International Journal of Early Childhood Environmental Education

ISSN: 2331-0464 (online)

Climate Superheroes: Impact of a STEAM Camp on Preschool Children's Ideas about Climate-Friendly Actions

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Submitted February 20, 2025; Accepted September 4, 2025

ABSTRACT

Climate change is an urgent global environmental crisis that requires widespread action and an educated, motivated citizenry. This study explored the impacts of a Climate Superheroes STEAM camp on preschool children's ideas about climate-friendly actions. The research employed a mixed methods experimental design approach including a quantitative pre/post-test, qualitative activity prompts, field notes, and a post-camp parent survey. The sample included 27 children aged 3 to 6 years and 11 of their parents. Preschool children made significant gains on their understanding of climate-friendly actions, using reusable materials, turning off lights when not in use, and gardening. Children demonstrated many correct ideas about how and why climate-friendly actions helped the Earth and some common misconceptions as well. Children gained knowledge of accessible climate actions, and qualitative results show some increase in agency for taking climate action. Implications for early childhood education and environmental education related to climate change are explored.

Keywords**:** climate change, climate change education, early childhood education, informal education, early childhood environmental education

Anthropogenic climate change is an urgent environmental concern occurring on a global scale (Intergovernmental Panel on Climate Change [IPCC], 2022). The extensive impacts of climate change affect ecosystems, humans, society, and infrastructure (IPCC, 2022). Climate extremes have already caused extensive global damage and some irreversible impacts. Climate vulnerability is not uniform across the Earth but can significantly differ between regions. Collective actions that limit global warming to 1.5 degrees Celsius would largely reduce future impacts and losses (IPCC, 2022). Hence, education that includes mitigation and adaptation actions is essential (Krasny & DuBois, 2016; Stevenson et al., 2017). Students must become engaged citizens who are willing to take collective actions to reduce fossil fuel use and practice sustainable policies (Stevenson et al., 2017). Finally, climate change education should begin in the early years so students can develop a deep understanding of climate change (Boylan, 2008), and become empowered to take action (Gambino et al., 2009).

Young Children and Climate Change Education

Environmental literacy is the ability to make and act on informed environmental decisions, and it requires environmental knowledge, dispositions, skills, and behavioral strategies (Hollweg et al., 2011). Environmental educators have postulated that environmental literacy is achieved by moving up the environmental literacy ladder, a model with increasingly complex environmental literacy components such as awareness, knowledge, attitudes, skills, and eventually action (Elder, 2003). Elliott and Davis (2009) assert that educators must not underestimate

young children by assuming that they have too little science content knowledge to understand climate change or should be sheltered from this worrisome topic. In fact, climate change instruction can and should be addressed in early childhood for several reasons. First, young children have demonstrated their sophisticated reasoning about environmental problems (Palmer & Suggate, 2004) and pro-environmental solutions (Kos et al., 2016). Second, when environmental issues are taught in grade-appropriate ways, young children feel empowered to be a part of environmental solutions (Gambino et al., 2009). Third, compared to adults, young children are going to be both more impacted by climate change consequences and required to take adaptation actions (Hahn, 2021). Thus, young children's climate literacy, a component of environmental literacy, is particularly important. Fourth, compared to adolescents, young children have more pro-environmental attitudes (Otto et al., 2019) and willingness to take action (Lee et al., 2020) and are thus potentially more receptive to climate instruction (Lieflander & Bogner, 2014).

Elementary children have some understanding of climate change. When asked about the impacts of climate change on polar creatures, very young (four-year-old) children provided only short-term effects, but 90% of ten-year-olds offered reasonable long-term effects (Palmer & Suggate, 2004). In fact, in a review of youth perceptions of climate change, most children accurately understand climate change impacts as including rising temperatures, melting ice caps, and ecosystem changes (Lee et al., 2020). Children recognize that climate change results from human activities but hold common misconceptions about the causes including pollution, a hole in the ozone layer, the sun getting nearer to the Earth, and seasonal change (Lee et al., 2020; Palmer & Suggate, 2004). Previous research has indicated that preschool children do not necessarily understand language related to sustainability (Engdahl & Rabusicova, 2011; Honig & Mennerich, 2013) but do have knowledge about the environment and views about humans' responsibilities toward the environment (Engdahl & Rabusicova, 2011). Preschool children have some understanding of recycling (Honig & Mennerich, 2013), plant and animal interactions (Madden & Liang, 2017), and flora and fauna (Fraijo-Sing et al., 2020). Indeed, a primary grades curriculum in Greece accomplished climate change education for sustainable development by addressing topics such as food, water, education, health, gender equality, and a clean environment as basic needs and human rights (Gkotzos, 2017).

Interventions that include direct engaging experiences that emphasize the impact of human activities on the environment show the most promise for increasing children's understandings of the natural world (McClain & Vandermaas-Peeler, 2016; Kos et al., 2016). Children ranging from ages 4 to 6 have improved environmental knowledge (Gambino et al., 2009), environmental attitudes (Gambino et al., 2009; Samur, 2018), and an awareness of how they as humans influence the environment (Kos et al., 2016; Samur, 2018). Furthermore, elementary-level interventions may find a particularly receptive audience given that children's environmental attitudes begin to form around 7, increase until 10, plateau until 14, and then decrease until adulthood (Otto et al., 2019) and that age is a negative predictor of pro-environmental behaviors from children ranging in age from 6 to 12 (Collado et al., 2015).

As children become aware of climate change, they experience many emotions. In a survey of Australian parents and teachers, even young children reported feeling low to moderate stress about climate change (Baker et al., 2021). When asked how climate change makes them feel, Canadian children aged 8 to 12 most frequently described sadness, followed by anger, fear, and stress (Leger-Goodes et al., 2023). These children's sadness centered on the suffering of humans and other animals, demonstrating a strong empathy toward animals (Leger-Goodes et al., 2023). In a study of nine- and ten-year-old children from England engaged in climate change education, children experienced anger, sadness, and helplessness (Jones & Whitehouse, 2021). These children demonstrated more hope during an activity focused on who or what could help those impacted by climate change (Jones & Whitehouse, 2021).

Ojala (2012) identified coping strategies that young people employ to deal with climate worry: problem-focused strategies that entail taking individual or collective action; emotion-focused strategies that may involve de-emphasizing the threat of climate change, distancing, seeking social support, and hyperactivation; and meaning-focused coping that includes reframing climate change positively, employing general positive thinking, and putting trust in other sources. In studies of younger children, children mostly employ emotion-focused coping (distancing), problem-focused coping (individual action), and meaning-focused coping (trusting others) (Leger-Goodes et al., 2023; Ojala, 2012).

In reviews of research about climate change education in Turkey and Korea, researchers are finding that most studies investigate children's awareness, knowledge, and attitudes without an explicit attention to eco-friendly behaviors (Ozturk, 2023; Park et al., 2020), essentially never reaching the top rungs of the environmental literacy ladder (Elder, 2003). Furthermore, when expert environmental educators from around the world were asked about their students, most teachers expressed that their environmental education instruction did not include pro-environmental actions (Huoponen, 2023). Yet, given the urgency of climate change, many primary and secondary teachers in England sought action-oriented climate change instruction (Howard-Jones et al., 2021). These educators indicated that action-oriented climate instruction for primary school grades should include mitigation projects like conservation, tree-planting, and family advocacy (Howard-Jones et al., 2021). This form of climate action instruction, combined with efforts to promote climate awareness, knowledge, and attitudes, is essential for achieving environmental and climate literacy (Elder, 2003).

Given this prior research, the current study seeks to advance this literature by examining children's pro-environmental behaviors at a younger age in the context of a climate change STEAM camp that employs several research-based methods including: (1) direct experience, (2) opportunities to investigate human impacts on the environment, and (3) opportunities to investigate the impacts of pro-environmental actions. This study was guided by the following research questions:

(1) What are preschool children's ideas/feelings about climate change and climate-friendly actions?
(2) To what extent can preschool children explain reasons for climate-friendly actions?
(3) How do preschool children's ideas of climate-friendly actions change following an action-orientated climate change camp?
(4) Following an action-oriented climate change camp, what actions do preschool children tell their parents about?

METHODS

This study used a mixed methods case study approach (Creswell & Plano Clark, 2018) that included semi-structured qualitative protocols for student work, open-ended questions from a parent/guardian survey, a quantitative pre-/post-assessment of children's ideas of climate-friendly actions, and a quantitative parent/guardian survey of climate actions mentioned by children and performed at home. The Kent State University Institutional Review Board approved this research project (IRB #815).

Intervention

This camp was designed based on environmental education literature about theories of pro-environmental behavior and environmental topics and activities that have been successfully used with young children. The intervention was guided by the value-belief norm theory (Stern et al., 2000). The value-belief norm theory (Stern et al., 2000) posits that one's value orientations (egoistic, altruistic, and biospheric) influence one's beliefs including their ecological worldview, awareness of adverse consequences of their behavior for the environment, and their beliefs about their ability to reduce threats to the environment. These beliefs shape one's moral obligation for pro-environmental behavior and ultimately their personal norms. These pro-environmental behaviors may take the form of activism, nonactivist public-sphere actions, private-sphere actions, and behavior in organizations. The camp was also built around a problem-focused coping strategy (Ojala, 2012) for coping with climate anxiety. This strategy emphasizes learning more about climate change and climate-friendly actions and actually engaging in those actions mitigate worry about climate change (Ojala, 2012). Specific topics for this camp were selected because previous literature showed promise for young learners engaging with this content. This content centered around human actions that contribute to climate change and human actions that can help mitigate climate change. For example, Gkotzos (2017) identified the topics of food and water as appropriate contexts for teaching primary grades students about sustainability, and Honig & Mennerich (2013) found that preschool children can understand recycling. The camp also employed the tooth-brushing water conservation experiment utilized successfully by Kos et al. (2016). The camp did not address scientific mechanisms that explain climate change but did address common misconceptions about

climate change from the literature including how climate change is different than pollution and seasonal change (Lee et al., 2020; Palmer & Suggate, 2004).

The week-long "Climate Superheroes" intervention was part of a larger 10-week STEAM summer camp for children aged three through six. The camp targeted 10 climate-friendly actions (Table 1). The authors planned the instructional activities, worked with the lead teachers in the Older and Younger classrooms to lead the activities, and observed each of the five instructional days. The Day 1 children's book, *Coco's Fire* by Jeremy D. Wortzel & Lena K. Champlin, served as a foundational text for the camp. In the story, a squirrel named Coco learns about climate change using an analogy of the Earth being overly warmed by putting blankets around it, and these blankets were the result of various human activities. In the story, Coco experiences climate anxiety, talks to her parent and other experts, and learns to cope with climate anxiety by doing various individual and collective climate actions. The first author and children referred back to this story and these blankets several times throughout the week.

During the weeklong intervention, children were guided through several investigations highlighting climate-friendly actions (Table 1). The overall goal of the camp was to empower children to take climate actions, and the concept of superheroes was presented as a means by which children could exert agency in the face of environmental challenges. As an embodiment of this superhero concept, children were given fleece capes and earned a badge each day that was affixed to their capes. Children earned badges for saving energy, saving water, reducing/reusing/recycling, and saving food. Each day opened with a morning meeting during which the first author introduced the day's superhero badge, described and discussed the importance of that climate action and some of the ways "we" could be superheroes in that regard, and included a climate change and/or pro-environmental action children's book that the first author read. During the book reading, the first author sought to solicit children's ideas about climate change and the climate actions featured for the day's badge. At the end of the morning meeting, the authors described the various choice activities (Table 1) that children could do for the remaining hour. Then, children freely chose between three and five options, at least two of which were staffed by the first and second authors.

Table 1. Summary of Intervention

Day	Theme	Targeted Actions	Activities
1	Energy	● Turn off lights/ appliances ● Walk/bike/ride bus ● *Use solar, wind energy*	Superhero cape construction, green city diorama, windmill craft, lights out signs
2	Water	● Turn off water when brushing teeth, bath etc. ● *Collect rainwater for re-use*	Superhero masks, toothbrush water experiment, rain gauge construction, cloud water conservation craft
3	Materials	● Recycle items ● Reuse water bottles, bags, & clothes ● Reduce: Buy less, use old	Windsock craft, decorate reusable bags, ocean clean-up recycling sort
4	Food	● Earth-friendly food choices ● Garden ● Reduce food waste & compost	Climate-friendly picnic, compost bin exploration, decorate herb pots and plant
5	Collective Action	● Work with others to improve the climate	Climate signs, bird feeder construction, polar bear animal habitat, Earth Sun catcher

Note. Italicized actions did not appear on the 10-item pre/post-test.

Sample

The sample of participants was drawn from 3- to 6-year-olds attending this week-long "Climate Superheroes" camp. Children's parents/guardians were given the recruitment letter and consent form at the beginning of camp and invited to participate in the study. In total, 27 children (14 in the Older Class and 13 in the Younger Class) had parental/guardian consent to participate in the study. Because the project also included a post-camp Parent/Guardian Survey inquiring about children's experiences and what they learned from the camp, the

parents/guardians are adult members of the study sample as well. In total, 11 parents/guardians responded to the parent survey. These parents' children included one 3-year-old, six 4-year-olds, three 5-year-olds, and one 6-year-old.

Data Sources

The data sources included researcher field notes, collected student work including a pre/post-test, and a post-camp parent/guardian survey described below:

- **Researcher field notes of classroom observations.** Field notes were taken by the second author following guidelines from Bogdan and Biklen (2007). Field notes were recorded on a laptop each of the five days during carpet time when the first author was introducing the theme of the day, reading a new science picture book, and asking the children follow-up questions. The descriptive field notes included what the researcher heard, saw, and experienced while observing both preschool classrooms.
- **Pre-/Post-test.** On Day 1 and Day 5, children worked with a teacher in small groups to provide responses on a pre- and post-test. This test asked children to make dichotomous choices about which of two pictured activities were better for the Earth. The pre-test was piloted with a 3-year-old not involved in the study to determine if the pre-test items were sensible. Based on this initial feedback, two images were modified (by adding carrots on a plate and worms in the compost) to better clarify these actions.
- **Collected student work.** Children had free choice to rotate to various activity tables. At most of the tables, a researcher helped the child with the investigation and recorded children's ideas to various pre-planned questions associated with the activities. Because of the free choice, not all children participated in each assessment task. Table 2 shows the number of participants in each activity for both classes.

Table 2. Data Sources

Day	Assessment Task	N	Actions
1	10-item Pre-test	25	All 10
1	Green City Diorama	9	Renewable energy, biking, riding a bus
1	Windmill Craft	10	Renewable energy, pro-environmental actions
1	Lights Out Sign	8	Turning off lights, energy conservation
2	Toothbrush Water Experiment	7	Turning off water
2	Rain Gauge Making	16	Water conservation
2	Water Conservation	7	Home water conservation
3	Reusable Bags	13	Feelings about warming earth, taking action
3	Windsock Craft	12	Reusing
3	Ocean Clean-up	8	Recycling, Reducing
4	Earth-Friendly Picnic	12	Earth-friendly foods
4	Compost Exploration	6	Composting
5	Bird Feeder	13	Actions for helping animals
5	Polar Bear Habitats	11	Actions for helping animals impacted by climate
5	Earth Sun Catcher	13	Feelings about warming earth, taking action
5	10-item Post-test	24	All 10

- **Post-camp Qualtrics Parent/Guardian Survey.** This online survey was developed to understand what pro-environmental actions the child mentioned during the camp. Because re-using is closely linked to reducing, these two actions were combined in the parent survey. The Qualtrics survey was sent at the conclusion of the camp and consisted of four sections covering:
    - Nine items asking how often their child mentioned the nine targeted actions in the past week

- Two open-ended questions asking parents/guardians to explain what children talked about and any actions they took in connection to the camp and any additional comments about their child's experience with the camp

Data Analysis

Data analysis first entailed scoring participants pre- and post-tests for consistency with instruction for the 10 actions. First, descriptive statistics were used to characterize the pre/post scores and test assumptions of normality. The Kolmogorov-Smirnov test revealed that the pretest scores were normal, but the posttest scores were not (skewed toward maximum score). Consequently, a non-parametric related-samples Wilcoxon signed rank test was used to test the null hypothesis that there is no difference between pre- and post- scores. To characterize children's ideas about climate-friendly actions expressed to their parents, we conducted a descriptive statistics analysis of the parent/guardian survey.

Qualitative analysis of researcher table work, explanations provided during the pre- and post-tests, field notes, and open-ended parent survey data were analyzed using first-cycle descriptive coding (Saldana, 2021) to characterize children's ideas about climate change and climate-friendly actions and reasoning about climate-friendly actions. Both authors independently open-coded a set of children's qualitative responses, met to discuss the open codes, and developed and characterized three broad codes (correct ideas, misconceptions, and reasons). The authors independently coded the remainder of the transcripts and met to discuss and achieve consensus on those three broad codes. Then, based on this discussion, preliminary subcodes for the three broad codes were developed. The authors then independently coded the transcripts for these subcodes and again met to discuss and achieve consensus. These subcodes, their descriptions, exemplars, and frequencies are presented in Tables 3, 4, and 5. Second-cycle pattern coding (Saldana, 2021) was then used to interconnect descriptive codes in order to develop assertions about how young children learn about climate-friendly actions.

Results

The quantitative and qualitative findings are integrated in the sections below to answer each research question.

RQ1: Children's Ideas and Feelings about Climate Change and Climate-Friendly Actions

Throughout the daily activities, children shared many ideas about climate-friendly actions that were consistent with instruction. Table 3 highlights the most common correct conceptions about climate change and climate actions. The most commonly articulated correct conception about climate-friendly actions was the need to help animals in species-appropriate ways such as protecting animal habitats. In the Day 4 morning meeting (Field Notes), children explained why we should re-use items. One child (C6, age 5) explained, "don't throw plastic into the ocean because it hurts the fish." Another child suggested reusing a balloon because "something might eat it" (C3, age 6). Several children recognized fossil fuel-reduction actions and actions to save energy. For example, C6 (age 5) said, "I helped the Earth by riding my bike. I don't want it to have any more blankets" (Green City Activity). Similarly, C18 (age 4) explained how turning off lights when not in use helped the Earth because leaving lights on "wastes energy" (Turn Off Lights Activity).

Some children demonstrated misconceptions about climate-friendly actions as shown in Table 4. A common misconception was that any action that made an individual healthy was also helpful for the Earth. For example, C9 (age 4) suggested that eating "apples" would be good for the Earth "because they are good for you" (Picnic Activity). Similarly, during the morning meeting on Day 4, a child said, "burgers are better because they have meat," suggesting that meat is healthy for one's body (Field Notes, Day 4). Children also demonstrated another misconception: humans can help all wild animals by feeding them. For example, when asked how humans can help animals affected by climate change during a bird feeder activity, C22 (age 4) said "feed every animal" (Bird Feeder Activity). C21 (age 5) also conveyed this misconception (age 5) by suggesting "we could care for the polar bears and give them food" in order to help an animal endangered by climate change (Polar Bear Habitat).

Table 3. Correct Conceptions about Climate Change and Climate Friendly Action

Sub-code	Description	Exemplar	Frequency N=170
Animals	Help animals in species-appropriate ways in terms of providing/protecting food/habitat	"Help them, make them a home" (C36, age 4, Polar Bear Habitat Day 5)	22.4%
Water	Turn off water when not in use; Collect rainwater	"Turn off water when done washing hands" (C12, age 6, Cloud Day 2)	21.2%
Energy	Turn off lights/appliances; Walk/bike/ride bus; Use solar or wind energy	"Wind makes you have power because it has energy. We need wind energy to help us." (C8, age 4, Windmill Day 1)	18.2%
Food	Make Earth-friendly food choices; Grow own food; Reduce food waste and compost	"They're going to turn into dirt" (C18, age 4, Compost Day 4)	16.5%
Reduce/Reuse/ Recycle	Recycle items; Reuse water bottles, bags, & clothes; Reduce by buying/consuming less	"Reuse- so we can make something else" (C19, age 5, Windsock Day 3)	15.3%
Can Help	General indication that we can help the Earth and/or climate change without more elaboration	(Asked if there are things they can do to help our warming Earth) "Yes" (C28, age 3, Reusable Day 3)	5.3%
Together	Help make changes together	"Help with friends" (C7, age 5, Post 1)	1.2%

Table 4. Children's Misconceptions about Climate Change and Climate-Friendly Actions

Sub-code	Description	Exemplar	Frequency N=49
Irrelevant	Provides a response that is disconnected from the question	"Strawberry the size of a watermelon" (C38, age 3, Picnic Day 4)	32.7%
Human Health	Anything that makes me/humans healthy is good for the Earth	"Carrot because everyone needs to be strong" (C36, age 4, Picnic Day 4)	20.4%
Help the Earth	Suggests that any pro-environmental action is also a climate-friendly action	"Yes - something when I eat and my bag is empty it goes in the trash" (C27, age 4, Windsock Day 3)	14.3%
Using Resources	Suggests that using a resource is somehow saving it or helping the Earth in some way.	(Asked what they can do to help save water) "We could drink water. I love water" (C27, age 4, Rain Collector Day 2)	14.3%
Feed Animals	Suggests feeding wild animals that should not be fed as helping the Earth	"Fox/bear - get a string and put food for them" (C5, age 5, Birdfeeder Day 5)	8.2%
Wind is Helpful	Suggests that wind is helpful for breathing (not related to energy generation)	(Asked if wind energy is good for the Earth) "Yes because it helps give the	6.1%

		Earth more air" (C13, age 4, Windmill Day 1)	
Can't Help	Indicates that people cannot help the warming Earth	(Asked if there are things they can do to help our warming Earth) "Not that much" (C7, age 5, Reusable Day 3)	4.1%

Children were asked on Day 3 and Day 5 to express how they feel about our Earth getting warmer. On Day 3, three children responded, "I don't know", three indicated anger (e.g., C34 (age 3), "so so angry"), and the majority (n=8) indicated sadness (e.g., C5 (age 5), "bad and sad.") By Day 5, twelve children indicated sadness, three children indicated anger, and two children indicated a desire for action. As examples, C5 (age 5), said, "bad but we can fix it."

RQ2: Children's Reasoning about Climate-Friendly Actions

Qualitative data were analyzed from 27 preschool children to explain their reasons for taking climate-friendly actions. Table 5 shows the six reasons that emerged for why children choose to take climate-friendly actions. Children frequently mentioned conserving resources and helping humans or animals as reasons for taking climate-friendly actions. Regarding conserving resources, children discussed saving water, electricity, and materials. For instance, when asked, "Do you think it is better to reuse these materials or throw them away? Why?" C19 (age 5) answered, "Reuse, so we can make something new" (Windsock Activity). Regarding helping humans or animals, children discussed making healthy choices for themselves and making choices to help animals. For example, when asked, "What food is good for the Earth? Why?" C22 (age 4) explained, "Carrots, because it keeps everyone healthy" (Picnic Activity). Least often, children discussed reasons related to combating global climate change. C6 (age 5) shared that they do not want Earth to "have any more blankets." This statement was made after reading the children's book *Coco's Fire*, in which the book explains climate change to children by comparing the warming of the Earth to adding blankets around the Earth.

Table 5. Children's Reasons for Climate-Friendly Actions

Sub-code	Description	Exemplars	Frequency N = 82
Conserve Resources	References conservation of resources including energy, water, food, etc.	"Turn off the lights so they don't run out of battery" (C5, age 5, Reusable Day 3)	35.9%
Helping People & Animals	References helping animals or humans, the action helps the organism in some way	"So that every animal that lives in the water can stay living there and no pollution" (C17, age 6, Cloud Day 2)	26.8%
General	Explains that the action is good for Earth without much explanation, or the alternative action is bad for Earth	"Helps the Earth" (C19, age 5, Pre-test Day 1)	17.1%
Irrelevant	Child mentions a "because…" that makes no sense	"I got a pink bike" (C34, age 3, Pre-test Day 1)	13.4%
Clean the Earth	Action helps keep the Earth clean or cleans the environment	"Because it is not littering the ground" (C18, age 4, Picnic Day 4)	6.1 %
Adult Influence	References an adult asking them about the action or telling them to do the action	"My mom told me" (C34, age 3, Pre-test Day 1)	2.4 %
Combat Climate Change	Clearly references climate change, earth heating, or adding blankets (Coco's book)	"I don't want it to have any more blankets" (C6, age 5, Green City Day 1)	1.2%

RQ3: Change in Children's Ideas

Table 6 shows the descriptive statistics for the overall pre- and post-tests. Because the post-test scores were skewed toward the maximum score, a non-parametric related sample Wilcoxon Signed Ranks Test was used compare pre/post scores for the 17 students with complete data. This test produced a Z-statistic of -2.347 ($p<0.05$) indicating a significant gain from pre- to post-scores. Table 7 shows that most post-test item scores were quite high (above 63% correct). An examination of the item-level gain statistics (Table 7) reveals that children made the most gains on using re-usable water bottles, turning lights off when not in use, and growing garden vegetables instead of buying them. However, these gain findings must be contextualized given that several pre-test item scores, especially for collective action, eating vegetables instead of meat, and brushing teeth with water off, were quite high and afforded little opportunity to show gains.

Table 6. Descriptive Statistics Comparing Pre/Post Tests

	N	Minimum	Maximum	Mean	S.D.
Pre-Test	25	4	10	6.88	1.69
Post-Test	19	5	10	8.37	1.64

Table 7. Item-Level Gain Statistics

Item	Action	N	Pre Mean	Pre SD	Post Mean	Post SD	Mean Gain	Gain S.D.
5	Using re-usable water bottle	18	0.61	0.50	0.94	0.24	+0.33	0.48
1	Turning lights off	20	0.55	0.51	0.85	0.37	+0.30	0.57
8	Growing garden vegetables	18	0.61	0.50	0.89	0.322	+0.28	0.46
4	Re-using old coats	19	0.42	0.51	0.63	0.50	+0.21	0.63
7	Recycling paper	18	0.67	0.49	0.83	0.38	+0.17	0.38
9	Composting instead of trash	18	0.78	0.43	0.89	0.32	+0.11	0.47
3	Brushing teeth with water off	20	0.85	0.37	0.90	0.31	+0.05	0.39
6	Eating vegetables instead of meat	17	0.88	0.33	0.76	0.44	-0.12	0.33
2	Riding bike instead of car	20	0.75	0.44	0.70	0.47	-0.05	0.60
10	Collective action instead of individual	18	1.00	0	0.83	0.38	-0.17	0.38

RQ4: Children's Ideas about Climate-Friendly Actions from Parents

Survey data from 11 parents were used to determine Earth friendly actions children discuss at home and what actions the family takes. The first section of the survey asked parents to share the frequency in which their child mentions nine actions at home to help our warming Earth. As shown in Table 8, children were most likely to discuss working with others to help the Earth, recycling, and turning off the lights when not in use. Children were least likely to discuss using a refillable water bottle, eating more fruits and vegetables and less meat, and composting food scraps. The second section of the survey asked parents to share the frequency in which their household takes the same nine actions to help our warming Earth. The families were most likely to recycle, use a refillable water bottle, turn off the lights when not in use, and turn off the water when brushing teeth. The families were least likely to ride a bike or walk instead of using a car, grow food in a garden, and compost food scraps.

At the end of the parent survey, parents were asked to share what their child talked about and what actions they took in connection to the camp. These qualitative results help explain how "working with others to help the Earth" was the frequently mentioned action during the week. Multiple parents described how the superheroes camp positioned children as working with fellow superheroes for the climate. The parent of C8 (age 4) quoted her child as

saying, "'Me and 'X' were superheroes today. We're still in training, but we're going to save the world and that's how we help it.'" Similarly, the parent of C22 (age 4) quoted her child as saying 'we "all have to work together to save the earth."' Parents also described how the superhero theme supported their child's agency for climate action. The parent of C16 (age 5) said, "He really loved his cape and badges and I think especially loved feeling empowered to make changes that HE could do without an adult (or without waiting for an adult to take action first)."

Table 8. Frequency of Children's Mentions of Climate Action from Parent Survey

Action	Average	Standard Deviation
Working with others to help the Earth	3.27	1.49
Recycling	2.91	1.14
Turning lights off when not in use	2.45	1.21
Growing food in a garden	2.18	1.17
Riding a bike or walking instead of using a car	2.09	1.20
Turning water off when brushing teeth	2.09	0.94
Using a refillable water bottle	2.00	1.55
Eating more fruits and vegetables and less meat	2.00	1.61
Composting food scraps	1.82	0.87

Discussion

Findings from this project can contribute to the teaching and learning of science in several ways. First, these findings demonstrate that climate-friendly actions can successfully be taught to children in the 3-6 years age group. Second, this work identifies particular action topics and activities that may be more and less successful for early childhood curricula.

Overall Findings

The findings from this study indicate that young children are capable of learning about climate change and are not too vulnerable of an audience (Elliott & Davis, 2009). Further, young children can play a role by choosing climate-friendly actions (Stevenson et al., 2017). We discuss the main findings below:

Correct Conceptions and Gains

Conserving energy, especially by turning off lights when they are not needed, was an action that was frequently cited in daily work, mentioned by parents in the survey, and showed large gains from pre- to post-test. Several reasons may explain why this action was readily learned by the preschool children. First, this action was addressed on Day 1 and was revisited each following day. Second, one of the table activities allowed the children to make a reminder sign to hang near their light switch at home. Qualitative findings from the parent surveys indicated that several children took these signs home and used them. Additionally, this "turning off the lights" is an action that is readily accessible to children.

Children also frequently mentioned conserving water in their daily work. Conserving water by turning off the water during teeth-brushing showed little gain from pre- to post-test, but the vast majority of students already selected this pro-environmental action on the pre-test, presenting little opportunity for growth.

On the daily work, children offered many responses related to reusing and recycling materials. These findings support literature that has demonstrated that young children have some understanding of recycling (Honig & Mennerich, 2013). On the survey, parents also indicated that many children talked to them about recycling as a result of the camp. Additionally, children more readily supported reusing water bottles than reusing old coats. Some

children commented on the pre-test that "new" was better than "old." This preference for new materials should be further explored in sustainability instruction.

Conceptions Inconsistent with Instruction

Based on the pre- post-tests, children demonstrated a loss on their view that collective action is better for dealing with the warming Earth than working alone. This finding may be explained by at least three possibilities. First, every child who completed this item on the pre-test selected collective action, and consequently post-test item scores could not improve. However, the percentage of students selecting collective action did decrease in the post-test. Another possible explanation is that collective action was addressed only on Day 5, and the children had less opportunities to engage with this concept either through direct instruction or learning stations. Although collective action was addressed in one of the books, only one learning station (making climate signs) addressed it on Day 5. Finally, the camp's instruction positioned each child as a climate superhero who could engage in climate action. The instruction provided several individual actions that children could take themselves in their daily lives, and this emphasis on actions doable for preschool children may have over-emphasized individual actions at the expense of collective action. Surprisingly, working with others to address climate change was one of the most frequently selected actions on the parent survey. Parents may have been interpreting their children's accounts of what "we" did at camp each day as collective rather than individual action.

Several children expressed the idea that any pro-environmental action necessarily also helped to mitigate the warming Earth. This conflation suggests that children are not understanding how climate change is different from other environmental issues. The camp did not address scientific mechanisms associated with climate change such as the greenhouse effect beyond the analogy from the children's book in which human actions are akin to wrapping blankets around the Earth, thus trapping heat. More age-appropriate instruction is needed to support students in making more direct connections to climate actions that generate greenhouse gases and *how* these actions mitigate climate change by reducing greenhouse gas emissions.

Even though young children had several correct notions of Earth-friendly actions, they also had several misconceptions. One of the most frequent misconceptions discussed by young children included the inappropriate feeding of wild animals to help the Earth. For example, young children expressed the misconceptions of feeding a bear by putting out food on a string or feeding raccoons in the backyard. The backyard bird feeder activity may have contributed to young children's misconceptions by suggesting that feeding backyard birds is akin to feeding any wild animal. This distinction between feeding animals that are already habituated to human civilization and those that are not may be too confusing for young children to understand.

Several children conveyed the idea that any food that contributed to their health was necessarily good for the environment and climate change. This finding may be explained in at least two ways. First, this thinking may reflect an egocentric stage of development for these young preschool children. Second, children may have conflated their own health with the health of the Earth, and more careful characterizations about the actions intended to mitigate climate change could have helped children understand this distinction.

Feelings and Motivations to Take Action

Young children expressed multiple valid reasons for taking climate-friendly actions, including conserving resources, helping animals, and cleaning the Earth. The desire to take action to help animals is consistent with previous studies that have identified children's strong empathy for animals (Leger-Goodes et al., 2023). A few children described their reasonings related to adult influence such as a parent telling a child to recycle. This finding makes sense given the important roles that parents play in modeling pro-environmental behaviors (Leger-Goodes et al., 2023). The young children (aged 3-5) from our camp may not have the autonomy to make choices on their own. For instance, they may not be able to choose if their family recycles or composts. However, they can still choose some actions, such as turning off their bedroom light when they leave the room or turning off the water when they brush their teeth. To avoid parental influence, future interventions could focus exclusively on actions that young children are able to take individually.

Even though our camp was designed to teach young children about climate change, only one student (C6, age 5) discussed reasons related to combating climate change. This student referenced the book *Coco's Fire* and explained that they do not want the Earth to have any more blankets as a reason for taking action. This low frequency suggests that more time and resources may be needed to teach young children about climate change. Yet, there are a limited number of children's storybooks that explain the human impacts of climate change (Benevento, 2023).

Children's emotional response to climate change primarily included sadness and anger as in previous studies (Leger-Goodes et al., 2023). From the Day 3 to Day 5 assessments of children's emotional state, children offered fewer "I don't know" responses and least two agency-coded responses that entailed a turn to action. The overall framing of the intervention was built around a problem-focused coping strategy for dealing with climate anxiety (Ojala, 2012), and at least some of the participants demonstrated this strategy. Further early childhood interventions that attend to children's emotions and foster hope through agency should be developed and researched to help identify best practices for countering children's climate anxiety.

Limitations

The findings of this study must be understood in the context of the limitations of this study. First, the pre-post gains were assessed using an author-designed instrument with no further validity/reliability data to support it. Furthermore, some children on the pre-test and more children on the post-test obtained the maximum score of ten, indicating the need to include "difficult to endorse" climate action choices. Second, the intervention itself was relatively short in duration, and learning about pro-environmental actions and changing one's willingness to engage in those actions likely takes more time. Third, the camp took place in a university-affiliated child development center that primarily serves the children of faculty and graduate students. Thus, the sample is likely biased toward children with higher income parents and parents with higher levels of formal education. For this reason, gains demonstrated by this sample may be larger than in preschools more broadly.

Implications

Our results support calls for sustainability education for preschool children (Ginsberg & Audley, 2020). Findings from this study have implications for both formal and informal environmental educators. First, the children in this study had a difficult time explaining climate change and instead discussed climate change very generally and abstractly. One way for young children to get a better understanding of climate change is through place-based learning (Orr, 2013; Smith, 2002). Orr (2013) advocated for the integration of place into education to afford opportunities for connection, direct observation and experimentation, and learning "the art of living well where they are" (Orr, 2013, p. 186). This place-based pedagogy may particularly help young children understand local climate impacts, capitalize on their natural care for their own surroundings, and engage in climate actions that are locally meaningful. For instance, educators can connect climate change to the place-based theme of nature studies by examining local species that are impacted due to climate change. Educators can also invite children to investigate timely, local changes to the climate that students can observe and relate to such as phenological shifts in leafing, budding, and migration; flooding; fires; and increased pests and their visible impacts. In addition, making climate change relevant to children can help increase agency (Littrell et al., 2020) as children explore strategies for "living well where they are" (p. 186).

Children in this study faced misconceptions related to feeding individual species. Children had difficulty understanding which individual species safely benefit from human feeding and dangers associated with feeding other species. Further, scientific research regarding climate change suggests an ecosystem-based approach to conservation to support both biodiversity and resource management (Munang et al., 2013). Therefore, young children can alternatively be taught the importance of caring for and conserving ecosystems instead of being taught to help or feed individual species. An ecosystem approach to conservation could help avoid feeding misconceptions while also helping species impacted by climate change by supporting a larger variety of biodiversity. Furthermore, instruction about dangers associated with wild animals becoming dependent on humans can be included. In future versions of this camp, more emphasis will be placed on how animals meet their needs within their habitats.

Children's conflation of climate-friendly actions with *any* pro-environmental action represents a special challenge for early childhood climate change education. Very few children seemed to understand the greenhouse effect analogy (blankets) included in the book, and the camp did not otherwise address scientific mechanisms associated with climate change. Children may need to have more opportunities to explore heat, how heat is generated, and how heat can be trapped. This would allow children to make more direct connections to climate actions that generate greenhouse gases and *how* these actions can help mitigate climate change. Analogous situations such as being inside a warm car on a sunny day can be used to connect to children's experiences. Future iterations of this camp will build on the Coco's Fire analogy of putting blankets on the Earth by physically demonstrating blankets being placed on a model Earth.

Future interventions must consist of a balance of collective and individual actions. Our focus on individual actions was intended to empower children who may have no means to participate in collective action. Yet, interventions must have opportunities to help students become aware of collective actions. Future interventions could include organizing a climate march/walk on school grounds or writing a letter from the class about climate action improvements for the school. The extent to which climate education can foster hope by modeling collective action also warrants further curriculum development and efficacy research.

Findings of this study also have implications for future research about early climate change education. The assessment used for this study should be improved. Several children received the maximum score on both the pre- and post-tests, indicating that the assessment was not able to discriminate children's understandings at the high end. More dichotomous action choices with higher difficulty should be added to increase the person separation for this instrument.

Funding Statement: No funding was received to support this research project.

Author Contribution Statement: Both authors were involved in the conception and design of the intervention and research project, data collection and analysis and interpretation, and the drafting and revisions of the paper. Both authors approved of the published version and agree to be accountable for all aspects of the work.

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