex system, as, rather than thinking about the environment as a fragmented system, they are beginning to think about the environment as an 'interconnected' whole. In the same way, another teacher remarked about the behavioral changes in students.

> *"I noticed that students started paying attention to what is considered to be water waste, even during breaks. There were students who said: Don't leave the tap fully open, this affects the environment!"*

In this case, students no longer focus on understanding a concept but rather on taking action. Learners appreciate the human-environment connection, and some learners approach this as a value and take on a proactive monitoring role. Such peer influence demonstrates that the element of environmental identity is beginning to transform into group identity within the context of emotion, deriving from relationships and experiences in the classroom.

The quote from a teacher that addresses a student's project on the environment illustrates the depth of this change.

> *"They spoke with me: What do you think about planting a tree to replace the one that was cut down? Trees are important for all living things because they give out oxygen, and we can't keep cutting them down."*

This quote captures the absence of environmental maturity, where one does not understand or think about the consequences of their actions and simply explains the problem using irresponsible substitute solutions devoid of scientific reasoning or emotional understanding. Such reasoning shows that students do not view themselves as passive observers. They see themselves as members of the ecosystem who possess the ability to tip the scales of ecology with their small positive actions.

Taken together with the high frequencies of the classroom activities mentioned above, these quotes provide significant proof that the goals of the science instruction do focus on environmental awareness on the affective and behavioral levels. This indicates that students not only progress on the knowledge level of thinking, but on emotions, ethics, and actions as well, becoming increasingly responsible to the environment and society they reside in.

This snippet makes clear that lessons in environmental science do more than simply recount historical events; they also redefine students' attitudes and relationships with the subject matter. Schools then stop functioning merely as places of knowledge acquisition and instead begin to cultivate and practice sustainable environmental values. Students then begin to embody the image of an environmental citizen in the community—self-aware, willing to think critically, practice sustainability, and initiate change.

3.2. Category Two Results: Nurturing Environmental Values and Promoting Sustainable Behaviors

The analysis of classroom observations revealed that environmental science education, when delivered within an integrated framework directly connected to students' daily lives, significantly contributes to the consolidation of environmental values and the promotion of positive behaviors that support sustainability. Engagement with environmental issues went beyond mere theoretical learning or rote memorization of terms, clearly manifesting in daily classroom practices and attitudes that reflect a growing emotional and ethical awareness toward the environment and its components.

A detailed examination of 60 classroom observations documented numerous practices indicating the emergence of an environmental value system among students. These were evident in class discussions, group activities, individual behaviors, and spontaneous responses that demonstrated maturity in thinking and an internalized sense of responsibility. These practices are summarized in Table 2:

Table 2. Frequencies and Percentages of Classroom Practices that Nurture Environmental Values and Promoting Sustainable Behaviors.

No.	Observed Educational Practice	No.	%	Illustrative Examples
1	Involving students in discussions on the importance of environmental conservation	59	98.33%	Discussions about the importance of trees, harms of littering, the individual's role in protecting the environment
2	Expressing environmental values through real-life actions	53	88.33%	Avoiding food waste, reusing materials, turning off devices when not needed
3	Conducting classroom activities embodying sustainable environmental behavior	51	85.00%	"Clean Your Classroom" project, planting indoor plants, making waste sorting boxes
4	Promoting teamwork to address environmental issues	49	81.67%	Planning awareness campaigns, drawing environmental posters, group discussions on reducing paper usage
5	Linking environmental values to classroom rules and daily conduct	47	78.33%	Maintaining quiet to reduce noise pollution, arranging desks for easier cleaning, conserving water
6	Encouraging active student participation in environmental activities	45	75.00%	Organizing cleaning campaigns, participating in environmental competitions, presenting innovative environmental solutions

Table 2 highlights six key classroom activities that effectively promote the development of environmental values and sustainable behaviors among students. Firstly, involving students in discussions about the importance of environmental preservation was the most frequent practice, occurring in 98.33% of observations. These discussions were not mere recitations of theoretical knowledge but real opportunities for students to engage with environmental issues such as the significance of trees and the dangers of littering. This created a learning environment that encouraged critical thinking and reflected the teacher's role in guiding students toward adopting positive ethical stances and considering their personal responsibilities toward the environment.

In terms of the school activities aimed at adoption of sustainable practices, 85% of observations noted a strong effectiveness in helping students practice environmental concepts. The "Clean Your Classroom" initiative, as well as the growing of in-class plants, were much more than pedagogical activities; they were practical manifestations of the environmental principles the students were being taught. Such initiatives enable students to contribute to the solution of environmental challenges, thereby cultivating a sense of environmental responsibility.

Working collaboratively to resolve the identified problems, noted in 81.67% of cases, was instrumental in reinforcing students' environmental beliefs. Participation in public awareness programs, or poster production, illustrates that collaboration is not only a means of resolving environmental problems but also a vehicle for enhancing students' communication and social skills. These efforts positively change students' mindsets about environmental problems, emphasizing their understanding that such problems are tackled best when approached collectively, and embody the principles of social responsibility and constructive thinking.

About linking environmental values to the rules and behavior of the classroom, 78.33% of observations noted students practicing these values in their behavior within the class. Students' commitments like being clean and orderly, organizing their desks for the purpose of tidiness, and reducing water and paper use contributed to a growing understanding of

the environment not only as a school subject, but as a dimension of life. Such understanding illustrates the students' growing environmental awareness and the wish to practice environmental values in their actions.

Finally, significant encouragement from teachers for active participation in environmental activities was evident, with 75% of observations noting student involvement in cleaning campaigns or environmental competitions. Such motivation promotes students to take concrete steps toward environmental protection and demonstrates how environmental activities have become part of their school and personal lives.

Overall, Table 2 clearly shows that teachers do not limit their role to teaching environmental values through the curriculum alone but also contribute to forming sustainable behaviors in students through interactive, life-related practices. Classroom activities encompassing environmental discussions, group work, and practical applications of daily life collectively foster students' environmental awareness and motivate them to adopt sustainable behaviors beyond academic learning. Consequently, students become capable of transforming environmental concepts into concrete practices, both inside the classroom and within their local communities.

These classroom observations are strongly supported by interview findings, where most participants confirmed that science education has directly contributed to enhancing students' environmental awareness and changing their attitudes toward it. The students have come to appreciate that safeguarding the environment is both an individual and social responsibility. This change was reflected in students' actions both during the lessons and in the rest of their daily activities. The teacher said the following:

> *"Students started telling me: If we cleaned the public park like we clean the classroom, there wouldn't be any trash!"*

What is intriguing is the students' attempt to construct the classroom and the public park as an ecosystem in the neighborhood, and there are some real paradigm shifts when a pupil says 'I wish I could clean the public park the way I clean the classroom.' This has changed the nurturing picture of schools and can be replicated by the neighborhood. This illuminates the sophisticated and complex behavioral ethics and philosophy of life that embraces several contexts surrounding the environment. This is yet another quote by a teacher.

> *"On one occasion, a student said: I don't throw any paper on the ground because it might get blown into the sea and the fish could get hurt!"*

It is evident that the student has flights of fancy in thinking about the ocean and the animals living in it, which is an extended scope than what is envisioned by many. This is a case of a deep level of reasoning that is also advanced ethically and intellectually and can appreciate the consequences of minor actions that are highly destructive to nature. Students' ability to see the impact of what they do is worrying, considering that others her age do not appreciate the implications of what she understands. A co-worker of mine has also observed that:

> *"They formed a team to reuse notebooks, saying: This way, we save paper and reduce pollution."*

This suggests that the students not only changed from being users of the environment to being users and defenders of the environment. This reflects the students' initiative to actively participate in suggesting a way to curb pollution and protect the reuse of notebooks. I do find it interesting that something as simple as reusing notebooks could have a positive impact on the environment. And how few people it seems have looked at what has been done. It gives an impression to the rest of us about the way in which students are trained to deal with a given problem creatively, as opposed to just memorizing.

Based on the interview data, the findings indicate that teaching science successfully ties the gap between students' common understanding of the environment and the sustainable behaviors they practice in their daily lives. This undoubtedly displays that students are not only acquiring knowledge about the environment but are dynamically engaging in pro-environmental activities both independently and collaboratively with their peers.

3.3. Category Three Results: Enhancing Environmental Behavior and Daily Practices Among Students

There is evidence to support that teaching science is far more complicated and sophisticated than merely equipping students with knowledge of the environment. It is an attempt to change their behavior towards the environment in such a way that they are able to incorporate ecologically sustainable practices in their day-to-day activities. It goes without saying that such an alteration goes a long way in improving the students' sense of accountability towards the environment at the personal and social levels, in their attitudes and practices in the classroom. In this case, the behavior of students with regard to practices conserving environmental resources and their daily activities with respect to waste management was targeted.

The theoretically constructed practice of behavior in and outside the classroom was made possible by the acquisition of knowledge on the environment and the patterned practices seemingly unlearning the behavior. The practices that stood out the most focused on practicing resource conservation, cleanliness, and taking part in cooperative activities to advance the cause of environmental education. These practices clearly indicate that environmental behavior has become part of the students' identity, as they now view the environment as an essential element to be preserved in their daily lives as shown in Table 3.

Table 3. Frequencies and Percentages of Classroom Practices that Enhance Environmental Behavior and Daily Practices among Students.

No.	Observed Educational Practice	No.	%	Illustrative Examples
1	Maintaining personal and classroom cleanliness	58	96.6%	Turning off lights when leaving, arranging seats, avoiding littering on the floor
2	Conserving resource consumption within the classroom	55	91.6%	Reducing paper use, turning off computers when not in use, managing water consumption
3	Implementing group initiatives to raise environmental awareness	52	86.6%	Organizing campaigns to reduce waste, collecting recyclable materials
4	Participating in field activities applying environmental principles	50	83.3%	Planting classroom plants, organizing school environmental clean-up activities
5	Encouraging teamwork and collaboration on environmental projects	48	80.0%	Group work to reduce paper use, waste collection campaigns, creating environmental posters

Table 3 shows that results from the classroom observations demonstrate that science education not only instills environmental concepts but also fosters their translation into sustainable behaviors, influencing students' daily lives. Environmental awareness is no longer just theoretical academic knowledge about environmental challenges but has become a part of real and tangible practices. Students who initially learned about how to protect the environment began to take practical steps within the classroom, including behaviors such as maintaining personal and classroom cleanliness and using resources wisely.

In this case, 96.6% of the observations showed students practicing behaviors that aligned with the expected standards of personal and environmental hygiene. Students were able to self-regulate by turning off the classroom lights when leaving. Students were able to assist in the neat arrangement of desks and chairs after the lesson and showed a high level of awareness concerning the problem of waste. Although these behaviors are very elementary in nature, they indicate a significant change in students' attitudes towards the functioning of the environment. Rather, it is more than just the effect of the 'do' command that teachers give, but rather, it is the more profound insight of the divide and united responsibility towards the environment that has emerged.

Moreover, 91.6% of classroom observation reports record the proactive management of resources by learners, particularly of paper, water, and energy. Resource conservation was no longer just an abstract idea that lacked real action, but rather, it emerged as an accepted behavior. Students would actively shut down unused devices, practice paper use and waste reduction, and more, in order to minimize energy consumption and paper waste. Such behaviors indicate that many of their daily activities are entrenched in routinized environmental behaviors as opposed to merely 'thinking' about the environment.

In regard to communal activities, environmental education, to which waste reduction and recycling drives were a part, received organized group work participation reports by learners to a degree of 86.6% and above. These actions demonstrate a new level of understanding of environmental issues problem by students as not a personal issues, but a social challenge to be solved collectively. Such social awareness not only enhances students' collaboration skills, but more importantly, their willingness to work on common environmental problems, which is crucial for their socio-ecological problem-solving skills.

Additionally, it was found that 83.3% of students participated in field activities that involved application of learned skills. For example, students planted plants in the classrooms or took part in the school environmental clean-up. Such activities allowed students to use and explore the concepts they were taught in the classroom in the real world. As these students engaged in activities, they started to develop a sense of perceived equitable solution and shifted from being passive to active changers of the environmental condition.

On the other hand, teamwork and collaboration for the achievement of the specific objectives of environmental projects was described as an intensive partnership and active collaboration by 80% of the students in classroom environmental activities. For example, students collaborated to minimize paper consumption, execute waste reduction campaigns, and design posters for environmental education. These initiatives helped to promote diverse environmental behaviors and develop environmental social responsibility by students. In addition, these initiatives also created an opportunity for students to develop a learning environment that fosters cooperative problem solving and responsive action towards environmental issues.

The results from interviews with teachers corroborated these observations quite emphatically. Most teachers agreed that the education of science has positively impacted the students' behaviors towards the environment. One teacher said:

> *"I have observed that students have started taking responsibility for their environment, both within the classroom and outside. They have begun showing their concern for the environment through their actions on a daily basis."*

This means that learners perceive their responsibility toward the environment as extending beyond the confines of the school to include their home and community. This means that environmental education has transcended beyond classroom learning to be part of the students' lifestyle. Another teacher commented:

> *"Students started seeing environmental behavior as part of their personal identity. They began talking about how to preserve the environment in their daily lives, not just in school activities."*

This statement captures the change in students' perceptions towards their environmental actions, to the extent of claiming them as their own. Instead of having class discussions about the environment, they think of it as an important part of life that needs care and attention. This shift means that some trace of an environmental conscience is starting to take form in their minds and actions.

As I have been able to discern, the analysis of the reflection reports on the classroom observations along with the interviews suggests the start shift from the theoretical grasp of having an awareness of an environment to the concrete integration of its practical usage in everyday life to these learners. These learners do not only study the environment, but also have the ability to engage in and practice good environmental behavior in their daily activities. There is an emerging understanding that there is an environment which they are duty-bound to defend through the principles of sustainable development like resource saving, environmental protection, and civic clean up, as well as providing responsible stewardship. These outcomes are indicative of far-reaching impacts of science education in guiding the behaviors of students in and out of school, and in their community and civic engagements.

3.4. Category Four Results: The School as a Model for Sustainable Practices

This category's findings relate to the role of the school as a pivotal environment that significantly influences students' awareness and behavior. Therefore, transforming the school into a living model of sustainable practices represents a fundamental step in embedding environmental values and promoting sustainable behaviors. The analysis of classroom observations showed that schools adopting sustainable environmental practices within their organizational structure and daily routines directly contribute to creating a learning environment that fosters positive environmental values and behaviors.

The analysis of 60 school observation records revealed that many sustainable environmental practices have become an integral part of school activities, reflecting the school's influence as a nurturing environment for sustainable environmental practices. A set of behaviors demonstrating environmental commitment at the school level was documented and is summarized in Table 4:

Table 4. Frequencies and Percentages of Observed School Environmental Practices Reflecting the school as a Model for Sustainability.

No.	Observed Educational Practice	No.	%	Illustrative Examples
1	School waste management through sorting and recycling	55	91.6%	Providing waste sorting bins, recycling collection campaigns
2	Conserving energy and water consumption in school	53	88.30%	Use of energy-efficient lighting systems, regular maintenance to prevent water leaks
3	Continuous awareness programs for all school members	50	83.30%	Awareness seminars, environmental posters in corridors, student supervision of school cleanliness
4	Organizing regular environmental school events and activities	47	78.30%	Clean-up campaigns, tree planting, special environmental days
5	Integrating sustainability into school policy and management	45	75.00%	Existence of environmental plans and strategies, school environmental committee

Table 4 shows that school waste management through sorting and recycling was among the highest documented practices, appearing in 91.6% of observations. This indicates that schools implemented effective waste management systems by activating sorting bins and organizing recycling campaigns. This environmental practice extended beyond administrative measures to include student participation, fostering an environmental culture that contributes to shaping their daily environmental responsibility.

Regarding energy and water conservation within schools, 88.3% of observations demonstrated clear commitment to using energy-efficient lighting systems and regular maintenance to prevent water leakage. These initiatives not only conserve resources but also raise students' environmental awareness. By witnessing these systems in their daily routines, students learn the importance of resource conservation and waste reduction, which reinforces their role as future sustainable citizens.

For ongoing awareness programs, 83.3% of observations indicated that schools held environmental seminars and workshops for everyone and provided awareness posters for the corridors. These efforts contribute to the educational setting that fosters the embrace of sustainable behaviors and encourages students to become stewards of the environment.

With regard to the organization of regular environmental activities in schools, 78.3% of observations noted that schools attempted to carry out clean-up drives, the planting of trees, and the observance of special days for the environment. These not only serve as leisure activities but also as crucial exercises in weaving the principles of sustainability into the very fabric of the school. Through these activities, students are able to integrate the principles they have learned in the classroom into their daily surroundings, thereby enhancing their level of environmental awareness and responsibility.

Regarding the integration of sustainability into school policies and management, 75% of observations revealed the existence of clear environmental strategies and plans implemented through a school environmental committee. This administrative organization not only enhances the sustainability of the school environment but also ensures the continuity of environmental practices over the long term. These plans form part of the school's comprehensive strategy to foster environmental behaviors among all members.

The interviews with teachers strongly supported these classroom observations. One teacher stated:

> *"The school has become more than just a place for study for the students; it is a comprehensive educational environment that encourages environmental preservation, and they see this in every corner of the school."*

The quote here definitely demonstrates how a school constructs a students' understanding of the world around them, especially the environment. The school's geographical location becomes a classroom as students engage with it every day. Thus, caring for the environment becomes an integral aspect of the school's philosophy. Students do not only learn the theory of the environment through the curriculum but also practice the values of sustainability in every space of the school. This means that in addition to curriculum-centered textbook or in-class studies, sustainability needs to be practiced on a day-to-day basis. One of the teachers stated.

> *"When we involve students in waste management and organizing events, we instill in them a sense of caring for the environment, which reflects in their behavior both inside and outside the school."*

This quote captures the essence of how students' belief systems around the environment are shaped, in this case, through the school's ecosystem. Participation in such environmentally friendly actions is not merely a physical exercise, but a profound learning opportunity aimed at developing the philosophy of sustainability. Students who dedicate

their time to waste sorting or clean-up campaigns learn, in practice, their duties as responsible citizens of the planet. This participation goes beyond the school environment and affects their actions in the community, helping to nurture socially responsible citizens who are able to act responsibly in their daily lives. Related to this, a third teacher remarked:

> *"Learners do not restrict themselves to the four walls of the classroom in acquiring knowledge of the environment. They are actively encouraged to be leaders in the school community."*

Implementing programs within the school facilitates learners in acquiring relevant knowledge and competencies that will enable them to actively take part in the nurturing of environmental sustainability. In this regard, a culture is developed that demonstrates the school's dependence on the learners as the principal and most active beneficiaries in the achievement of the school's goals. In this paradigm, their roles empower learners to view school practices as transformative pathways to assert their agency, which, in turn, improves their engagement with the ecosystem. The fourth teacher made the following remark as a way of illustrating the influence of environmental programs on learner outputs.

> *"The school, as a result of the environmental programs, becomes a place where learners move from doing target activities to engaging in conservational activities."*

These comments show the school now emphasizes having practices that demonstrate responsible use and care of the environment and resources. In these scenarios, there is nothing that is learned in the classroom that is in contradiction to the activities. Environmental Days, clean-ups, and tree-planting activities are opportunities for learners to go beyond understanding environmental problems to doing something about them. They begin to see the importance of the environment beyond the walls of the school and the need to integrate it into everyday life. One teacher also put it this way:

> *"I believe that more and more students realize, on a daily basis, that their school is the place where they are taught to love and to restore our planet."*

This insightful quote provides a deeper understanding because it goes beyond the surface of appreciating the earth to romanticize the attachment the students have with it. The school does not merely stop with equipping children with academic knowledge but assists them with nurturing emotional bonds deep with the environment. The ownership of the planet and its nature is not something one needs to conserve. It is an identity one possesses and values. It is this emotional bond with nature that makes one a true defender of advocacy because this is the only thing that one can deeply relate to.

From the verified observations and interviews, the school's role in fostering environmentally responsible behavior and its nurture through education, integrated sustainability, and resource management is vital, and yes, these schools are working under the circumstances the best they can. Interviews corroborate the fact that, within the school systems, environmental education is not only the teaching of principles and theories in isolation, but also integration with other school activities, which lead to the formation of sustainable habits. These students are authors of more than just the textbooks. The school is textbook authors of real, physical concepts, of activities. It is in this context that the school is seen as a living, thoughtful textbook of sustainability, with each from a corner of its physical surroundings infused with environmental concepts, doing nurturing and hoping that the concepts will be part of the students' everyday life.

3.5. Summary of Key Findings

A qualitative analysis of the interview and classroom observation data revealed four main categories that explain how the educational intervention supported the development

of students' environmental identity and their engagement with sustainability. These categories appeared consistently across multiple data sources, indicating a shared and coherent understanding of environmental values among the participants. The categories include:

1. Raising Awareness of Human-Environment Interdependence
   Classroom activities and instructional approaches played a crucial role in helping students recognize the fundamental, reciprocal relationship between humans and the natural world. This enhanced understanding encouraged students to view the environment not merely as a resource, but as an essential partner. This change in perspective represents an important foundation for cultivating meaningful environmental awareness.
2. Instilling Environmental Values to Foster Sustainable Behavior
   Teachers deliberately sought to instill core environmental values, such as respect for nature, environmental justice, and both individual and collective responsibility toward the planet. By weaving these values into discussions and classroom activities, educators shaped students' attitudes and encouraged the adoption of sustainable practices.
3. Encouraging Pro-Environmental Actions in Everyday Life
   The findings indicate a clear behavioral shift among students. Many began to adopt environmentally friendly habits at school and at home, including reducing plastic use, recycling, and conserving water and energy. These concrete actions provide strong evidence of growing environmental awareness and the emergence of a solid environmental identity.
4. The School as a Living Model of Sustainability
   The school itself functioned as an active participant in environmental education by implementing practical sustainability initiatives. Programs such as school gardens, recycling campaigns, and environmental awareness projects allowed students to observe sustainability principles in action. This hands-on approach effectively connected theoretical knowledge with real-world practice, enhancing the overall learning experience.

In summary, the findings demonstrate that the educational intervention extended beyond the mere transmission of environmental knowledge. It actively influenced students' values, behaviors, and sense of identity. This suggests that fostering environmental identity and sustainable behavior effectively requires a holistic approach that integrates the efforts of educators, curriculum design, and the broader school environment.

4. Discussion

4.1. Discussion of the First Category

In knowing the collaborative relationships between the different levels of science, students appreciated the human-nature relationship, which reflected classroom concepts in reality. A shift in thinking, although positive, was not merely theoretical. Students, having been introduced to the complex ideas of the different elements of ecology, reached a level of understanding that remained transcendent. This informs the trends of classroom environmental education, in which many studies support the need to teach students the scientific concepts of the environment in context to the real world [49]. Such education articulates the intricacy of the actions of the people to the environment, as noted by [50], revealing the importance of teaching students in the context of life in the world.

In every lesson, the analysis of students' work revealed that they were beginning to connect their day to day actions with applying positive efforts towards the environment. Students transcended beyond the levels of theoretical knowledge and began to comprehend that their actions, such as the consumption of water and energy, do have consequences for the environment at large. The change in behavior from knowledge to action is a significant

determinant of the success of environmental education and instruction aimed at motivating students. Such findings resonate with Kang & Tolppanen [51] on the importance of fostering and maintaining positive behavior change through education that is relevant to the context of the world, as the world is now.

Students still illustrated awareness that humans do not exist in, and as passive spectators of, ecosystems. There was considerable free flow of conversation around such destructive environmental processes as bulldozing, overgrazing and even intentional pollution. This is the reason some scholars of environmental education argue that increased awareness of environmental issues is linked to the ability to understand the significant consequences of human actions on natural systems.

Positively, the incorporation of local environmental issues, such as pollution of the coastal zone, solid waste on the streets, and other regions, as a part of school assignments helped create a greater understanding of the interdependence of humans and nature. This fosters critical awareness whereby students feel that they can do something to help and thus become more responsible for the local ecology. This is consistent with the findings of Al-Rifai [52], which highlights the importance of local, context-relevant, pragmatic issues over theoretical instruction in engaging students with real-life environmental challenges.

To begin with, case studies demonstrated the importance of interactive teaching methods with activities aimed at comprehension of the human-environment interaction. To the students, the importance of the activities was hands-on and practical. Completing the activities helped the students understand environmental concepts and their practical importance in the importance of the environment and its conservation. This supports the findings of Ohlsson et al. [53] who said that 'interactive education promotes deeper and more lasting understanding of the environment.

4.2. Discussion of the Second Category

Integrated teaching of environmental science, as demonstrated in this category, positively impacts the development of environmental values among students and their adoption of sustainable practices. The results indicate a change in the students' interaction with environmental issues; the understanding of the environment goes beyond theoretical understanding and becomes a part of their practical everyday actions. This is in line with the more recent recommendations that advocate for the integration of environmental values in teaching at all levels of education to promote desirable environmental attitudes in the younger generation [18,22,23,42].

Students learn these environmental approaches and fuse them with sustainable practices through research and classroom instructions incorporating green education. For example, Interventions in the classroom taught them how to conserve the environment in their daily lives by conscious habits like shutting off unused lights, appliances, and not wasting food. This case illustrates how learning science is also learning to accept the duality identity of the self and of the society, as it is one with the environment. This supports other work advocating the combination of hands-on and teamwork to enhance environmental action [21,39].

Fostering behavioral change through education that focuses on integration and practice is also supported by these results. Participating in activities such as the "Clean Your Classroom" projects and plant care allowed students to take action to protect the environment. Studies show that these activities do much more than simply heighten students' awareness and concern about the environment; they also assist students in developing and maintaining pro-environmental behaviors in the long run [30,31,41,45]. These activities enable students to recognize the intricate connections between humans and the environment;

therefore, they enhance the students' decision-making regarding the environment in their daily activities and the degree of sustainability in those activities.

With these outcomes, it is observed that environmental science education goes beyond recording environmental behavior to foster it. During their educational experiences, students started to understand the importance of environmental protection as a group rather than as individuals, which requires collaboration and coordination. In group work on awareness campaigns and environmental posters, students' collective responsibility, critical thinking, and teamwork skills are enhanced. Such results emphasize the urgent need to address environmental education as a part of the curriculum to increase the positive impact of education on the new generation's behavior towards sustainability [7,8,11,12,54].

In the teachers' interview, the respondents emphasized how science education changed students' attitude towards the environment. Responses suggest that students began viewing the environment of their school as a standard to be attained, especially the condition of their classroom, as juxtaposed to the rest of the community. In this case, students kept their classroom in a cleaner condition than the rest of the community. This feedback demonstrates a change in attitude towards the environment, making it value-added for their day-to-day practices while at school and in the neighborhood.

4.3. Discussion of the Third Category

The results in this category illustrate that the scope of education in environmental science entails more than the acquisition of environmental concepts. It also includes the fostering of actionable practical environmental behaviors. This is made possible through the amalgamation of theory with practice in a sparingly pragmatic application of environmental concepts. The functions of teachers go beyond information dissemination to the cultivation of the environmental selves of the learners. This requires the learners to integrate environmental attitude as a behavioral disposition rather than as a mere school subject. Such results are in consonance with international trends regarding the focus of environmental education on the enhancement of learners' interaction with the environment as a means of fostering the adoption of sustainable behaviors [26,27,35].

In addition, these findings confirm earlier works focusing on the necessity of the internalization of environmental values for practice in socially influential behaviors. Learners who were once passive recipients of environmental education with no practical dimension are now demonstrating the active application of this knowledge in their daily activities. The transition, which is the focus of this study, is "learning about the environment" to "applying environmental values" is a move towards more sustainable environmental behavior that is broader than the classroom context but is also applicable in the home and community [9,10,24].

The results also show that pupils started changing their habits with the view of conserving resources such as water and power, as well as improving their waste disposal techniques. This shows that their understanding of the environment has changed; it is no longer a subject to be learned about but is now integrated into their daily lives. The fact that such behaviors can be practiced indicates that the aim of environmental education has been achieved, as students are motivated to change their behaviors, as the authors highlight the need for environmental education to be practiced, not just taught. These findings are consistent with international research that stresses the need for environmental behavior to be practiced in everyday life [34,55,56].

In light of these findings, the authors of this study believe that the teaching of environmental science should aim to develop students' environmental behaviors through teaching practices that allow them to use environmental concepts in their day-to-day activities. In this way, environmental education can more effectively alter the behavior of students in

several spheres of their lives. The authors also suggest the need to strengthen programmatic work that integrates environmental education with cooperative activities, as these also help to foster not only environmental problem awareness, but also the collaboration and teamwork skills that are essential for integrated environmental actions.

4.4. Discussion of the Fourth Category

The data showed that the school has a very important role in supporting students' practice of environmental behaviors by means of integrated sustainability practices adopted within the school. This can be connected with the positive effects that daily environmental practices have on the students' behaviors. It shows that the school is not only a center of theoretical education but also a nurturing environment for adopting sustainable behaviors where students avail themselves to and are fully integrated into environmental education in their daily activities. Students not only learn about sustainability in theory but also in practice through environmental activities that are implemented in the school.

In this context, the results illustrate the extent to which schools that implement sustainable environmental practices of waste sorting, and energy and water conservation activities, along with consistent environmental education, are able to enhance students' environmental awareness. These practices take education a step beyond theory to active application that cultivates environmental awareness and assists students to relate the environmental concepts to their daily lives. Active participation in environmental activities, within and beyond the classroom, helps students to internalize positive environmental attitudes and embrace a school culture that strongly advocates a sustainable lifestyle.

Similarly, the findings of this research accentuate the need for districts and schools to function as microcosms of sustainable practices [13,14,28]. Several studies [14,40,46,57] have indicated that schools that have incorporated environmental practices into their organizational and pedagogical frameworks facilitate the emergence of a generation with sustainable environmental decision-making capabilities. In this regard, the school transforms from a mere center of learning to a dynamic space that fosters students' environmental consciousness and inspires them to internalize sustainable practices in their lives and professions.

Furthermore, these findings confirm the relevance of previous work emphasizing the necessity of incorporating environmental practices into the routine activities of every school. For instance, some studies [24,40,46] found that activities such as sorting waste and planting trees, in a school setting, are not simply environmental activities but are constructive innovations that enable students to practice environmental principles in practical scenarios. As a result, learners are not only recipients of theoretical environmental education, but active participants in processes that enhance their environmental consciousness and influence their actions towards the environment in the future.

Teachers and other members of the school community are also affected by the school's environmental initiatives, something that students have all the time. Environmental Activities Report show that participating in environmental initiatives fosters a sense of collaboration and concern for one another within the school. Environmental Activities Report also supports that environmental activities improve students' relationships and their collective sense of responsibility, resulting in better school–student and student–student interactions. Such activities certainly assist in the creation of an eco-school, which is also a school community that facilitates environmental collaboration among all members, including educators, students, and school administrators.

The other side of the coin is that these extended practices may be the result of integrating sustainability into the school's governance framework. The presence of a specialized environmental committee, paired with the effectiveness of school environmental policies,

helps ensure the continuation of environmental initiatives. Single-handed support from the school administration and regular teachers, reinforced by a well-articulated environmental policy, multiplies the positive impact of these initiatives. Schools that are governed by articulated policies on environmental sustainability are likely to maintain a high level of environmental activity and achieve their set environmental objectives.

To summarize, this makes clear that the school's function has an ever-greater reach beyond the academic dimension, becoming an essential educational setting for fostering sustainable environmental behavior among students. Being active in the school setting, along with taking part in environmental actions, does not only increase concern for the environment, but helps students develop practices of sustainability in their day-to-day life. This transformation in the function of the school is a positive development in the efforts to cultivate a generation of students with a high degree of active and responsible environmental behavior in the community.

4.5. Discussion of Key Aspects of Environmental Identity

The findings of this study reveal the complex and evolving nature of students' environmental identity, showing it as a cumulative and interconnected process shaped by their interaction with environmental content, educators, and the wider school environment. The analysis highlights that environmental identity goes well beyond mere cognitive understanding of ecological issues. It involves a multifaceted internal framework that includes values, beliefs, attitudes, a sense of connection to nature, and behaviors that together define a person's relationship with the environment.

The four main themes identified—awareness of human-nature interdependence, development of environmental values, transformation of daily habits, and the role of the school as a living example—demonstrate that students moved beyond theoretical comprehension. They began to actively reconstruct their self-identity as individuals who are deeply connected to, and responsible for, the environment. This growing recognition of interdependence, fostered through classroom activities, laid the groundwork for an ethical and emotional awareness, which is crucial for establishing a strong environmental identity. These findings align with existing research in the field.

Moreover, the values emphasized by teachers—such as respect for nature, environmental justice, and personal responsibility—were not confined to abstract discussions but were clearly reflected in students' practical actions both at school and at home. Observed behavioral changes, including waste reduction, recycling, and conservation of resources, suggest that students' environmental identity evolved from abstract knowledge into a consistent lifestyle and habitual practice.

The school setting itself played a vital role in fostering this identity formation. By acting as a real-life model that actively promotes sustainability, the school created an environment conducive to experiential learning. Programs like school gardens and recycling initiatives allowed students to directly observe sustainability in practice, effectively connecting abstract environmental values with tangible actions.

From a grounded theory standpoint, the concepts emerging from the data are grounded not merely in theory but in students' lived experiences within a structured educational framework. Therefore, the study concludes that environmental identity is neither an inherent characteristic nor a fleeting behavior. Instead, it emerges from the dynamic interplay between knowledge, values, a sense of belonging, and ongoing practice. This identity is gradually built through continuous, meaningful educational experiences supported by a school culture that embodies environmental principles.

5. Conclusions and Recommendations

This study deepens our understanding of how science education can embed sustainability practices within school environments to support the formation of students' environmental identity. The findings reveal that integrating everyday school activities with scientific environmental concepts produces a learning environment that goes beyond theoretical instruction. Students become more deeply involved with sustainability through hands-on experiences, which reinforces their comprehension of environmental science and encourages practical behavior change.

The data highlights that environmental science education is most effective when paired with concrete initiatives—such as waste sorting, awareness campaigns, or tree planting—that connect theoretical principles to visible, real-world actions. Such practices help students interpret environmental challenges within the context of their daily school lives, thereby reinforcing the idea that sustainability is not just a theoretical subject but part of the school's lived culture.

From these findings, it follows that sustainability concepts should be interwoven throughout the full academic curriculum, not confined to science alone, and embedded into routine school life. This approach helps form a more robust environmental identity by making sustainability a lived, everyday experience. Moreover, the research underscores the necessity of involving all stakeholders—teachers, students, parents, and the wider community—to foster a shared culture of sustainability in schools.

The theoretical contribution of this work lies in demonstrating that environmental education, paired with context-sensitive practical opportunities, significantly contributes to shaping students' environmental identity and sustainable behavior. These insights provide a solid basis for designing educational programs that link scientific content directly with students' daily practices, fostering consistent and meaningful environmental engagement in school settings.

6. Limitations, and Future Research Directions

This study contributes valuable insight into how science education supports the development of an environmental identity among students and fosters sustainability practices in school settings. However, there are several limitations to the research design and context that readers should keep in mind, and a few directions that future studies might take to build upon these findings.

One important limitation is the sample. We worked only in private schools within two regions, and only male teachers were involved, due to cultural and institutional constraints. While this setup was necessary under the local conditions, it prevents us from knowing whether the findings would be the same in public schools, or in rural areas, or with female educators. Future studies should expand the sample to include participants from both genders, different types of schools, and a wider geographic spread to enhance how broadly the results can be applied.

Another limitation is methodological: the study relied exclusively on qualitative instruments—classroom observations and semi-structured interviews. These methods gave us rich, detailed insights into behaviors and attitudes, but may have left out measurable patterns or comparisons that larger-scale quantitative tools can reveal. Including tools like standardized surveys or behavioral scales would help future research assess what we saw here in more measurable terms.

Moreover, a methodological limitation of this study lies in its exclusive reliance on qualitative instruments—namely, classroom observations and semi-structured interviews. While these methods provided in-depth, context-rich insights into participants' behaviors, perceptions, and attitudes, they do limit the objectivity and generalizability of the findings.

This methodological choice was influenced by contextual constraints, including limited access to large-scale data sources within the national setting. In future studies, incorporating quantitative tools—such as standardized surveys, behavioral scales, or statistical data—would enhance the verifiability and broader applicability of the results by allowing for measurable patterns and more objective comparisons.

Additionally, the perspectives of students themselves, and of their parents, were not collected. Their voices are essential for understanding how environmental initiatives in schools are experienced, accepted, or challenged. Including them in future work would add depth to our understanding of the school community's dynamics around sustainability.

A further constraint is the cross-sectional nature of this research. We have a snapshot of students' identity, behavior, and perceptions at one point in time. We cannot trace how these evolve, strengthen, or weaken over months or years. Longitudinal studies will be useful to observe changes over time and to understand the lasting impact of environmental education practices.

Finally, two conceptual elements warrant clearer operationalization: *environmental identity* and *sustainable behavior*. In this study, environmental identity refers to a student's awareness of their two-way relationship with the natural environment, a felt sense of responsibility both ethically and behaviorally, and values and beliefs that guide daily choices. Sustainable behavior describes the conscious habitual actions students take—such as recycling, reducing waste, conserving water or energy—with the intention of protecting the environment now and for the future. Having these definitions makes it easier to design measurement tools and compare results across different studies.

Based on the findings and limitations of this study, several recommendations for future research emerge:

- Expand sustainability integration beyond science classes into other subject areas (e.g., language, social studies, arts), making sustainability themes a cross-curricular commitment rather than a niche topic.
- Emphasize experiential learning through practical initiatives—such as waste sorting, tree planting, and school–community projects—that allow students to apply scientific knowledge in real-world contexts.
- Encourage program designs that embed sustainability into students' daily lives, so schools become living models of sustainability. In such environments, environmental identity is nurtured not only through instruction but through consistent, value-driven practice.
- Prioritize developing or adopting validated instruments (questionnaires, scales) tailored to measure environmental identity and sustainable behavior in school settings.
- Conduct longitudinal studies to track changes in identity and behavior over time, assessing the lasting impact of educational interventions.
- Include more diverse populations—students, parents, teachers of all genders, and schools in differing contexts—to improve the generalizability and richness of findings.

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References

1. Elrick-Barr, C.; Clifton, J.; Cuttler, M.; Perry, C.; Rogers, A. Understanding coastal social values through citizen science: The example of CoastSnap in Western Australia. *Ocean Coast. Manag.* **2023**, *238*, 106563. [CrossRef]
2. Ernst, J.; McAllister, K.; Siklander, P.; Storli, R. Contributions to sustainability through young children's nature play: A systematic review. *Sustainability* **2021**, *13*, 7443. [CrossRef]
3. Ghosh, A.; Baidya, S.; Gupta, A.K. Climate change impact on landuse and livelihood in Sundarbans: A case study of Sagar Island. In *Disaster Resilience and Green Growth*; Gupta, A.K., Gupta, A., Acharya, P., Eds.; Springer Nature: Berlin/Heidelberg, Germany, 2024; pp. 403–434. [CrossRef]
4. Güler Yıldız, T.; Öztürk, N.; İlhan İyi, T.; Aşkar, N.; Banko Bal, Ç.; Karabekmez, S.; Höl, Ş. Education for sustainability in early childhood education: A systematic review. *Environ. Educ. Res.* **2021**, *27*, 796–820. [CrossRef]
5. Hadjichambis, A.; Paraskeva-Hadjichambi, D.; Georgiou, Y.; Adamou, A. How can we transform citizens into 'environmental agents of change'? Towards the Citizen Science for Environmental Citizenship (CS4EC) theoretical framework based on a meta-synthesis approach. *Int. J. Sci. Educ. Part B* **2023**, *14*, 72–92. [CrossRef]
6. Eryaşar, A.; Özel, R. Early education for a sustainable future: The perspectives of pre-service preschool teachers. *Indep. J. Teach. Learn.* **2025**, *20*, 68–98. [CrossRef]
7. Alme, H.; Reime, M.A. Nature kindergartens: A space for children's participation. *J. Outdoor Environ. Educ.* **2021**, *24*, 113–131. [CrossRef]
8. Aslan, M.; Uygun, S. Evaluation of kindergarten education curriculum through the CIPP model. *J. Curric. Stud.* **2019**, *51*, 648–662.
9. Awewomom, J.; Dzeble, F.; Takyi, Y.D.; Ashie, W.B.; Ettey, E.N.Y.O.; Afua, P.E.; Sackey, L.N.A.; Opoku, F.; Akoto, O. Addressing global environmental pollution using environmental control techniques: A focus on environmental policy and preventive environmental management. *Discov. Environ.* **2024**, *2*, 8. [CrossRef]
10. Baptista, M.; Pinho, A.S.; Alves, A.R. Students' learning for action through inquiry-based science education on a local environmental problem. *Sustainability* **2025**, *17*, 3907. [CrossRef]
11. Boyd, D. Early childhood education for sustainability and the legacies of two pioneering giants. *Early Years* **2018**, *38*, 227–239. [CrossRef]
12. Buil, P.; Roger-Loppacher, O.; Tintoré, M. Creating the habit of recycling in early childhood: A sustainable practice in Spain. *Sustainability* **2019**, *11*, 6393. [CrossRef]
13. Jabeen, T.; Parveen, F.; Shakeel, N. The transformative potential of nature-based activities: A pilot study of early childhood education (ECE) in Karachi, Pakistan. *J. Environ. Educ.* **2025**, *56*, 327–341. [CrossRef]

14. Kioupi, V.; Voulvoulis, N. Education for sustainable development as the catalyst for local transitions toward the Sustainable Development Goals. *Front. Sustain.* **2022**, *3*, 889904. [CrossRef]
15. Luff, P. Early childhood education for sustainability: Origins and inspirations in the work of John Dewey. *Education 3–13* **2018**, *46*, 447–455. [CrossRef]
16. Neurohr, A.L.; Pasch, N.; Bergmann-Gering, A.; Möller, A. Linking students' interest in nature to their self-reported pro-environmental behavior and nature activities—A cross-sectional study in grade 5 to 9. *J. Environ. Educ.* **2024**, *55*, 460–479. [CrossRef]
17. Pandey, K.; Wathre, S.; Pandey, S. Role of teachers in environmental education among school children. *Int. Res. J. Educ. Technol. (IRJEdT)* **2022**, *4*, 137–143. Available online: https://www.irjweb.com/Role%20of%20teachers%20in%20environmental%20education%20among%20school%20children.pdf (accessed on 20 March 2025).
18. Pramling Samuelsson, I.; Engdahl, I.; Ärlemalm-Hagsér, E. What content in early childhood education for sustainable development is present in Swedish preschools? *Int. J. Changes Educ.* **2024**, *2*, 1–9. [CrossRef]
19. Lithoxoidou, L.; Georgopoulos, A.; Dimitriou, A.; Xenitidou, S. "Trees have a soul too!" Developing empathy and environmental values in early childhood. *Int. J. Early Child. Environ. Educ.* **2017**, *5*, 68.
20. UNESCO. *Berlin Declaration on Education for Sustainable Development*; Federal Ministry of Education and Research: Berlin, Germany, 2021.
21. Weldemariam, K.; Boyd, D.; Hirst, N.; Sageidet, B.M.; Browder, J.K.; Grogan, L.; Hughes, F. A critical analysis of concepts associated with sustainability in early childhood curriculum frameworks across five national contexts. *Int. J. Early Child.* **2017**, *49*, 333–351. [CrossRef]
22. Samuelsson, I.P.; Park, E. How to educate children for sustainable learning and for a sustainable world. *Int. J. Early Child.* **2017**, *49*, 273–285. [CrossRef]
23. Simsar, A. Young children's ecological footprint awareness and environmental attitudes in Turkey. *Child Indic. Res.* **2021**, *14*, 1387–1413. [CrossRef]
24. Ertz, M.; Karakas, F.; Sarigöllü, E. Exploring pro-environmental behaviors of consumers: An analysis of contextual factors, attitude, and behaviors. *J. Bus. Res.* **2016**, *69*, 3971–3980. [CrossRef]
25. Borg, F.; Pramling Samuelsson, I. Preschool children's agency in education for sustainability: The case of Sweden. *Eur. Early Child. Educ. Res. J.* **2022**, *30*, 147–163. [CrossRef]
26. Edwards, R.C.; Larson, B.M.H.; Clayton, S. Navigating eco-anxiety and eco-detachment: Educators' strategies for raising environmental awareness given students' disconnection from nature. *Environ. Educ. Res.* **2023**, *30*, 864–880. [CrossRef]
27. Ebitu, L.; Avery, H.; Mourad, K.; Enyetu, J. Citizen science for sustainable agriculture—A systematic literature review. *Land Use Policy* **2021**, *103*, 105326. [CrossRef]
28. Lanza, K.; Alcazar, M.; Chen, B.; Kohl, H.W., III. Connection to nature is associated with the social-emotional learning of children. *Curr. Res. Ecol. Soc. Psychol.* **2023**, *4*, 100083. [CrossRef]
29. UNESCO. *Education for Sustainable Development Goals: Learning Objectives*; UNESCO: Paris, France, 2017.
30. Spiteri, J. Too young to know? A multiple case study of child-to-parent intergenerational learning in relation to environmental sustainability. *J. Educ. Sustain. Dev.* **2020**, *14*, 61–77. [CrossRef]
31. Spiteri, J.; Higgins, P.; Nicol, R. It's like a fruit on a tree: Young Maltese children's understanding of the environment. *Early Child Dev. Care* **2020**, *192*, 1133–1149. [CrossRef]
32. Hedefalk, M.; Almqvist, J.; Östman, L. Education for sustainable development in early childhood education: A review of the research literature. *Environ. Educ. Res.* **2015**, *21*, 975–990. [CrossRef]
33. Cooper, J. *Measuring Behaviour*; Merrill: Columbus, OH, USA, 1981.
34. Dankiw, K.A.; Kumar, S.; Baldock, K.L.; Tsiros, M.D. Parent and early childhood educator perspectives of unstructured nature play for young children: A qualitative descriptive study. *PLoS ONE* **2023**, *18*, e0286468. [CrossRef]
35. Dockx, Y.; Bijnens, E.M.; Luyten, L.; Peusens, M.; Provost, E.; Rasking, L.; Nawrot, T.S. Early life exposure to residential green space impacts cognitive functioning in children aged 4 to 6 years. *Environ. Int.* **2022**, *161*, 107094. [CrossRef]
36. Li, M.; Zhang, Y.; Yuan, L.; Birkeland, Å. A critical analysis of education for sustainability in early childhood curriculum documents in China and Norway. *ECNU Rev. Educ.* **2020**, *2*, 441–457. [CrossRef]
37. Li, W.T.; Shein, P.P. Developing sense of place through a place-based Indigenous education for sustainable development curriculum. *Environ. Educ. Res.* **2023**, *29*, 692–714. [CrossRef]
38. Al-Barakat, A.A.; Al-Hassan, O.M.; AlAli, R.M.; Al-Hassan, M.M.; Al-Sharief, R.A. Role of female teachers of childhood education in directing children towards effective use of smart devices. *Educ. Inf. Technol.* **2023**, *28*, 7065–7087. [CrossRef]
39. Watt, B.A.; Frydenberg, E. Early childhood education for sustainability: Outcomes for social and emotional learning. *Australas. J. Early Child.* **2024**, *50*, 131–145. [CrossRef]
40. Kopnina, H. Future scenarios and environmental education. *J. Environ. Educ.* **2014**, *45*, 217–231. [CrossRef]
41. Tal, A. The environmental impacts of overpopulation. *Encyclopedia* **2025**, *5*, 45. [CrossRef]

42. Torsdottir, A.E.; Olsson, D.; Sinnes, A.T.; Wals, A. The relationship between student participation and students' self-perceived action competence for sustainability in a whole school approach. *Environ. Educ. Res.* **2024**, *30*, 1308–1326. [CrossRef]
43. Danielsen, H.; Olsen, T.A.; Eide, H.M.K. Performing nationalism – Sámi culture and diversity in early education in Norway. *Eur. Educ. Res. J.* **2023**, *22*, 683–700. [CrossRef]
44. Ernst, J.; Burcak, F. Young children's contributions to sustainability: The influence of nature play on curi-osity, executive function skills, creative thinking, and resilience. *Sustainability* **2019**, *11*, 4212. [CrossRef]
45. Srisathan, W.; Malai, K.; Narathawaranan, N.; Coochampoo, K.; Naruetharadhol, P. The impact of citizen science on environmental attitudes, environmental knowledge, environmental awareness to pro–environmental citizenship behaviour. *Int. J. Sustain. Eng.* **2024**, *17*, 360–378. [CrossRef]
46. Kahn, P.H., Jr.; Weiss, T. The importance of children interacting with big nature. *Child. Youth Environ.* **2017**, *27*, 7–24. [CrossRef]
47. Sihvonen, P.; Lappalainen, R.; Herranen, J.; Aksela, M. Promoting sustainability together with parents in early childhood education. *Educ. Sci.* **2024**, *14*, 541. [CrossRef]
48. Adamou, A.; Georgiou, Y.; Paraskeva-Hadjichambi, D.; Hadjichambis, A.C. Environmental citizen science initiatives as a springboard towards the education for environmental citizenship: A systematic literature review of empirical research. *Sustainability* **2021**, *13*, 13692. [CrossRef]
49. Chawla, L. Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. *People Nat.* **2020**, *2*, 619–642. [CrossRef]
50. Holden, E.; Linnerud, K.; Banister, D. Sustainable development: Our common future revisited. *Glob. Environ. Change* **2014**, *26*, 130–139. [CrossRef]
51. Kang, J.; Tolppanen, S. Exploring the role of science education as a catalyst for students' willingness to take climate action. *Int. J. Sci. Educ.* **2024**, 1–19. [CrossRef]
52. Al-Subaie, F.S.M.; Saini, S.; Darras, G.M.H. The role of colleges of education in achieving sustainable development goals: An overview of Saudi's Vision 2030 from an educational perspective. *Res. J. Adv. Humanit.* **2024**, *5*. [CrossRef]
53. Ohlsson, A.; Gericke, N.; Borg, F. Implementing education for sustainability in preschool: Teaching strategies and learning environments. *J. Outdoor Environ. Educ.* **2024**. [CrossRef]
54. Ager, P.; Cinnirella, F. Froebel's gifts: How the kindergarten movement changed the American family. *CESifo Work. Pap.* **2020**, 8504. [CrossRef]
55. Woolley, H.; Lowe, A. Exploring the relationship between design approach and play value of outdoor play spaces. *Landsc. Res.* **2013**, *38*, 53–74. [CrossRef]
56. Ahmetoglu, E. The contributions of familial and environmental factors to children's connection with nature and outdoor activities. *Early Child Development and Care* **2019**, *189*, 233–243. [CrossRef]
57. Castro, M.P.; Gómez Zermeño, M. Challenge based learning: Innovative pedagogy for sustainability through e-learning in higher education. *Sustainability* **2020**, *12*, 4063. [CrossRef]

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