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Enhancing preschool children's environmental awareness and understanding of climate change through an experiential educational intervention

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ABSTRACT

This qualitative pre-post intervention study explored whether an experiential educational intervention could enhance preschool children's environmental awareness and emerging understanding of climate change. The study was conducted over two weeks in a public kindergarten in Greece with a convenience sample of 18 children aged 4-6 years. The intervention used developmentally appropriate, play-based activities, including educational videos, guided discussions, collaborative projects, hands-on experiments, artistic expression, and recycling and renewable energy activities. Data were collected through semi-structured interviews conducted before and immediately after the intervention, complemented by parental observations. Interview data were analyzed using inductive qualitative content analysis supported by NVivo, with pre- and post-intervention responses compared across the five interview questions. The findings indicated improvements in children's environmental vocabulary, recognition of human responsibility, understanding of selected climate change impacts, and identification of simple mitigation actions. Parents also reported increased environmental interest and related discussions at home. Although the findings suggest that preschool children can engage meaningfully with foundational climate concepts when these are taught through developmentally appropriate experiential strategies, the results are exploratory due to the small, single-site sample and the immediate post-intervention assessment.

Keywords: preschool education, climate change awareness, experiential learning, environmental education, parental observations, ecological consciousness

INTRODUCTION

Climate Change: A Global Challenge

Climate change has emerged as one of the most urgent global challenges of the 21st century (Abbass et al., 2022). There is strong scientific consensus, as documented by the intergovernmental panel on climate change (IPCC), that anthropogenic activities, notably the burning of fossil fuels and land use changes, have significantly contributed to global warming, leading to profound impacts on natural and human systems (IPCC, 2023). Rising global temperatures are already associated with increased frequency and intensity of extreme weather events, accelerated glacier and ice-sheet melting, sea-level rise, and substantial biodiversity loss (Beckmann & Winkelmann, 2023; IPCC, 2022; Parmesan & Yohe, 2003; Rilov et al., 2021; Rullens et al., 2022). Without timely and effective mitigation measures, climate change is projected to pose escalating risks to ecosystems, human health, food security, and economic stability, disproportionately affecting vulnerable populations and future generations (Adom, 2024; IPCC, 2023; Saleem et al., 2024; Sanober, 2023; Tchonkouang et al., 2024; Tschakert et al., 2013).

Importantly, climate change is not only an environmental crisis but also a social and ethical challenge, since those who have contributed least to the problem, including young children and marginalized communities, are likely to bear some of its most severe consequences (Adger et al., 2013; D. A. Brown, 2001; Derviş, 2007; O'Hara & Abelsohn, 2011). Addressing climate change therefore requires not only mitigation and adaptation, but also educational responses that help citizens develop knowledge, values, and dispositions for informed and constructive action (Abbass et al., 2022; Anderson, 2012; Feigin et al., 2025; Hampton & Whitmarsh, 2023; Henderson & Serafeim, 2020; Tosun, 2022). International organizations have emphasized this educational imperative; UNESCO, for example, has argued that transformative learning is necessary for human and planetary

survival and that education systems must equip learners to respond to climate-related challenges (Douglas et al., 2024; UNESCO, 2021a). Within this broader agenda, there is growing recognition that sustainability education should begin in the earliest years of life rather than being postponed until later schooling (Abo-Khalil, 2024; Hosany et al., 2022; Pauw et al., 2015; Somerville & Williams, 2015).

The Role of Early Childhood Education in Climate Change and Sustainability

Education is widely recognized as a critical means of promoting sustainable development and addressing climate change (Hosany et al., 2022; Ozturk, 2023; Pauw et al., 2015; Somerville & Williams, 2015; Vare & Scott, 2007). Although climate change education has traditionally focused on adolescents and adults, early childhood is increasingly viewed as an important period for laying the foundations of environmental awareness, values, and habits (Ardoin & Bowers, 2020; Chawla & Cushing, 2007; Davis, 2009; Lamanauskas, 2023; Papanikolaou et al., 2020). Research in developmental psychology and environmental education suggests that young children's curiosity, emotional responsiveness, and capacity to care for living things make them especially receptive to experiences that nurture responsibility toward the natural world (Hosany et al., 2022; Van De Wetering et al., 2022; Yoshikawa & Kabay, 2015).

For this reason, introducing environmental education at the preschool level is increasingly seen as educationally significant rather than premature (Barratt Hacking et al., 2007; Ernst & Monroe, 2004; Grindheim et al., 2019). Early childhood is a period in which basic understandings of weather, nature, place, and community are formed, making it a valuable stage for introducing age-appropriate ideas about environmental care and emerging climate-related understanding (Davis, 2009; Hedefalk et al., 2015; Meier & Sisk-Hilton, 2017; Spiteri, 2019). At the same time, young children are not merely future citizens; they can also influence present-day practices within their families and communities. Studies have shown that children can act as "agents of change" by communicating environmental ideas and encouraging practices such as recycling and energy saving at home (Ballantyne et al., 2001; Milakovich et al., 2018; Percy-Smith & Burns, 2013; Sear, 2018; von Braun, 2017; Walker, 2017).

Recent scholarship has moved beyond arguing that sustainability belongs in early childhood education and has begun to examine how it can be meaningfully enacted. Systematic reviews indicate that early childhood education for sustainability can support agency, participation, and ecological awareness when it is embedded in pedagogies that are relational, inquiry-oriented, and developmentally appropriate (Ardoin & Bowers, 2020; Hedefalk et al., 2015). Barratt Hacking et al. (2007) argue that effective environmental learning in the early years depends on connected pedagogies rather than simple transmission of information, while Cutter-Mackenzie-Knowles et al. (2020) emphasize that even complex issues such as climate change require pedagogical forms that respect children's ways of knowing. Elliott and Davis (2009) similarly highlight both the promise of sustainability education in early childhood settings and the institutional and professional constraints that often limit its implementation. More recent work has reinforced these points by showing that contemporary preschool curricula increasingly frame sustainability in terms of participation, investigation, and collaboration (Ohlsson et al., 2022), and that play and children's agency remain central to how sustainability is interpreted in early childhood settings (Kahriman-Pamuk & Borg, 2024). Together, these studies suggest that the question is no longer whether sustainability belongs in early childhood education, but how it can be translated into pedagogically coherent practice.

International policy developments point in the same direction. UNESCO (2021b) has called for education for sustainable development to be embedded across curricula, and recent research continues to argue that high-quality early childhood education can serve as a foundational context for environmental awareness, climate literacy, and sustainable living (Ardoin & Bowers, 2020; Güler Yıldız et al., 2021; Hedefalk et al., 2015; Somerville & Williams, 2015; Spiteri, 2023a). Even so, climate change remains less consistently addressed than sustainability more broadly, and in many contexts early childhood educators still receive limited guidance on how to teach it in developmentally appropriate ways.

Challenges in Teaching Climate Change to Preschoolers

Despite the strong rationale for beginning early, teaching climate change in preschool is not straightforward. The literature points to three interrelated challenges: developmental complexity, emotional sensitivity, and pedagogical or institutional constraints.

First, climate change is cognitively demanding for young children. Preschoolers are typically described as being in Piaget's (1952) preoperational period, which is associated with concrete thinking, egocentrism, and limited capacity to understand abstract, large-scale, and long-term processes (Fleer & Hedegaard, 2010). Climate change, however, involves invisible mechanisms such as greenhouse gas accumulation, probabilistic patterns, long-term temporal scales, and complex causal chains (Bilgili et al., 2024; Hansen et al., 2025; L. Chen et al., 2022). Young children tend to reason through immediate and tangible experiences, which can make it difficult to distinguish climate from weather, or to connect everyday actions with broader planetary processes (D. D. Brown, 2008; Dündar-Coecke et al., 2021; Langevin et al., 2019; Sedlak & Kurtz, 1981; Yerlikaya et al., 2020). Research shows that children often conflate environmental problems, for example by linking littering directly to hotter weather or by treating climate change as equivalent to visible pollution (Brody, 1993; Covitt et al., 2009; Liu & Green, 2024; Mokhele-Ramulumo et al., 2025; Shepardson et al., 2009; Spiteri, 2022). Even when young children can articulate simple cause-and-effect relationships, they may still overgeneralize or hold misconceptions about environmental processes (Aksit, 2012; Gavrilas & Kotsis, 2024; Gontas et al., 2020; Liu & Green, 2024; Palmberg & Kuru, 2000; Palmer, 1995; Shepardson et al., 2012; Spiteri, 2023b; Spiteri & Pace, 2023). These developmental characteristics do not make climate education impossible, but they do mean that abstract scientific ideas must be translated into concrete, meaningful, and age-appropriate experiences

(Gavrilas et al., 2024; Papanikolaou et al., 2021; Sanson et al., 2018).

Second, climate change poses emotional and ethical challenges. Because the issue is often communicated through alarming narratives, educators may worry about provoking fear, helplessness, or eco-anxiety in young children (Baker, 2024; Burke et al., 2018; Galway & Field, 2023; Jimenez Gomez Tagle & Vito, 2024; Karataş, 2014; Lammel, 2025; Léger-Goodes et al., 2022; Ojala, 2016; Öhman, 2016; Pihkala, 2020; Sangervo et al., 2022). This concern is especially salient in the early years, when children may have limited emotional resources for processing global threats. Educators therefore face a delicate task: they must foster awareness without burdening children with despair. Studies suggest that some teachers hesitate to address climate change precisely because they regard it as insufficiently developmentally appropriate or potentially distressing for young learners (Beaver & Borgerding, 2023; Burke et al., 2018; Ginsburg & Audley, 2020; Hickman et al., 2021; Ojala, 2012). This tension highlights the need for pedagogies that support agency, care, and constructive engagement rather than fear-based learning.

Third, practical and institutional barriers continue to limit implementation. Many early childhood educators report limited preparation in climate science and uncertainty about how to translate complex issues into simple, meaningful classroom experiences (Anderson, 2012; Beasy et al., 2023; Borg et al., 2014; Christoforaki et al., 2025; Gavrilas & Kotsis, 2025; Gontas et al., 2021; Hoekstra et al., 2024; Kharrazi et al., 2018; Kotsis & Gavrilas, 2025; Moshou & Drinia, 2023; Plutzer et al., 2016; UNESCO, 2019). Curricular pressures, the absence of explicit institutional guidance, and parental sensitivities can further discourage teachers from engaging with climate change in preschool settings (Davis & Elliott, 2014; Ginsburg & Audley, 2020; Hägglund & Samuelsson, 2009; Lammert, 2024; Lawson et al., 2019). Thus, the challenge is not simply whether preschool children are capable of beginning to engage with climate-related ideas, but how educators can design learning experiences that are scientifically meaningful, emotionally appropriate, and pedagogically feasible.

The Importance of Experiential and Play-Based Learning

The literature increasingly suggests that experiential and play-based learning offers a strong response to these challenges. Rather than treating climate change as a topic to be explained abstractly, experiential pedagogies translate it into forms of learning that are concrete, sensory, collaborative, and action-oriented (Bubikova-Moan et al., 2019; Edwards et al., 2014; Parker et al., 2022; Vartiainen et al., 2024). This is especially important in early childhood, where children learn most effectively through direct experience, exploration, dialogue, and symbolic expression rather than through formal exposition (Broadhead & Burt, 2012; Catucci et al., 2024; Gavrilas et al., 2025; Samuelsson & Kaga, 2008; Tamblyn et al., 2023). In this sense, experiential learning is not simply an engaging technique; it is a theoretical and pedagogical response to the developmental realities of early childhood.

Experiential approaches help make abstract environmental processes tangible. Hands-on investigations, visual materials, guided discussion, artistic representation, and collaborative projects enable children to connect unfamiliar concepts with observable phenomena in their everyday worlds (Davis, 2009; Georgopoulos et al., 2011; Hayes & Kraemer, 2017; Kaufman & Eshbaugh, 1996; Poudel et al., 2005; Trott & Weinberg, 2020; Yilmaz et al., 2024). Play-based learning also provides an emotionally supportive context in which children can explore environmental themes without being overwhelmed by them (Adamowski et al., 2020; Tekinbaş, 2008). Through imaginative, social, and creative activity, children can develop empathy, perspective taking, and problem solving in ways that remain developmentally appropriate (Alkair et al., 2023; Barratt Hacking et al., 2007; Cutter-Mackenzie & Edwards, 2013; Lieung et al., 2019; Wei et al., 2020). Recent work has continued to underline the pedagogical value of such approaches, showing that sustainability in early childhood is closely tied to play, participation, and agency (Kahriman-Pamuk & Borg, 2024), while inquiry-based learning in natural settings can support children's early scientific understanding through educator-guided exploration (Speldewinde, 2024).

Research also indicates that experiential environmental learning can deepen children's connection to nature and strengthen pro-environmental attitudes over time. Regular playful engagement with natural environments, including gardening, outdoor observation, and exploratory activities, has been associated with increased nature connectedness, care, and responsibility (Barrable & Booth, 2020; Chawla, 2008; Ernst & Theimer, 2011; Fägerstam & Samuelsson, 2014; Liefländer et al., 2013; Palmberg & Kuru, 2000). These findings are especially relevant to climate education, because they suggest that effective early interventions may depend less on transmitting complete scientific explanations and more on building meaningful experiential foundations from which understanding can grow. Experiential and play-based learning therefore offers not only a practical classroom strategy, but also a coherent theoretical basis for introducing complex environmental issues in the preschool years (Fyffe & Lewis, 2024; Spiteri, 2025).

Research Gap and Study Purpose

Although the case for early childhood sustainability education has become stronger, a more specific gap remains in relation to climate change education in preschool settings. Most empirical studies and intervention-based research on climate change education have focused on older learners in upper primary, secondary, and tertiary education, leaving the preschool years comparatively underexamined (Bhattacharya et al., 2021; Devecchi et al., 2025; García-Vinuesa et al., 2024; Kolenatý et al., 2022; Kundariati et al., 2025; Muccione et al., 2025; Stevenson et al., 2013; Tang, 2022). As a result, there is still limited empirical evidence about what preschool children can meaningfully understand about climate change, how that understanding can be supported without generating confusion or anxiety, and which pedagogical forms are most appropriate for this age group (Ardoin & Bowers, 2020; Elliott & Davis, 2009; Inter-Agency Network for Education in Emergencies [INEE], 2023; UNICEF, 2023). Furthermore, while national and international early childhood frameworks increasingly reference sustainability, explicit and pedagogically clear guidance on climate change remains uneven across contexts, including Greece until recently (Hedefalk et al., 2015;

Kalogiannakis et al., 2021; Moshou & Drinia, 2023; Organisation for Economic Co-operation and Development [OECD], 2023).

More specifically, the literature still shows three weaknesses. First, many studies discuss the importance of early climate education in general terms, but fewer examine how preschool children actually articulate environmental and climate-related ideas before and after a structured educational intervention. Second, although experiential and play-based learning are frequently recommended, the link between these theoretical principles and the concrete design of climate-related activities is often assumed rather than explicitly demonstrated. Third, there is limited evidence from preschool contexts in Greece regarding how such interventions may influence not only children's talk and understanding in the classroom, but also whether environmental awareness extends into the home environment through parent-observed changes. Addressing these gaps is important for both practice and theory: for practice, because educators need developmentally appropriate models they can use; for theory, because the field still needs clearer accounts of how experiential and play-based principles can be operationalized in early childhood climate education.

The present study addresses this gap by designing, implementing, and evaluating an experiential educational intervention focused on environmental awareness and climate change understanding among preschool children in Greece. The intervention used developmentally appropriate, play-based methods, including educational videos, guided discussions, collaborative group projects, hands-on experiments and demonstrations, artistic representations, and recycling and renewable energy activities, in order to introduce basic climate-related concepts in concrete and meaningful ways. In doing so, the study contributes not only practical evidence about the feasibility of early childhood climate education, but also a more explicit account of how experiential and play-based learning principles can be translated into an intervention framework for preschool settings. Accordingly, the study was guided by the following research questions:

- How does participation in an experiential educational intervention influence preschool children's environmental awareness?
- How does participation in the intervention influence preschool children's emerging understanding of climate change, including its causes, impacts, and possible solutions?
- How do parental observations reflect possible changes in children's environmental interest, language, and everyday practices following the intervention?

METHODOLOGY

Research Design

This study employed a qualitative pre-post intervention design to explore whether an experiential educational intervention could enhance preschool children's environmental awareness and emerging understanding of climate change. This design was considered appropriate because the study aimed to examine how young children expressed environmental and climate-related ideas before and after participation in a developmentally appropriate educational program, rather than to test causal effects through experimental comparison. Given the exploratory nature of the study and the young age of the participants, a qualitative design allowed close attention to children's language, perceptions, and meaning-making processes.

Table 1. Age-group and gender distribution of the participating children

Age group	Boys	Girls	Total
Pre-kindergarten children (4-5 years old)	5	5	10
Kindergarten children (5-6 years old)	5	3	8
Total	**10**	**8**	**18**

Participants

Participants were 18 children aged 4 to 6 years enrolled in a public kindergarten in Greece (**Table 1**). The sample was drawn from a single classroom using convenience sampling, as the intervention was implemented within the natural setting of the class. Although small, this sample was considered appropriate for an exploratory qualitative study focused on in-depth examination of children's responses within a specific educational context.

Written informed consent was obtained from all parents or legal guardians, and verbal assent was obtained from each child before participation. These procedures followed established ethical principles for research with young children, with particular attention to voluntary participation, children's comfort, and their right to withdraw at any point (Alderson & Morrow, 2011).

Research Tool

The primary research instrument was an individual semi-structured interview protocol designed to assess children's environmental awareness and basic understanding of climate change. Semi-structured interviewing was appropriate because it allowed flexibility to explore children's spontaneous ideas while maintaining enough consistency across participants to support comparison between pre- and post-intervention responses (Christensen & James, 2017).

The interview protocol was developed in relation to the aims of the study and was reviewed for developmental appropriateness for preschool-aged children. It consisted of five open-ended core questions:

1. Do you know what climate change is? If yes, what is it? If not, what do you imagine it to be?
2. What causes climate change?
3. Who is responsible for climate change?
4. What are the impacts of climate change, and what can we do to prevent it?
5. Have you heard about ice melting? What happens there?

These questions were phrased in simple language to encourage children to express their own ideas, explanations,

Table 2. Structure and pedagogical alignment of the intervention

Intervention component	Pedagogical rationale	Intended learning focus
Viewing of educational videos	Visual and concrete presentation of unfamiliar concepts	Introduction to weather changes, greenhouse effect, and nature conservation
Guided discussions	Dialogic reflection and shared meaning-making	Verbal expression of ideas, clarification of emerging misconceptions
Collaborative group projects	Social and active construction of understanding	Application of concepts through teamwork and creative production
Hands-on experiments and demonstrations	Direct sensory experience and observable cause-and-effect learning	Concretization of abstract climate-related phenomena
Artistic representations	Symbolic expression of understanding and emotion	Communication of environmental ideas in developmentally appropriate ways
Recycling and renewable energy activities	Action-oriented and practical learning	Connection between everyday habits, responsibility, and sustainability

and associations. When needed, gentle prompts were used to invite elaboration without directing responses.

In addition to the child interviews, parental observations were collected after the intervention as supplementary data to explore whether the children's environmental interest and climate-related talk extended beyond the classroom. Parents were invited to respond to the question: "Have you noticed increased interest from your child regarding the impacts of climate change (melting ice, extreme weather events, global warming)?" These reports were used as supportive contextual evidence rather than as an independent validated measure and were interpreted cautiously.

Data Collection

Data were collected through face-to-face individual interviews conducted with each child at two time points: once before the intervention and once immediately after the two-week intervention period. Each interview lasted approximately 10-15 minutes and was conducted in a quiet, familiar space within the kindergarten to support the children's comfort and engagement. The interviewer followed the semi-structured protocol in a gentle, conversational manner, using prompts when necessary to help children elaborate on their answers while preserving the openness of the interaction.

All interviews were conducted in Greek, the children's native language, to ensure comfort and authentic expression. With parental permission, interviews were audio-recorded and then transcribed verbatim. For the purposes of the manuscript, selected excerpts were translated into English with attention to preserving the meaning of the children's original expressions (Squires, 2009).

Following the intervention, parental observations were also collected in order to document any climate- or environment-related comments, questions, or behaviors noticed at home. These data were used to complement the interview findings and to provide a broader picture of the possible reach of the intervention beyond the classroom setting.

Data Analysis

The interview data were analyzed using an inductive qualitative content analysis approach supported by NVivo 11 (QSR International). The analysis focused on comparing children's pre- and post-intervention responses across the five interview questions in order to identify recurring response patterns, shifts in vocabulary, and changes in the ways children describe climate-related ideas.

First, the pre- and post-intervention transcripts were read repeatedly to achieve close familiarity with the data. Meaningful segments of text were then coded in relation to the study focus, including environmental awareness, climate change understanding, human responsibility, perceived impacts, and suggested actions. The codes were compared across participants and across the two time points in order to identify recurrent patterns and descriptive changes in the children's responses. These patterns were then synthesized and presented question by question in the Results section.

As a complementary analytic aid, word-frequency queries were also conducted in NVivo to generate the word clouds presented in the Results section. These visualizations were used descriptively to illustrate changes in the salience of key terms across the two time points; they did not constitute the primary analytic procedure.

Formal inter-rater reliability was not calculated, as the study was designed as a small-scale exploratory qualitative investigation. However, the analytic process was conducted reflexively through repeated comparison of transcripts, codes, and emerging response patterns in order to strengthen consistency and interpretive transparency. This absence of formal inter-rater reliability is acknowledged as a limitation of the study.

Educational Intervention

The educational intervention was implemented over a period of two weeks and was integrated into the kindergarten's regular curriculum. It was designed as an experiential and play-based educational program aimed at enhancing children's environmental awareness and introducing foundational climate change concepts in developmentally appropriate ways. Activities were implemented collaboratively by the classroom teacher and the researchers.

The intervention was grounded in the view that young children learn most effectively through concrete experience, guided dialogue, active participation, and symbolic expression rather than through abstract, lecture-based instruction. Accordingly, the intervention sought to make climate-related ideas tangible and meaningful through activities that promoted observation, discussion, collaboration, experimentation, artistic expression, and everyday

Figure 1. Children engaging with age-appropriate educational videos to explore environmental topics such as weather changes, the greenhouse effect, and nature conservation (the authors' own elaboration)

Figure 2. Children participating in collaborative group projects to creatively explore environmental themes through teamwork and hands-on activities (the authors' own elaboration)

environmental action. **Table 2** presents the pedagogical alignment of the intervention activities.

More specifically, the intervention comprised six components as follows.

Viewing educational videos

Children watched short, age-appropriate videos introducing basic environmental phenomena such as weather changes, the greenhouse effect, and the importance of nature conservation (**Figure 1**). These visual materials provided accessible representations of unfamiliar ideas and supported the transition from everyday observation to emerging environmental concepts.

Guided discussions

After each video or major activity, the children participated in teacher-facilitated group discussions. Open-ended questions encouraged them to reflect on what they had seen, describe their ideas, and ask questions. These discussions supported verbal expression, collective meaning-making, and clarification of developing understandings.

Collaborative group projects

Children engaged in cooperative projects such as creating a mural about the earth's climate, assembling collages contrasting clean and polluted environments, and building simple model ecosystems (**Figure 2**). These activities enabled them to apply new ideas in social and creative contexts and reinforced learning through participation and dialogue.

Hands-on experiments and demonstrations

Age-appropriate science activities were used to illustrate selected climate-related phenomena. For example, children observed the melting of ice cubes to simulate ice loss and rising water levels, and they participated in a simple demonstration of heat retention under glass to model the greenhouse effect (**Figure 3**). These activities were intended to bridge the gap between abstract environmental concepts and direct sensory experience.

Artistic representations

Children were invited to express their understanding through drawing, painting, and crafting (**Figure 4**). They produced artwork on themes such as *our environment*, *changing weather*, and *caring for the earth*, allowing them to communicate their interpretations in symbolic and developmentally appropriate ways.

Recycling and renewable energy activities

The intervention also included practical sustainability activities, such as sorting classroom waste for recycling and

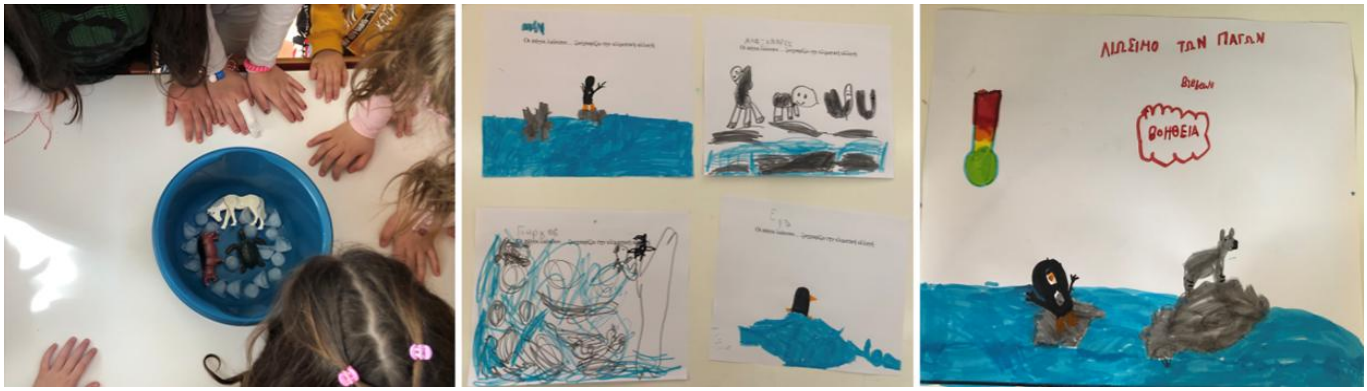

Figure 3. Children conducting hands-on experiments to explore climate-related phenomena, making abstract concepts tangible through sensory experience (the authors' own elaboration)

Figure 4. Children expressing their understanding of environmental topics through drawing, painting, and crafting activities (the authors' own elaboration)

Figure 6. Word clouds of children's responses to question 1 (*Do you know what climate change is? If yes, what is it? If not, what do you imagine it to be?*) before (left) and after (right) the intervention (the authors' own elaboration)

reusing materials in art projects (**Figure 5**). Simple demonstrations involving a solar-powered toy and pinwheels were used to introduce the ideas of renewable energy and responsible resource use in an accessible form.

Throughout the intervention, the educators acted primarily as facilitators rather than didactic instructors. Their role was to organize interactive learning situations, ask guiding questions, and encourage reflection, participation, and constructive engagement with environmental issues.

RESULTS

Consistent with the structure of the interview protocol and the study's comparative pre-post design, the findings are presented according to the five interview questions used before and after the intervention. Within each question, recurrent response patterns are described and illustrated with representative excerpts from the children's interviews. The word clouds are included as descriptive visual aids to illustrate shifts in vocabulary and expression across the two phases of data collection.

Question 1. Do You Know What Climate Change Is? If Yes, What Is It? If Not, What Do You Imagine It to Be?

Before the intervention, most children showed limited familiarity with the term *climate change*. Their responses were typically uncertain, vague, or speculative, as also reflected in the prominence of words such as "don't," "know," "something," and "what" in the pre-intervention word cloud (**Figure 6**). For example, one child responded, *"No ... I don't*

Figure 5. Children engaging in recycling and renewable energy activities to explore sustainability through practical, hands-on experiences (the authors' own elaboration)

Figure 7. Word clouds of children's responses to question 2 (*What causes climate change?*) before (left) and after (right) the intervention (the authors' own elaboration)

Figure 8. Word clouds of children's responses to question 3 (*Who is responsible for climate change?*) before (left) and after (right) the intervention (the authors' own elaboration)

know," while another said, *"Climate change … I think it's something you change."* These responses suggest that, initially, the term had little clear environmental meaning for most participants.

After the intervention, the children's responses became more concrete and more closely related to environmental change. In the post-intervention word cloud, words such as "weather," "earth," "changes," "heat," and "air" became more prominent, indicating a shift toward a more developmentally appropriate understanding of climate change as a change in environmental conditions. One child stated, *"Yes … it might flood … the weather changes."* Another explained, *"Climate change is something where … when we use cars, factories … lights and all those things and shops, then the earth … can have climate change… the earth heats up. That's what climate change means."* Overall, the post-intervention responses suggest greater conceptual clarity and stronger links between climate change, human activity, and environmental effects.

Question 2. What Causes Climate Change?

Before the intervention, the children's responses were marked by uncertainty, as shown by the prominence of terms such as "don't," "know," "how," and "what" in the pre-intervention word cloud (**Figure 7**). Although words such as "air," "change," and "climate" appeared, they were not usually connected to clear causal explanations. For example, one child said, *"I don't know how it is caused,"* while another answered, *"I think it is caused … the change is something you change."*

After the intervention, the children's responses became more specific and more clearly associated with human activities. In the post-intervention word cloud, terms such as "cars," "factories," "smoke," "release," "earth," and "thermometer" became more prominent. One child stated,

Figure 9. Word clouds of children's responses to question 4 (*What are the impacts of climate change, and what can we do to prevent it?*) before (left) and after (right) the intervention (the authors' own elaboration)

"With too many cars … with the smoke they release … it gets sick … the thermometer goes into the red." Another said, *"The earth … burns … the sun's rays hit it … carbon dioxide … goes into the sky … and pollutes the earth."* Although simplified, these responses indicate a more developmentally appropriate understanding of climate change causes, especially the role of pollution and emissions.

Question 3. Who Is Responsible for Climate Change?

Before the intervention, many children appeared unsure about who or what might be responsible for climate change. This uncertainty is reflected in the prominence of words such as "don't," "know," "maybe," "nothing," and "think" in the pre-intervention word cloud (**Figure 8**). Some responses were hesitant or imaginative rather than environmentally grounded. For example, one child answered, *"Maybe a thief dressed up as a person,"* while another simply said, *"I don't know."*

After the intervention, the children more often identified people and everyday human activities as linked to climate change. The post-intervention word cloud gives greater prominence to words such as "people," "cars," "factories," "humans," and "many." One child stated, *"We … with cars … and with factories,"* while another said, *"People … use too many cars."* These responses suggest a clearer recognition that climate change is associated with human actions rather than with random or imaginary causes.

Question 4. What Are the Impacts of Climate Change, and What Can We Do to Prevent It?

Before the intervention, most children showed limited understanding of both the impacts of climate change and possible ways to respond to it. The pre-intervention word cloud was dominated by terms such as "don't," "know," "nothing," "maybe," and "who" (**Figure 9**). In some cases, the children interpreted the word *change* in an everyday sense rather than in an environmental one. For example, one child said, *"I don't know,"* while another replied, *"Where change means that something changes … like if I say give me that toy, then I will change and say no, not that one."*

After the intervention, the responses became broader, more specific, and more action-oriented. In the post-intervention word cloud, words such as "wind," "turbines," "electric," "recycling," "cars," "bicycles," "sea," "floods," and "melts" became more prominent. These responses suggest

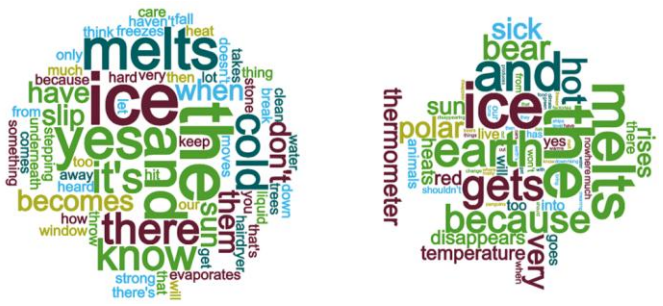

Figure 10. Word clouds of children's responses to question 5 (*Have you heard about ice melting? What happens there?*) before (left) and after (right) the intervention (the authors' own elaboration)

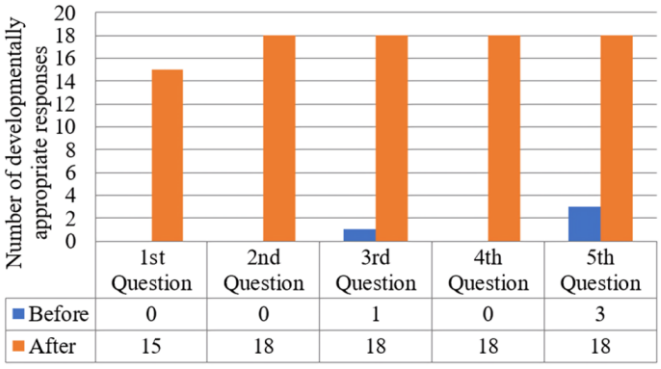

Figure 11. Number of responses reflecting developmentally appropriate understanding before and after the intervention across the five interview questions (the authors' own elaboration)

that the children were beginning to connect climate change with visible consequences such as rising temperatures, melting ice, and flooding, while also identifying practical actions such as recycling, reducing car use, and choosing alternative means of transport. One child stated, *"The ice breaks ... we flood ... and it gets very hot ... we shouldn't use many cars ... we should use electric cars ... walk ... use bicycles ... skateboards ... have wind turbines to produce electricity."* Another said, *"Some animals might be on the ice and then fall into the sea if the ice melts ... there might be sea water entering the houses ... floods when the waves come ... we should install wind turbines, not leave the lights on ... we should use bicycles ... we can use trucks ... and school buses."*

Question 5. Have You Heard About Ice Melting? What Happens There?

Before the intervention, the children's responses reflected limited and mainly everyday understandings of ice melting. In the pre-intervention word cloud, words such as "know," "don't," "there," "ice," "cold," and "yes" were most prominent (**Figure 10**). Although some children recognized that ice melts, their responses were usually linked to familiar daily experiences rather than to environmental change. For example, one child answered, *"Let me think ... a hairdryer,"* while another said, *"No ... I don't know."*

After the intervention, the children's responses showed clearer links between ice melting, rising temperatures, and environmental consequences. In the post-intervention word cloud, words such as "melts," "ice," "earth," "polar," "bear," "temperature," "hot," "sun," "rises," and "disappears" became more prominent. One child stated, *"There is climate change... the ice melts ... the water level rises."* Another explained, *"The ice melts ... with the sun ... and if the earth gets sick ... it will get very hot ... the polar bears and penguins disappear ... because there is too much sun ... the ice melts ... and from the rising temperature of the earth."* These responses suggest an emerging age-appropriate understanding of the relationship between warming, melting ice, and effects on animals and sea levels.

Developmentally Appropriate Understanding Before and After the Intervention

Figure 11 presents a descriptive summary of the number of responses reflecting developmentally appropriate understanding across the five interview questions before and after the intervention. Before the intervention, such responses were minimal across most questions, indicating that the children initially had limited familiarity with climate change concepts and related environmental processes. In contrast, after the intervention, the number of responses reflecting age-appropriate understanding increased substantially across all five questions, with most children demonstrating greater conceptual specificity and stronger links between human actions and environmental outcomes.

This descriptive pattern is consistent with the qualitative findings presented above. Overall, the post-intervention responses were more relevant to the questions, more environmentally grounded, and more clearly connected to the main themes addressed during the educational program.

Parent Observations

To explore whether the children's engagement with environmental issues extended beyond the classroom, both student responses and parental observations were examined. As a supplementary post-intervention prompt used for comparison with parental observations, children were also asked, *"What actions will you take from now on to protect the earth from overheating?"* and parents were asked, *"Have you noticed increased interest from your child regarding the impacts of climate change (melting ice, extreme weather events, global warming)?"* **Table 3** presents the paired student and parent responses.

The children's responses indicate that many were able to name practical everyday actions such as recycling, turning off unnecessary lights, using bicycles, avoiding littering, and reducing car use. Examples include: *"I will recycle and use fewer cars," "I'll turn off unnecessary lights,"* and *"Ride a bicycle and avoid polluting the sea and forests."* These responses suggest that the intervention supported the expression of simple and concrete forms of environmental responsibility.

The parent reports offer additional descriptive support for this pattern. Many parents noted increased interest, curiosity, or discussion at home regarding melting ice, endangered animals, rising temperatures, pollution, and global warming. In some cases, parents also described further engagement through drawing or attention to environmental messages in the media. For example, one parent reported that the child had created drawings at home showing the earth's thermometer

Table 3. Summary of student responses and parental observations

Student	Student's response	Parent's observation
1	I will walk to school.	Mentioned only the existence of climate change.
2	I'll use an electric car and a bicycle and do many things not to pollute the earth.	Did not understand.
3	I will recycle and use fewer cars.	Yes; mentioned ice melting and animals at risk.
4	I will recycle and ride my bicycle.	No.
5	I will use a bicycle, take fewer things, and install wind turbines.	Did not mention anything.
6	I'll be careful, won't cut trees or throw garbage.	Yes; mentioned penguins endangered by melting ice.
7	I'll use fewer cars, install wind turbines, avoid polluting seas, and not cut trees.	Yes; referred to animals losing their families due to ice melting.
8	I'll turn off unnecessary lights.	Explained global warming and impacts on polar animals.
9	I'll recycle, walk, or use electric cars.	Yes; said earth is "sick" and ice is melting.
10	I'll recycle, use wind turbines, and buy fewer toys.	Yes; described rising temperatures and potential flooding.
11	I'll walk, bike, or use a scooter instead of cars.	No.
12	I will use wind turbines, bicycles, and electric cars.	Mentioned melting ice and polar bears dying.
13	Bicycle riding, skateboarding, and using electric cars.	Mentioned melting ice, global warming, and tree cutting.
14	Use bicycles and recycle to prevent pollution.	No.
15	Recycle and not cut down trees.	Only mentioned ice melting.
16	Avoid littering and ride a bicycle.	Yes; began watching relevant television advertisements.
17	Use fewer cars and recycle.	Mentioned melting ice, rising temperatures, and tree cutting.
18	Ride a bicycle and avoid polluting the sea and forests.	Yes; created drawings at home showing earth's thermometer and melting ice.

and melting ice, while another noted that the child had started paying attention to relevant television advertisements.

Not all parents reported clear post-intervention changes, and these observations should be interpreted cautiously. Nevertheless, the parent reports suggest that, for many children, the classroom experience continued beyond school through conversations, expressions, and everyday environmental references in the home setting.

DISCUSSION

The findings of this study suggest that an experiential, play-based educational intervention can support preschool children's environmental awareness and emerging understanding of climate change when the topic is introduced in developmentally appropriate ways. Following the intervention, the children's responses became more specific, more environmentally grounded, and more closely connected to human activity, environmental consequences, and simple forms of action. This pattern is consistent with previous research showing that young children can engage meaningfully with environmental issues when these are approached through concrete and participatory learning experiences (Borg et al., 2019; Liu & Green, 2024; Mliless et al., 2024; Spiteri, 2022, 2023b). It also aligns with more recent studies suggesting that preschool children can express early forms of ecological awareness, care, and responsibility when environmental content is made accessible to their developmental level (Mousavi et al., 2024; Sihvonen et al., 2024).

An important strength of the present study is that it clarifies the connection between the experiential and play-based framework and the actual design of the intervention. In the present case, climate-related ideas were not introduced through abstract explanation alone. Instead, they were approached through educational videos, guided discussions, collaborative group projects, hands-on experiments and demonstrations, artistic representations, and recycling and renewable energy activities. These components reflect key principles of experiential and play-based learning because they engage children through observation, participation, dialogue, symbolic expression, and practical action. This interpretation is consistent with scholarship arguing that early childhood environmental education is most effective when learning is grounded in concrete, relational, and participatory pedagogies rather than in the transmission of abstract information (Barratt Hacking et al., 2007; Cutter-Mackenzie & Edwards, 2013; Edwards et al., 2014). It also agrees with more recent work emphasizing the importance of children's agency, play, and participation in sustainability-oriented early childhood education (Kahriman-Pamuk & Borg, 2024).

The findings also resonate with research on early climate cognition. Before the intervention, many children responded with uncertainty, imaginative associations, or everyday meanings of the word *change*. After the intervention, they more often linked climate change to cars, factories, pollution, heat, melting ice, and floods. Even so, their understandings remained simplified and strongly tied to visible and familiar examples. This pattern is developmentally plausible. Preschool-aged children typically reason through immediate, concrete, and sensory experiences rather than abstract systems or long-term causal chains (Fleer & Hedegaard, 2010; Piaget, 1952). For this reason, the value of early climate education should not be judged by whether children achieve complete scientific understanding. Rather, it should be understood as fostering developmentally appropriate forms of awareness, emerging causal reasoning, and emotional connection to environmental issues (Brush et al., 2022; Nusche et al., 2024; Saracho, 2023; Trott, 2020).

The study also suggests that the effects of such learning may extend beyond the classroom. Many parents reported that their children discussed melting ice, endangered animals, pollution, or global warming at home. Some also described

related drawings or references to environmental messages in the media. Although these reports are limited and subjective, they are consistent with earlier research suggesting that young children can influence family conversations and practices around environmental issues (Ebrahim, 2011; von Braun, 2017). More recent reviews likewise emphasize that children can act as agents of change within their households and communities when environmental learning becomes meaningful to them (Hosany et al., 2022; Séraphin, 2022; Sorbring & Kuczynski, 2018). The parent reports in the present study therefore provide preliminary support for the idea that early childhood environmental education may have a relational reach beyond school, even if such influence should not be overstated.

At the same time, the findings should be interpreted cautiously. The post-interviews were conducted immediately after the intervention, when the children's memory of the activities was still fresh. This means that the study primarily captures short-term responses rather than stable conceptual development. The findings therefore indicate immediate post-intervention shifts in children's talk and understanding, but they do not demonstrate long-term retention. This limitation is important because early changes in vocabulary or explanation do not necessarily translate into stable knowledge or sustained behavior over time. Previous research suggests that repeated and sustained experiences are important for shaping longer-term pro-environmental orientations (Spiteri, 2020; Tucker & Izadpanahi, 2017; Yan et al., 2025; Zsóka et al., 2013). Liefländer and Bogner (2014) further showed that younger children may be especially responsive to environmental programs, which strengthens the rationale for early intervention, but also highlights the need for continuity rather than one-off exposure.

Another important issue concerns the emotional dimension of climate education. The broader literature has shown that climate-related topics may evoke fear, confusion, or eco-anxiety, especially if they are presented in alarming ways (Burke et al., 2018; Hickman et al., 2021; Ojala, 2012, 2016; Pihkala, 2020). In the present study, the intervention was designed to encourage constructive engagement by emphasizing participation, discussion, concrete examples, and simple actions rather than fear-based messaging. However, children's emotional responses, sense of agency, and possible anxiety were not examined systematically as distinct analytical categories. For this reason, the present study cannot make strong claims about the emotional effects of the intervention. What it can suggest is that an action-oriented and supportive pedagogical approach may offer a productive direction for early climate education, one that helps children engage without being overwhelmed.

A related issue concerns scientific misconceptions. The intervention appeared to help children connect climate change with pollution, heat, melting ice, and human responsibility, but it did not examine in depth how specific misconceptions emerged, changed, or persisted. This is especially relevant in climate education, where simplified explanations, although developmentally necessary, may also lead children to form incomplete or inaccurate models of climate-related processes. The present study therefore contributes more to understanding how young children begin to talk about climate change than to demonstrating mastery of climate science. Future research would benefit from examining how age-appropriate climate science content can be introduced more systematically in order to support understanding while reducing oversimplification or misunderstanding.

Taken together, the findings support a modest but important conclusion: climate change education in the preschool years is feasible and pedagogically meaningful when it is framed through experiential and play-based learning. The study does not suggest that young children can fully grasp the complexity of climate change. Rather, it suggests that they can begin to develop developmentally appropriate understandings of environmental change, human responsibility, and simple mitigation practices. In this sense, the study contributes not only practical evidence from an applied intervention, but also a clearer illustration of how experiential and play-based principles can be translated into climate-related educational practice in early childhood settings.

CONCLUSIONS

This study indicates that climate change and environmental education can be introduced meaningfully in preschool through an experiential, play-based intervention. The findings suggest that children aged 4-6 years can develop more developmentally appropriate understandings of climate-related ideas, including human responsibility, selected environmental impacts, and simple everyday responses, when learning is grounded in concrete, participatory, and age-appropriate activities.

A second key conclusion concerns pedagogical value. In this study, educational videos, guided discussions, collaborative group projects, hands-on experiments and demonstrations, artistic representations, and recycling and renewable energy activities appeared to help make abstract environmental ideas more visible, tangible, and meaningful for young children. This suggests that the value of early climate education lies not only in *what* is taught, but also in *how* it is taught.

At the same time, the study remains exploratory. It points to the feasibility of early childhood climate education and to the potential of experiential pedagogy, but it also highlights the need for further research on long-term learning, emotional responses, and the development of more structured age-appropriate climate science content.

Limitations

Several limitations should be acknowledged. First, the study involved a small convenience sample of 18 children from a single public kindergarten in Greece. The findings are therefore context-specific and cannot be generalized beyond this setting without caution. The sociocultural and educational characteristics of this particular context may have influenced both the intervention process and the children's responses.

Second, the study relied primarily on qualitative data, including child interviews and parental observations. These methods were appropriate for the age of the participants and the exploratory aims of the study, but they also involve

interpretive challenges. Young children's verbal expressions are often brief, symbolic, or context-dependent, which increases the possibility of researcher over-interpretation. In addition, the parental observations offered useful complementary insight, but they were subjective and were not based on a standardized instrument.

Third, the post-interviews were conducted immediately after the intervention. As a result, the study captures short-term post-intervention responses rather than long-term conceptual retention or sustained behavioral change. It therefore remains unclear whether the observed changes would persist over time.

Fourth, formal inter-rater reliability was not calculated. Although the inductive qualitative content analysis was conducted systematically and reflexively, the interpretation of the data may still have been influenced by researcher assumptions and analytic decisions.

Finally, some important dimensions were beyond the scope of the study. The research did not examine children's emotional responses, climate-related anxiety, or sense of agency in a systematic way. Nor did it investigate in depth how specific scientific misconceptions were reduced, maintained, or transformed through the intervention.

Recommendations and Future Research

The findings suggest that environmental and climate education can be meaningfully incorporated into early childhood settings when content is presented through concrete, participatory, and developmentally appropriate pedagogy. In practice, this means that preschool educators may be better supported by approaches that combine visual materials, guided discussion, collaborative creation, hands-on experimentation, artistic expression, and practical sustainability activities rather than abstract explanation alone. Early climate education should aim to foster foundational awareness, care, and simple forms of action while remaining sensitive to children's developmental stage.

At the policy level, the study supports the inclusion of environmental and climate-related learning within early childhood curricula as an integrated and developmentally appropriate area rather than as an occasional or isolated topic. This also implies a need for stronger support for early childhood educators through professional development, pedagogical resources, and curriculum guidance that help them address climate-related issues with confidence and sensitivity.

Future research should build on the present study in several ways. First, larger studies across multiple preschool settings are needed to examine whether similar patterns emerge in different educational and cultural contexts. Second, longitudinal research is especially important in order to explore whether the changes observed immediately after the intervention are sustained over time. Third, future studies should investigate more directly how early climate education can support children's sense of agency while avoiding fear or emotional burden. Finally, more research is needed on how age-appropriate climate science content can be designed to reduce misconceptions and support progressively richer understanding in the early years.

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Ethical statement: The authors stated that ethical approval was obtained by institutional and national guidelines for research involving human participants. Prior to the start of the study, written informed consent was obtained from all parents or legal guardians of the participating children. In addition, verbal assent was obtained from the children, and participation was entirely voluntary. Children were informed that they could stop participating at any time without consequence. All data were collected and analyzed with strict attention to confidentiality and protecting participants' rights.

AI statement: The authors declared that AI-based tools were used exclusively for linguistic revision and stylistic refinement. The literature selection, critical synthesis, interpretation, and all conclusions are solely the authors' responsibility.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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