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Deepening Our Knowledge about Sustainability Education in the Early Years: Lessons from a Water Project

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Abstract: The transformative agenda of sustainability education constitutes the focus of early-years education. In quality sustainability educational projects, children are supported to draw links between nature and society and relate to the studied phenomena. Is this methodological approach realized in educational programs for the early years? The present work presents some of the significant findings of a case study on implementing a water project in early-year settings around Europe. It explores the characteristics and the methodological approaches the project implementation developed. Three types of implementation are derived from the qualitative analysis of data and reveal that there are still cases in which sustainability projects are focused on a descriptive approach rather than critical inquiry and analysis. In this sense, the need for educational designs that help children deepen their understanding of sustainability issues and become empowered citizens who will work for a sustainable future is highlighted.

Keywords: early childhood; sustainable development; science education

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1. Introduction

The goal of early childhood science education should be "to develop each child's innate curiosity about the world; to broaden each child's procedural and thinking skills for investigating the world, solving problems, and making decisions; and to increase each child's knowledge of the natural world" [1] (p. 45). The classification of the different trends (empirical, Piagetian, socio-cognitive, socio-cultural) presented by Ravanis [2] underscores establishing a distinct area of research and application that creates a break in the long tradition of Early Childhood Education and the relatively shorter one of Science Education. O'Connor, Fragkiadaki, Fleer, and Rai [3] illustrated that the empirical research on science concept formation in the early years had focused primarily on children aged three to six years. For Kambouri-Danos, Ravanis, Jameau, and Boilevin [4], the precursor model, which children construct, allows them to describe, predict, and explain the state of water changes in a way that is following the scientifically accepted explanation. However, Kallery, Psillos, and Tselfes [5] raised concerns about the quality of science experiences to which young children have access. It seems that a pervasive early-years strategy is frequently to have children seated around the adult while listening to a story being read. Nevertheless, is this an appropriate strategy for Education for Sustainability?

The Importance of Education for Sustainable Development

The United Nations raised the importance of Education for Sustainability in 2005, with a paradigm shift that aimed at drawing educators' attention to a transformative agenda. The primary vision for education was set to change people's minds for a sustainable future. For the early years, this created "holistic images of young children as active participants and decision-makers in their socio-cultural systems with competencies to act for the environment" [6] (p. 1). Education provided children opportunities to experience belonging with nature and develop an awareness of the complex interdependence between all the living and non-living beings in nature. Ultimately this would lead to empowered citizens who would actively work for a sustainable future (Elliott, 2012; Sterling, 2003). This is still very much a target today: the new roadmap for Education for Sustainable Development (ESD) of UNESCO [7] states clearly that the expectation is "the big transformation that is needed for sustainable development" (p. 18). The emphasis is put on teacher education and on building the capacities of educators to deliver ESD.

"Educators remain key actors in facilitating learners' transition to sustainable ways of life, in an age where information is available everywhere, and their role is undergoing great change. Educators in all educational settings can help learners understand the complex choices that sustainable development requires and motivate them to transform themselves and society" [7] (p. 30).

Researchers and educators focused on the methodological elements that can raise sustainability programs' quality, especially those engaging young children [8–12].

2. The Context of the Present Study

In the present study, we present a critical understanding we developed through a water project implemented in early year's educational settings in Europe: Kindergartens, Nurseries, and Day-Care Centers from seven European countries (Greece, Cyprus, Bulgaria, Bosnia and Herzegovina, Croatia, Poland, Iceland) (See Table 1).

Table 1. The number of Early Childhood Institutions that implemented the project.

Type of Institution	Number of Classes
Kindergartens (children aged 5–6)	37
Nurseries (children aged 4–5)	10
Day-Care Centers (children aged 3–4)	2
Total	49

We designed the project to prompt children to explore the relationship between water and human technological culture. Our purpose was to encourage teachers/educators (the terms teacher and educator are used in this study interchangeably) to support children's explorations through an inquiry-based approach. The scope was to take advantage of a "fabric" of scientific tools and ideas (e.g., we would encourage children to carry out observations and record their findings, make measurements, and compare their data). A total of 98 early-year educators in 49 classes (with class enrolling 10–20 children) implemented the program after receiving written implementation instructions. The instructions covered the main scope and the fundamental learning principles of the project and a few ideas about activities. There were also advisory tips that highlighted critical points and the most critical elements of the learning process, where educators focused their attention. No further training was provided to the educators, but they were encouraged to communicate with the researchers if they needed further explanations or clarifications. Written instructions put particular emphasis on the process of inquiry and delineated four main phases (see Figure 1):

- The phase of general preparation: Children were to be introduced to tools and research methods (measuring, observing, recording).
- The preparation of fieldwork (pre-fieldwork phase): Children were encouraged to detect a source of fresh water nearby and plan a field trip.
- The fieldwork phase: Children would have been encouraged to search, look, feel, and record findings.
- The data analysis phase (post-fieldwork phase), which followed fieldwork, emphasized that the four stages should be connected and interdependent as coherence was considered an essential factor for deeper learning. Children would have been encouraged to review information (data) collected during fieldwork to answer questions posed during the previous phases. They would also be encouraged to use multimodal

ways to present their findings (which included artistic and scientific manners of action such as models or graphs).

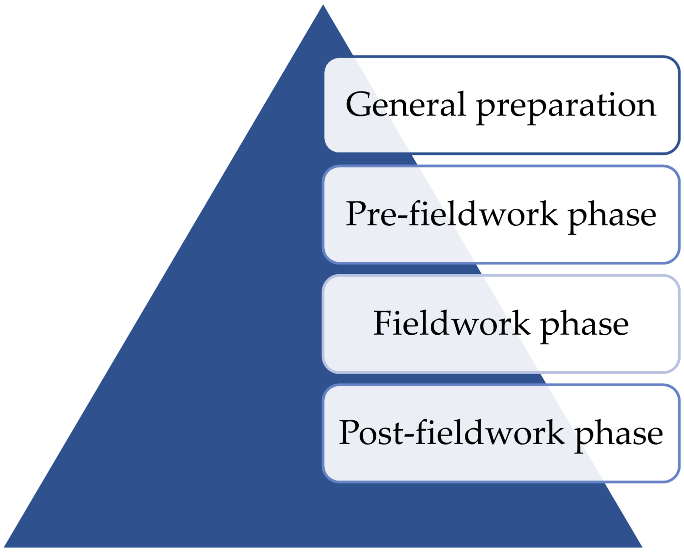

Figure 1. The four main phases.

We provided institutions with the freedom to organize the project at their own pace and time, according to their interests and needs, so each implementation could last from four or six weeks to four or six months if activities were spread over a more extended period. We aimed to embed water education into the broader frame of science education and inquiry-based learning. Most of all, we encouraged institutions and participants to turn their attention to the presence of human activity around the sources of freshwater and the need to protect the riparian zones, the life, and the benefits they accommodate. Teachers supported this through provocative and open-ended questions and the expression of thinking and feeling using multimodal and artistic work. For this reason, we also prompted the project participants (educators and children) to pursue expression through art. That is, to present their findings in a variety of artistic and multimodal ways. ICT was also an integral part of the development of the project. Participants were encouraged to utilize technology in every possible way: as a source of information and knowledge (through the use of the internet, DVDs, CDs, and other digital resources), as a tool of exploration (through the use of digital equipment), or as a facilitator of expression (through the use of technology for the presentation and communication of findings, or multimodal and artistic work). Due to the widespread use of Information and Communication Technologies (ICTs), various technological tools and services have found application in education [13,14]. Thus, we could not overlook that technology, and various applications could be used for environmental education and sustainable development [15].

2.1. Data Collection

The primary tool of data collection was the teacher's portfolio contain all, or some, of the following pieces of evidence (see Figure 2):

- The educators' log, a particular form prepared by the research team, contained open-ended questions that prompted participants to provide basic details about the activities they organized, time length, and essential outcomes of these activities.
- Copies of children's work
- Digital material in the form of selective recordings, photographs, or videos, representing children's achievements.
- Supplementary material used within the context of this project.

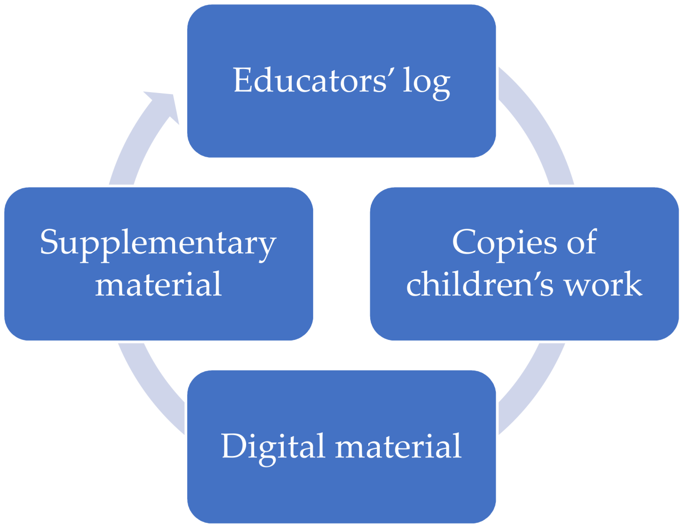

Figure 2. The four pieces of evidence.

The portfolio was chosen among other data collection tools for its "heightened sensitivity to the complexities of teaching and classroom dynamics" as well as for the "ongoing reflection" it instigates and "the expression of virtues developed through documenting a narrative that has intelligibility, [. . .] and communicative power" [16] (p. 110). It is believed that portfolios can go beyond mere reporting and reveal one's teachers' thinking, depending on the degree of insight and reflection teachers are engaged with when compiling the portfolio content [16]. The participants' logs included in these portfolios are also used in educational research as they have the potential to reveal "interesting accounts of developments" [17] (p. 128). Children's work and pictorial material such as photographs and videos are also used as a form of documentation and are perceived as a way to make children's "views," "understandings," and constructed meanings "more visible" [18] (pp. 1–2). Finally, we included selective recordings of children's interactions during the project's activities as these can also reveal what children learn. Portfolios as a whole enabled us to adopt a "systemic" approach to the evaluation of the project results [19] (p. 165).

2.2. Data Analysis

We analyzed the data coming from the above sources through qualitative analysis, which included the following processes:

a. Open coding [20], in which we tried to detect the following categories of evidence in all data sources:
    - The characteristics of curriculum planning.
    - The period over which activities were organized.
    - The educational resources and tools used during the activities.
    - The methodology of activities and instruction.
    - The nature of learning interactions.
    - Other issues that contributed to or hindered the successful implementation of the project.

Table 2 presents the codes which emerged in each category. The above categories reflect the methodological framework presented in the implementation instructions distributed to educators (e.g., in the methodology of activities, instructions urged educators to prompt children's questions and place them at the center of the inquiry process). This framework guided the coding process in a very general way (providing the general purpose of examining each type of evidence). However, the coding was open, and codes emerged as we read and compared the data to the methodological framework.

Table 2. Codes that emerged during the Open coding process in each category of evidence.

General Category	Codes
The characteristics of curriculum planning and implementation	Number (of activities) Coherence (between learning targets and activities) Concepts (exemplified and analyzed through activities) Ideas (developed through the activities) Stages (through which inquiry developed) Connections (with children's background, environment, and social life)
The period over which activities were organized	Number of months
The educational resources and tools used during the activities.	Books Tools Digital resources Artifacts Art and craft materials
The methodology of activities and instruction	Teacher-led instruction Teacher-initiated exploration Child-initiated exploration Child-led activities
The nature of learning interactions	Teacher's presentations Teacher-directed interaction Children-directed interaction Children's interactions dominated by the teacher Children's interactions without the dominance of the teacher
Other issues that contributed to or hindered the successful implementation of the project	

b. Axial coding [20], in which we tried to organize different groups that displayed similar implementation features. The scope of axial coding was developing a critical-hermeneutic narrative, a description of the project implementation that differed from the participants' account and led to a more thorough and profound understanding of the teaching and learning process [21]. The present work is a study of the events as they were presented to us, the researchers, and it reflects our attempt to "get inside" the teachers' experience "based on their description of it" [21] (p. 54). The portfolios submitted to us revealed how educators and pedagogues had interpreted the aims and methods of the project. They also revealed their understanding of how the project's aims and methods could be best met and implemented in their class.

c. From this point onward, we attempted to develop categories "that are systematically interrelated through statements of relationship to form a theoretical framework that explains" teachers' understandings and practices [20] (p. 22).

Coding was carried out by NVivo 12 Plus, and it followed the following procedure. Each of the three researchers coded independently the portfolios submitted by institutions. At the end of each stage of coding (Open, Axial, stage c), researchers met and compared their analysis. Each point of difference or disagreement was discussed, and a mutually accepted resolution was adopted to reach homogeneity and agreement in the results.

3. Our findings: Distinct Categories of Implementation

At the end of our analysis, three main category types of implementation were formed (Type A, B, and C), each of them displaying particular characteristics.

3.1. The characteristics of Type A

Box 1

Examples of project implementation of this type included many activities, which occurred in a short amount of time. Too many activities seemed to be "squeezed" into the time allocated. Moreover, activities displayed superficial coherence and a somewhat fragmented understanding of the topic. A large amount of encyclopedic knowledge was offered to children via teacher instruction and teacher-led presentations. This body of knowledge was overridden by complex concepts resulting in questionable levels of understanding. Sometimes teachers resorted to animism and anthropomorphism to help children understand complex phenomena, such as those involved in the water cycle. Fieldwork appeared to have a minor or peripheral role in comparison to structured classroom activities. There were also scarce opportunities for the children to engage in tactile and hands-on experiences. Their movements seemed to be highly controlled by adults in the name of their safety. There was no evidence that links were drawn between the preparatory stage, the fieldwork, and the post-fieldwork phase, and there was no mention of reflection and further study on the fieldwork findings. Fieldwork seemed to be more of an outing, a quick tour to places of interest rather than a site exploration with persistent observation and careful recordings. Children's engagement with artistic work heavily relied on the teacher's instructions, and there was no evidence that artwork was a means of the learners' sensemaking.

3.1.1. Examples of Projects Displaying the Type A Characteristics:

Example 1. *During the preparatory phase, children were given historical information such as the etymology of the word "water," the importance of water in ancient times, and ancient myths about water. They were also given presentations on the following matters: the importance of water for life; forms of water in nature; the water cycle; living organisms found in water; the correct treatment and use of water; the usefulness of water for households; how water can be transferred from one place to another; the use of water in religion; water as a topic in folk culture. They were also told fairy tales that include references to water. There was no evidence that children explored the above topics through an inquiry-based learning approach.*

As young as four and five years old, children were expected to look at pie charts, maps, and other graphic depictions to understand that water covers and constitutes the most significant proportion of the planet's surface and the human body. Children were also guided to carry out water measurements using standard units without prior experimentation with nonstandard measurements. Selected children executed some water experiments while their classmates were observing the procedure from a distance. Animism and anthropomorphism were used as a teaching strategy: a water drop was presented as a puppet with a human face, and planet Earth was depicted as a round big white bear.

A nearby river was chosen for fieldwork. Before the visit, children were presented with books, CDs, DVDs, and internet pages with information about the local river. Although children prepared equipment which included a camera, paper and color markers, buckets, and spades, during the visit, according to the teacher's report, children were encouraged to carry out measurements which seemed to be practically unmanageable: e.g., they were prompted to measure the volume of water in the river, the depth of the river, the number of pebbles in and around the riverbanks, the number of trees around the river (which, as the teacher noted, were countless), the anthills, and the rubbish on the riverbanks. In the post-fieldwork discussion, children expressed their impressions relating to various aspects, but there was no deep understanding of children's utterances. They also contained references that did not relate to the experiences they had during the field trip. E.g., In summarizing what they learned during the project, children said: "We got to know about ancient heroes," "we say "no" to the melting of Arctic ice, we say "no" to the "Earth's fever," "we learned about the animals of water."

Craft activities were paper constructions that were cut out of the same temple and used the same colors so that every child creates the same product. Crafts seemed to vaguely relate to the subject of water as they included penguins, white bears, and snowmen.

Example 2. *In another Nursery, children aged four were engaged in the following activities: In the preparatory phase, children played and experimented with snow and searched for invertebrates in the school playground after the rain or after the snow had melted. They looked at compound* *words in which the word "water" was the first part-word. They carried out some experiments by freezing water into the freezer and then melting it into the water again. Children were also given a presentation of a variety of paintings that had a reference to water. However, some of these paintings had puzzling symbolism carried: one of the paintings, for example, was "Golconda" by Magritte. Through this, Magritte wanted to pose questions about the connection between individuality and grouping. The teacher asked children to observe the paintings carefully and then answer questions such as: "what is the color of the water on this painting, why is this so, where can we fund water, what is the usefulness of water." No further artmaking (as reflective work on the paintings) was reported.*

Next, children experimented to discover the properties of water, e.g., that water is transparent and colorless, odorless, and tasteless, or that it is a liquid and takes the shape of its container. In a visit to their local public library, children were encouraged to discover fiction and non-fiction books on the topic of water and had stories that contained references to water read to them. For example, one of the stories that struck children's interest was the story of Alcyone. Back in the classroom, children were presented with information about the water cycle which was afterward dramatized under the teacher's guidance and supervision.

The daily fieldwork was reduced to an outing including a "water museum" visit, a dam, and its reservoir. In the museum, children came across tools used by the company that constructed the dam they were about to visit. These included all sorts of objects such as the typewriters and phones of the company administration office. No recordings were reported, and no focused exploration was carried out during the day. A second outing was later organized at a local creek in which some random and opportunistic observations of fauna and flora had occurred.

In the phase that followed their trip, children discussed the consequences of water shortage and tried to construct a small dam and its reservoir using rocks in their playground. As extension work, children were involved in the following activities: (a) themed collages which illustrated metaphors that use the word "water," (b) egg dying, (c) a UNICEF contest about children's rights, (d) a project on water conservation and, (e) drama work on the Greek epic poem of Odyssey.

3.1.2. Why This is not the Preferable Way to Organize Sustainability Projects

The serial presentation of loosely connected pieces of information makes learning problematic, especially for preschool-age children. For the sake of apprehension, pieces of information need to be presented "as an integrated whole with recognition of the relationship between parts" [22] (p. 8). The progressive work on the main ideas can be summarized in each part and then reviewed since repetition and reviewing are proved to support learning achievement. Drawing analogies and using models is essential to teaching because they can enhance clarity and facilitate learning [22]. Moreover, linking new information to what is already known and putting this into action is vital for young children [23]. It is also essential that information put into context and, if possible, becomes *"personally relevant"* or meaningful to children [24] (p. 136) [23,25]. Coherence and connecting links between mental models and concepts seem crucial for quality learning and necessary for challenging young children's naïve beliefs [23,25]. This needs careful planning and ongoing work on interlocking concepts instead of a random accumulation of information.

Providing choice and the opportunity to contribute ideas are also essential strategies that make a project meaningful to children and help in sustaining motivation. A *"need-to-know"* approach can meet the condition of the *"student input"* [25] (p. 68) [23]. Allowing children to enter the *"flow"* state is essential and can only be facilitated if there is no rush and activities are spread comfortably into time (Helm and Katz, 2001). Moreover, apprenticeship is vital for new skills. Therefore, it should be carefully planned and organized [23]. In our project, the introductory phase was supposed to resume and bring up the vital role of apprenticeship to help children claim new skills to use at later stages. Rushing through or overloading the introductory phase with various information and activities jeopardized the primary role of this phase. Thus, the provision of large amounts of information, which is somewhat fragmented and disconnected from context, or bares loose ties with a central topic, and outside children's experience or delivered in a short amount of time, does not qualify as a suitable teaching and learning approach.

Anthropomorphism is how teachers assign human characteristics to non-human beings and things [26]. Research reported by Kallery and Psillos [27] shows that Greek teachers tend to use anthropomorphism to help children access and understand complex concepts and connect their experiences with unfamiliar phenomena and elements. However, the debate has grown about whether or not the anthropomorphic speaking methods should be used in the classroom [28,29], primarily if they are modeled by the teacher [26,29]. Although children do not always appear to copy the anthropomorphic thinking of their teachers uncritically, they seem to align with their way of speaking generally.

Researchers, therefore, bring this issue into question for three main reasons:

(a) When it comes to science education, this type of conversation might hinder knowledge acquisition [26].
(b) Research on where anthropomorphism facilitates better understanding in young children and where not is scarce and inconclusive. Instead, it is argued that personification yields the danger of "unreasonable personifying responses" [27] (p. 308).
(c) Research also identified the need for young children to focus on the natural causes. Causal explanations of natural phenomena transition from their early animistic or artificialist way of thinking to a deeper understanding of the physical causality in the natural world [30].

In our project, some teachers used stories and poems in which water drops had human features (such as smiling faces), a gender (either male or female), emotions, and were able to think or relate like humans (had parents or siblings). They reported using this type of literature as core texts unquestionably and without hesitation. They even created puppets to enact narrative and encouraged children to draw these drops and elements such as the clouds or the Sun depicting human features.

The promotion of the sustainability goals does include spiritual elements and a dimension of animism, to the extent that we perceive planet Earth as a *"precious"* and *"sensitive"* ecosystem which is *"alive," "interdependent,"* and in a state of continual *"becoming"* [31,32]. However, this is not ascribing sentience to inanimate things as teachers do. *"In this strong animism, bonds of mutual life-giving subtend relationships among individuals and groups, across species; they include a great range of beings, even some landforms"* [33] (p. 496). Good practices introduce children to this *"ecological ontology"* by focusing on *"connectivities, continuities, and responsibilities"* [33] (p. 496) [34]. Storytelling and animism of the traditional stories can also be introduced to children as a sample of a *"different knowledge system"* [35] (p. 13), and this needs careful planning to avoid giving children false impressions.

We also need to discuss the issue of children's art and craft activities. Children's artmaking provides documentation of "cognitive and imaginative ways of knowing" [36] (p. x). Through art, children display their thinking, what they know, how they feel, and what they prefer [37]. Encouraging children to take up "risk and challenge" is essential to creativity [38] (p. 33). Furthermore, this cannot be achieved through controlled, uniform, and teacher-directed art and craft making. Children should be encouraged to respond freely to materials and feel that peers and adults respect this work. It is argued that, especially for young children, artmaking should be based on children's responses instead of being organized as a series of activities with predetermined end-product in mind (Brook, 2003). In strictly organized activities, children end up more "acted upon, rather than being active participants in artistic processes" [39] (p. 12).

3.2. The Characteristics of Type B

Box 2

In this type of implementation, the stages of the project were distinct and well developed. They contained a reasonable number of well-connected activities that led the project from one stage to the other with coherence. The content was straightforward to permit the process to develop in complexity. The children were taken to water sources and encouraged to observe, explore, play and record their findings or collect small objects as evidence and further study in the classroom. Investigations included consistent planning and inquiries [40]. Preparation also included the definition of concepts, familiarization with tools, measurements, and recordings. Children were encouraged to ask questions, and their questions were placed on a central stage during the inquiry. Interviews complemented fieldwork, and exploration expanded through various sources that included books, digital resources, and people. Throughout the process, teachers supported children in collecting and interpreting data, sometimes using mathematical thinking to help children elevate their levels of understanding. Through procedures that resemble scientific and well-documented inquiry, educators supported their children to construct explanations [40]. The project was successfully drawn to conclusions and an exhibition of findings. Alternative expression means were explored, such as 3D constructions with recycled material and or drama play.

3.2.1. Examples of Projects Displaying the Type B Characteristics

Example 1. *Children's interest was ignited through a couple of discussions: teachers recorded children's questions on a big poster and used them as a point of reference throughout the length of the project. Preliminary work with tools and measurements evolved around a simple question that emerged during free play: "How big are the puddles in the playground?" Children were encouraged to carry out measurements using nonstandard and standard units (e.g., they measured the width and the depth of the puddles) and compare measurements recorded at different times of the day to study the effects of rain in the playground. A gap in children's experience was identified from interactions with migrant staff: water shortages experienced in other countries of the world were less familiar to them since they lived in a place with plenty of water in the environment. A second mini-investigation was organized in which the class measured and recorded the water consumption at lunchtime in the kindergarten. Children in the fieldwork were encouraged to spot the nearest neighbor map (an ocean coast and a tiny island). Before the outing, they were also encouraged to form hypotheses (animals and earth elements they expected to find there), to decide about the equipment they needed to take with them (containers for collections, wool socks, buckets, magnifying glasses, cameras, iPad, fishing nets, etc.) and the mode of transportation. It was evident that children were the decision-makers in these processes and made several proposals based on their living experience. Fieldwork was repeated twice at different times of the year and allowed children to compare the differences in the environment (the first time everything was covered in snow, and the second spring was all around). Children were thrilled to discover elements hidden under the snow during the first visit, observe the colors and the riparian zone, and collected samples for further study in their classroom. In their post-fieldwork discussions, children were supported to classify the elements they discovered according to two criteria: (a) they separated plants from animals, and (b) they formed different groups of seaweeds according to size and color. Artmaking focused on children's idea to "paint the water." Children were given a choice to make their painting on pieces of cloth and decorate it with any materials and any manner they wanted. Individual pieces were sewn together to form a big patchwork sheet.*

Example 2. *Children started their project by watching a film about the importance of water for Earth. Several activities during the preparatory phase led children to realize and take notice of phenomena related to water and their impact on nature (absorption, flow, floatation, permeability, water saltiness, water pressure). They observed experiments in which leaves absorbed color or were left to dry in an empty glass. Many measurements with nonstandard and standard units enabled children to familiarize themselves with observation, measurement, and recording procedures and helped them develop a good sense of volume. Looking at pictures, children noticed that animals and plants live near sources of water. Thus, they interviewed a zoologist and a local fisherman to get more information about life in and around water sources. The zoologist tried to explain how* *the food chain works, and the fisherman concentrated on the importance of keeping water clean to enable healthy fish to grow. Water pollution then came into focus, and children experimented with filtering dirty water. With support, children sought to find sources of fresh water in their local area. They realized that there was a river with a marsh nearby and prepared an outing. Preparation included care for suitable vesture and necessary equipment such as magnifying glasses, meter, nets, boxes for collections, pond scope, binoculars, etc. It also included rules like "keep the noise and water disturbance to a minimum, or else small animals, fish, and invertebrates will be scared away." Children also looked at tourist guides about the places they were going to visit.*

The excursion included three significant stops: the river spring, the marsh, and the river delta. During the outing, children made observational drawings that depicted the colors of the environment, animals, and plants they saw, even the sounds they heard on the site. They measured the water temperature using nonstandard (by dipping their hands in it) and standard units with support (a proper thermometer) to realize that the water was colder at the river spring and warmer at the marsh or river delta. At the three stops, they tasted the water and noticed that saltness was felt near the delta, concluding that this was coming from the sea.

In the post-fieldwork phase, children discussed their findings. The discussion revealed that they had developed a good understanding of how water supports life and the growth of entire ecosystems. They also developed an excellent understanding of the purpose of their exploration and identified the need for environmental cleanliness and health as the most important thing they learned from their inquiry.

3.2.2. Why is This Important

Good quality sustainability programs develop learning sequences in which children are encouraged to search for answers to their questions and try to "explain what they observe." They also prompt children to use what they know "in reasoning about what they observe," and they share the belief that "struggling is critical to learning, just as it is a critical part of the way science is done" [40] (p. 12) (see also [41]).

Fieldwork is an essential part of experiential learning, especially in urban settings in which children have limited access to the flora and fauna of their geographical area. Limited experiences of the natural environment make it difficult for children to develop a sense of connection to nature, to build their experiential knowledge, and develop sensory awareness of their place in the ecosystem [41,42]. Mental activity is not downgraded but is used to help children link and apply new and abstract knowledge to the real world (materials, facts, and actions) [24].

Developing scientific literacy about water is expected to contribute to the development of a "water ecoculture" and help us understand the importance of water as a constituent of life and as an agent of culture. Therefore, good sustainability projects allow children to study the contribution of water in biological and social life using crosscutting scientific concepts. For example, teachers may encourage children to make recordings of water usage or consumption on several occasions, in and out of school. Apart from teaching children how to carry out measurements, these recordings enable children to observe patterns in water use, human behavior, and the factors that influence them (e.g., water leakage, water consumption rises, accruing environmental damage, and financial costs). In quality projects, teachers need to encourage children to pursue further inquiry, seek answers to their questions, gain some basic understanding of the relationship of cause and effect, and expand their inquiry at multiple levels in increasing depth and sophistication.

Finally, art activities that engage young children with debates add an emotional dimension to the learning process and are particularly important for sustainability education. This is because an appeal to people's rational cognition cannot always persuade people to change their behavior or become proactive, and sustainability as a cultural tool might be difficult to grasp [43].

3.3. The Characteristics of Type C

Box 3

Type C displayed all the characteristics of Type B (in a few words: simplicity, coherence, connections, emphasis on children's questions, strong congruence with scientific inquiry, multimodal ways of presenting findings). Moreover, projects of type C went a step ahead in that they connected children's learning to their backgrounds, their social environment and pursued deeper investigations into the subject of water as an element in human culture. Educators offered children opportunities to explore problems with their social dimensions [40]. This enabled children to draw meaningful, mutually consistent relationships between pieces of knowledge or information and yielded richer project results. Teachers also encouraged children to use models (and sometimes to develop models themselves) to understand and find answers or solutions [40]. Teachers enabled children to engage in arguments and hear contradictory views and aspects [40]. Apart from fieldwork, the inquiry processes included interviews of multiple agents (local community members, scientists, engineers, etc.) who could elaborate on different aspects of the main issue. During the interviews, people's personal stories and well-being were examined and paralleled to scientific judgments and technological achievements. Personal interests were compared to the common good and personal views intertwined with professional judgment and integrity. Cross-examination led to a countercheck of the individual to the collective and the subjective to the scientific. In this, children were also encouraged to discuss their concerns. As teachers supported children to obtain, evaluate and communicate information in various multimodal ways [40], projects made extended use of the possibilities offered by ICT and technology.

3.3.1. Examples of Projects Displaying the Type C Characteristics

Example 1. *Through guided inquiry, children studied the case of a local dam. They sought to find the need and purpose of this water management project, details about its construction, and details about the wetland features that develop in and around the reservoir. Children were prepared by monitoring and recording water consumption at school and home, looking at and analyzing water bills, and publications about water shortage. During a physical visit to the dam, they discovered a hamlet located inside the dam reservoir, which had to be abandoned. This hamlet sinks and re-emerges each year following the fluctuations of the water level in the reservoir. Children were thrilled by this discovery and asked to learn more about the sunk hamlet. Teachers then organized interviews with locals, as well as engineers from the treatment plant. Children discovered that local communities were strongly opposed to constructing the dam despite their compensation for expropriation. Older people refused to abandon the hamlet until the very last minute, just before the water level flooded their properties. Children heard contradictory arguments which interviewees carefully phrased using simple language and realized that public interest and the overwhelming need for drinking water prevailed. The dam was set to serve a population of 300,000 inhabitants. Artmaking supported every phase of the exploration to enable children to express their emotions, culminating impressions, and ideas. E.g., children made collective works of "land art" on-site when they visited the dam banks for field study. A group of children chose to make a colorful heart on the ground to express their sorrow for the abandonment and immersion of the hamlet.*

Example 2. *On another occasion, children explored the local coastline and discovered the underwater ruins of a sunken city. Children's interest sparked, and a series of interviews with locals led children to discover that this was the outcome of an ancient earthquake of great magnitude. Children asked to learn more about earthquakes, which developed a whole new twist to the water project. A new inquiry pathway emerged that enabled children to learn about earth plate movements, rifts, and their impacts on the landscape. Discussing the fate of ancient survivors who immigrated and rebuilt their communities in other locations of the same geographical area, children were encouraged to consider issues of immigration and displacement. At the culmination of their project, children linked their discoveries to issues of migration and refuge as experienced in their society (this was during a period that large numbers of migrants and refugees were crossing the Mediterranean to arrive in Italy, Greece, Spain, Cyprus, and Malta).*

3.3.2. Why Is This Important

Making inquiry meaningful and personally relevant elevates children's interest in a topic and contributes to a more profound understanding [24]. Science contributes in a unique way to the development of culture. Science has contributed to the development of values, ideas, and our worldview. Sciences contribute to and deepen our understanding of the world, and, thus, they are part of a "liberal education" [44]. To develop an understanding of the nature of science, educators probably need to act as cultural mediators [45]. Through engagement in the critique of scientific values and ideas, or explorations of contradictory views, and the impact of scientific projects in society, children are actively involved in developing culture. Reflection processes are also involved and help students derive knowledge from experience [41,46].

Embracing their local history and or ancestry is also an essential factor contributing positively to students' emotional connection with their physical environment [42]. The collection of oral stories and local inquiry into the lived experience of people help children to attach these stories to their own. This also increases the sense of attachment to places and the development of "a narrative about their own lives that is meaningful and focused on living in ways that support the welfare of others" [42] (p. 94).

3.4. The Classification in Numbers

Table 3 presents the number of classes classified in each Type (A, B, or C) according to the characteristics displayed in their implementation of the project.

Table 3. The number of classes in each type of implementation.

Type of Implementation	Number of Classes
Type A	24
Type B	21
Type C	4
Total	49

As Table 3 shows, most classes displayed characteristics that classify them as Type A in our classification. Type B follows, and only a minority of four classes displayed the Type C characteristics. The prevalence of Type A implementation is a matter of concern seeking further investigation and additional research. This goes beyond the scope of the present study, which is set to present, classify and discuss the different characteristics classroom implementations have developed.

4. Discussion

Successful sustainability projects helped children to draw links between nature and society and relate to the phenomena they studied. We can distinguish two major approaches to ESD that link to different paradigms: One that adopts a mainly "descriptive approach aiming at behavioral modification" and aims at a "democratic, participatory empowerment." The latter sets out to educate active citizens who will pursue democratic activities on sustainability [47] (p. 40) (See also, [48]). It is a request for "transformative action" according to UNESCO (see also [49]), and as such, it demands the following advances: "Disruption," which is necessary at first, to make people break their usual way of thinking, feeling, and acting. Critical reflection and insight are also pivotal for people to break their habits and exit their "comfort zone." When it comes to transformation, it seems that there are two pathways. It can either lead to the technical knowledge of how things happen or "to a deeper connection with the issues." The cultivation of empathy results from education processes that relate to compassion and relevance to one's own life, which means that learning must be realized through critical inquiry and analysis, exposure to different viewpoints, arguments [50] and debates, and empowerment to take action. Links between learning and social participation need to be drawn [7] (p. 57) [51]. "Multiple representations of content" and "multiple options for expression and control" [51] (p. 32) are needed as well as space and time for experimentation with new or "disruptive" ideas to enable children to become active and transformative learners [7] (p. 57).

One of the most fundamental defining characteristics of effective Environmental Education is the need for the subjects or objects of an inquiry or an activity to be approached with the help of all sciences at the level of school knowledge and practice [52–55]. A mobile learning perspective can enhance this approach. For instance, the combined use of smart mobile devices and QR codes could be used as a bridge between offline and online content, connecting physical objects with information related to the internet and access to multiple communication channels. This perspective has a strong potential for enhancing inquiry-based learning and the development of transformative action. In recent years, the development of mobile devices has profoundly shaped the landscape of mobile learning by changing its features and characteristics. Mobile learning is now provided through small, lightweight, reliable, and surprisingly powerful devices with internet connectivity and an impressive number of easy-to-use software applications (apps) made exclusively for a mobile device.

Given the abovementioned characteristics of mobile learning with technological tools such as the QR codes, mobile learning can link formal and informal learning and mobile technologies in environmental education programs, making learning happen anytime and anywhere [56]. Moreover, mobile technology can provide more options for the "multiple representations of content" and the "multiple options for expression and control" highlighted by Kershner [51] (p. 32). Further exploration and research are needed on the ways technology, ICT, and mobile devices can empower learners and become the tools of effective sustainability education [57] and deeply investigate the arguments advanced by young children during a problem-solving situation [58].

5. Limitations

The present study highlights and analyzes some of the most outstanding issues while implementing a water project in early childhood settings in Europe. The sampling was convenient and by no means representative of the population, so this article can only be a case study. The above findings are not conclusive and cannot be considered indicative of the practices realized in each country that participated in our project. Research of a grander scale is needed for safer conclusions regarding the standard practices in ESD for the early years in European Countries. However, our analysis brings up issues worth considering, especially regarding educators' potential to support teaching and learning for empowerment, equity, and sustainability.

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