


## Article

# Youth-Led Climate Change Action: Multi-Level Effects on Children, Families, and Communities

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**Abstract:** Empirical studies of children's climate change action are rare, especially beyond the formal classroom and among pre-teen youth. This mixed-methods study examined the multi-level impacts of climate action by ten- to twelve-year-olds following an after-school program that used participatory methods to encourage children's action at household and community levels. Through surveys and focus groups, children reported engaging in a variety of climate-protective actions to reduce their energy use and waste, with some children becoming more physically active as they left behind electronics to play outdoors. Children also provided abundant examples of sharing their climate change knowledge and inspiring action among family and friends, as well as being influential in school and community settings. Findings of the present study shed light on the importance of action opportunities in climate change educational settings, not only for children's mental and physical health, but for its transformative potential through children's intra- and intergenerational influence.

**Keywords:** action; children; climate change; intergenerational influence; participatory action; pro-environmental behavior; youth



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## 1. Introduction

The mental health consequences of climate change are increasingly recognized as an important dimension of young people's growing climate change awareness [1,2]. In a recent study conducted with more than five hundred youth (ages 15 to 25) from 52 countries, over 70% of young people reported feeling a sense of hopelessness about climate change [3]. Research suggests that taking action on climate change may serve to buffer its negative psychological consequences [4,5]. Through action-focused climate change education (CCE), for example, young people may gain a sense that their actions matter and that, together with others, they can take action to minimize harms [6,7]. Beyond its psychological benefits, young people's 'everyday activism' may influence the attitudes and behaviors of close others, thus expanding the real-world impact of children's climate action [8–12].

Despite these encouraging findings, CCE is less available to children (e.g., 12 and younger) compared to older youth, and CCE-based action opportunities are rarer still among this age group [13,14]. In part, this is due to ongoing debates about whether and what kind of CCE is appropriate for children given its cross-disciplinary complexity and political potency, as well as questions surrounding whether it is the role of educators to promote advocacy or action on societal challenges. Some have argued that late childhood, the period just before adolescence, is a critical time for children's climate change learning and action because it is around this age that children begin to make sense of abstract, complex societal challenges and their relationship to them [15,16]. Due to limited research in this area, however, there is a need to understand how younger children experience and encourage climate change action through CCE.

This article is part of a series of manuscripts examining what constitutes, and how to facilitate, children's constructive climate change engagement through the lens of *Science, Camera, Action!* (SCA), a multi-site research study and after-school program aimed to empower children's climate change awareness, agency, and action. This mixed-methods

study analyzes data from pre–post-surveys and post-program focus groups conducted with ten- to twelve-year-olds to examine children’s experiences with climate action through SCA, as well as whether and how their actions had ripple effects beyond the immediate program context and into family and community settings.

### *1.1. Children’s Climate Change Action*

For children and young people, actions within their sphere of influence often include changes to everyday practices and conversations with close others (e.g., family and friends)—a concept referred to as children’s ‘everyday climate crisis activism’ [17,18]. In most action-focused CCE contexts, climate change solutions are framed in terms of personal behavior change, rather than collective action for structural or policy change [19,20]. For example, to help address the problem, young people are often encouraged to engage in a number of ‘pro-environmental’ or ‘environmentally-significant’ behaviors primarily in the realm of everyday habits and lifestyle choices [21,22]. Specifically, young people may be invited to modify their behaviors with aims of lowering their ‘carbon footprint,’ that is, the equivalent pounds of CO<sub>2</sub> emitted into the atmosphere associated with day-to-day living [23]. Less often, children are invited to participate in collaborative, community-based action to address climate change [7,24,25].

From a psychological perspective, a main criticism of individual behavior change, or ABC (i.e., attitudes, behavior, choice) [26], approaches to climate action is that they may contribute to an undue sense of guilt and personal responsibility for the climate crisis when what is really needed is policy change. While there is no doubt that swift and sweeping legislation is urgently needed to avert the worst effects of climate change [27], research suggests that personal action-focused CCE may facilitate children’s constructive climate change engagement and confer psychological benefits. For example, a recent study found that children showed greater climate message engagement (vs. avoidance) when the problem was attributed to internal causes (vs. forces external to the self) [28]. Moreover, a growing body of research suggests that when people are given opportunities to act individually and collaboratively to address climate change, they are able to gain a sense of constructive hope and agency that it lies within their capabilities to take meaningful action to address the problem [7,25,29–31]. As such, rather than instilling a sense of guilt or other psychological burdens, action opportunities in CCE contexts may be a critical element in efforts to create empowering learning environments that support children’s positive and sustained engagement.

In CCE contexts, children’s action opportunities are often prescriptive rather than participatory. In other words, when action opportunities are made available to young learners, most often those actions are predetermined [21]. If children derive a sense of agency from climate action due in part to a sense of ownership over the issue and its solutions, a question for CCE scholars is: What kinds of climate-relevant actions would children take—at individual and collaborative levels—if given the choice? Additionally, what impact would such actions have on children and others within their sphere of influence?

### *1.2. Climate Change Education for Action: An Ecological Approach*

Children’s everyday climate crisis activism has been defined as “the diversity of ways that children and young people express and act upon climate and environmental concerns in different socio-spatial contexts” [32] (p. 2), especially beyond more visible and public forms of youth-led climate activism (e.g., strikes and marches) [33]. An important mode of everyday activism for children is sharing their knowledge of the climate crisis with others around them (e.g., family and friends), and encouraging others’ actions. As such, another benefit of action-focused CCE is the possibility for ‘ripple effects’ emanating outward from the immediate learning context into family and community settings. Research in this area has documented that children can be competent knowledge-bearers, environmental messengers, and change agents in the context of climate change [11,12,34,35]. Importantly, some CCE researchers have posited that transferring knowledge, attitudes, or behaviors from

children to parents [8]—child-to-parent intergenerational learning—may be an effective way to overcome “socio-ideological barriers” to adults’ climate concerns [9] (p. 458).

The potential for multi-level impacts in family and community settings, understudied in the CCE literature, adds a layer of significance to children’s action-taking. Rather than framing children’s action as merely ‘individual behavior change,’ children’s cumulative actions represent a broader collective shift towards sustainability that may emanate outward into a variety of socio-spatial settings [17,32]. Similarly, collaborative climate action projects by young people may end up involving or otherwise influencing surrounding adults. This could especially be the case for younger children whose actions are understudied in the CCE literature and who may require the assistance of family members in making desired changes. Consequently, a fuller account of the transformative potential of action-focused CCE requires a look at its possible multi-level impacts through children’s influence on close others. To date, few studies have examined the impacts of action-focused CCE beyond the immediate learning environment and among pre-teen youth. A key question for CCE scholars and practitioners is: What are the multi-level effects of children’s actions as they emanate outward from the program context?

### *1.3. The Present Study*

Despite the positive psychological impacts of action on learners, to date, most CCE does not involve an action component [14], and relatively few research studies have examined the impact of action-focused pedagogies on young learners, especially through participatory approaches. Moreover, the ripple effects of action-focused CCE, though highly theorized, are not well documented. The present research thus addresses important gaps in the literature concerning the multi-level impacts of children’s climate change action, while responding to specific calls to explore children’s actions across scales [7].

This article is part of a series of manuscripts examining children’s constructive climate change engagement through the lens of an after-school program that used participatory methods to encourage children’s individual and collaborative climate change action [24,36–38]. The present mixed-methods research draws on survey and focus group data to examine how SCA impacted ten- to twelve-year-old children’s climate change-relevant behaviors as well as whether and how these shifts had ripple effects in family and community settings. With aims of developing educational approaches that cultivate children’s constructive climate change engagement, this study addresses the following research questions:

1. How did children’s climate change behaviors change through the program?
2. How did children’s participation have ripple effects beyond the immediate program context?

## **2. Method**

### *2.1. Community Research Context and Program Participants*

The after-school program and research study took place at three Boys and Girls Clubs (BGC) in the Mountain West region of the U.S. The BGC is one of the oldest (est. 1860) and largest youth-serving organizations in the U.S.—in 2020 providing over 4.6 million youth with “a safe, affordable place [to go] during critical out-of-school time,” across more than 4700 clubs [39]. Program participants were 55 children across the three BGCs, with ages ranging from 10 to 12 at the start of the program (see Table 1). This study was approved by the institutional review board of the research institution where data collection took place. Parental consent and youth verbal assent were obtained for all participants, and all research and program activities were voluntary for the full duration of the program.

**Table 1.** Descriptive Statistics for Socio-Demographic Characteristics Across Research Sites.

Characteristic		Town (n = 9)		City (n = 19)		Suburb (n = 27)		Total (n = 55)	
		Total	%	Total	%	Total	%	Total	%
Gender	Girls	7	77.8%	12	63.2%	10	37.0%	29	52.7%
	Boys	2	22.2%	7	36.8%	17	63.0%	26	47.3%
Average Age		11.1 years		11.4 years		10.8 years		11.1 years	
Grade Level	4th	2	22.2%	4	21.1%	12	44.4%	18	32.7%
	5th	2	22.2%	7	36.8%	6	22.2%	15	27.3%
	6th	5	55.6%	4	21.1%	8	29.6%	17	30.9%
	7th	0	0.0%	4	21.1%	1	3.7%	5	9.1%
Race/Ethnicity *	White	3	33.3%	9	47.4%	19	70.4%	31	56.4%
	Hispanic/Latinx	3	33.3%	6	31.6%	5	18.5%	14	25.5%
	Multiple Ethnicities	3	33.3%	4	21.1%	1	3.7%	8	14.5%
Free or Reduced Price Lunch		4	44.4%	17	89.5%	13	48.1%	34	61.8%

Note. \* This survey item asked children: “How do you describe yourself? (You may check more than one.)” Across participants with multiple races and ethnicities, 19% identified as American Indian or Alaska Native, 14% as Asian or Pacific Islander, 10% as Black/African American, 24% as Hispanic/Latinx, and 33% as White.

## 2.2. Program Description

The after-school program, called *Science, Camera, Action!* (SCA), took place for one hour weekly over a fifteen-week period in 2016. The program, designed by the author and grounded in the ‘Head, Hands, and Heart’ model of transformative sustainability learning theory [40], consisted of: (1) climate change educational activities; (2) photovoice, a participatory action research (PAR) method, and (3) youth-led climate action projects, which positioned children as change agents in both family and community contexts (see Table 2). Educational activities aimed to make visible the invisible connections between Earth’s changing climate, ecosystems, and human actions. After each activity, children were given digital cameras to take home for the week and take photographs that represent the connections they see between program topics and the world around them. Three weeks of the program were dedicated to photovoice sessions, during which children printed and discussed their photographs—a process which helped identify action opportunities. Finally, children planned and completed action projects. First, the program’s ‘Carbon Footprint Contest’ invited children to design family action plans focused on everyday climate-relevant behaviors such as energy use and food choices. This program component was organized into a friendly competition across research sites, rewarding participants for their climate-relevant achievements. Later, over the course of the final five weeks of the program, children designed and implemented community action projects focused on collaborative awareness-raising actions such as tree-planting, local policy advocacy, and establishing a community garden. Program content is summarized in Table 2 [24,36,37].

**Table 2.** Overview of Program Activities: *Science, Camera, Action!* (SCA).

Week	Focus Area	Program Activity
2	<i>Science:</i> Educational Activities	1. Ecosystems
3		2. Climate vs. Weather
5		3. The Greenhouse Effect
6		4. Climate Change & Ecosystems
8		5. Sustainable Solutions #1: Energy & Waste
9		6. Sustainable Solutions #2: Teamwork & Leadership
4	<i>Camera:</i> Photovoice Process	Topics 1–2: Ecosystems & Climate
7		Topics 3–4: Climate Change-Process & Impacts
10		Topics 5–6: Individual & Collaborative Action
8–13	<i>Action:</i> Youth-led Projects	Family Action Plans
11–15		Community Action Projects
		Site 1: City Council Presentation & Tree-Planting Campaign Site 2: Photovoice Gallery Exhibition & Program Website Site 3: Community Garden

Note. Week 1 was dedicated to introducing the program and assessing children’s knowledge and interests using the Gallery Walk method. Weeks 2–10 consisted of three pairs of educational activities followed by photovoice sessions. Through photo-printing and dialogue, photovoice sessions helped identify children’s personal climate change connections and youth-led action opportunities.

### 2.3. Data Collection and Analysis

#### 2.3.1. Pre–Post-Program Survey

The pre- and post-program survey consisted of socio-demographic items and a series of scales assessing children’s climate change knowledge, attitudes, and behaviors. Findings related to children’s knowledge gains and attitudinal shifts are reported elsewhere [36,38]. To examine the impacts of the program on children’s climate-relevant behaviors, a 10-item scale was compiled by the author. The 10-item “Pro-environmental Behavior and Environmental Stewardship” (PEBES) scale, created for this study, measured attitudes toward environmental conservation as well as participants’ behavioral intentions and specific actions regarding the environment [41,42]. Of the ten items, four were unique to the eight-item “Pro-environmental Behaviour” scale [41], two items were unique to the seven-item “Environmental Stewardship Scale” [42] (p. 34), and four items were shared between these two scales. Both scales were previously validated with participants under age 12. At pre ( $\alpha = 0.81$ ) and post ( $\alpha = 0.82$ ), the internal reliability of the 10-item PEBES scale was strong [43].

#### 2.3.2. Carbon Footprint Survey

A separate pre–post-survey, administered during weeks 8 and 13 of the program, included 20 author-compiled items assessing participants’ environmentally-significant behaviors as part of SCA’s Carbon Footprint Contest. This survey included 13 items assessing energy use (e.g., through transport, food, electricity, and water consumption) and 7 items assessing the production and treatment of waste (e.g., reuse and recycling behaviors). Though some areas are more commonly and easily converted into the metric of pounds of carbon dioxide-equivalent (CO<sub>2</sub>e), such as transportation and energy use, all items were relevant to carbon emissions due to indirect creation of greenhouse gases in the form of embodied emissions associated with their production, maintenance, and use or overall product life cycles (e.g., water use and recycling). Items were not intended to be exhaustive of participants’ environmental impact.

#### 2.3.3. Post-Program Focus Groups

After the program, eleven focus groups ( $M = 38$  min; 4–5 children each) were conducted to explore whether and how the program impacted children’s climate change behaviors as well as how children felt they had influenced the people around them as a result of their program participation. Specifically, children were asked open-ended questions

such as, “What are some ways that your participation in this program impacted you?”, “Did this program help you to feel like you can make a difference in the world around you? In your family? In your community? Why?” and “Did this program impact your relationships with others? In your family? In your community? How?” Focus groups were audio-recorded and transcribed verbatim prior to analysis using NVivo 10 qualitative data analysis software. The multi-stage process of thematic analysis [44] was used to analyze focus group data. This involved: (1) reviewing the transcripts in their entirety prior to closer inspection and coding as a step towards data familiarization; (2) highlighting and labeling the data to generate an initial set of ideas addressing this study’s research questions; (3) organizing and categorizing participants’ experiences thematically, over multiple stages with direct reference to the focus group data; (4) combining thematic categories and describing their relationships with one another; and (5) generating written descriptions of each theme in order to capture and communicate participants’ experiences in response to this study’s research questions.

### 3. Results

#### 3.1. RQ1: Children’s Climate Change Behaviors

This study’s first research question explored shifts in children’s climate change behaviors through their program participation. In-depth analyses of focus groups clarify and expand on survey findings. Major themes and subthemes are provided for focus group analyses, and participants’ ages and pseudonyms follow each quotation.

##### 3.1.1. Surveys

*Pre-post-program survey.* The 10-item PEBES scale was used to assess children’s behavior with respect to the environment. Responses ranged from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”), with higher scores indicating greater pro-environmental intentions and behaviors. Overall, PEBES scores were high before the program ( $M = 4.14$ ,  $SD = 0.58$ ) as well as after ( $M = 4.35$ ,  $SD = 0.53$ ) and all items trended in the expected direction (see Table 3). A paired-samples *t*-test was conducted to assess pre-post differences in children’s pro-environmental behaviors and environmental stewardship. Inspection of a boxplot revealed no outliers. PEBES differences before and after the program were normally distributed, as assessed by Shapiro–Wilk’s test ( $p = 0.35$ ) and visual inspection of a histogram and a Normal Q-Q Plot. Difference scores were also determined to be normally distributed by examining skewness 0.01 ( $SE = 0.33$ ) and kurtosis  $-0.58$  ( $SE = 0.64$ ). Results of the *t*-test revealed that the mean increase of 0.21 in children’s pro-environmental behaviors and environmental stewardship, 95% CI [0.07, 0.35], was statistically significant,  $t(53) = 3.06$ ,  $p = 0.003$ ,  $d = 0.42$ .

*Carbon footprint survey.* A paired-samples *t*-test was conducted to examine differences in children’s carbon footprints at the beginning of the action phase and again five weeks later. This 20-item assessment included frequency of engagement in specific energy- and waste-related behaviors that have a measurable impact on the environment (see Table 4). Inspection of a boxplot revealed no outliers. The pre-post differences in children’s carbon footprint scores were normally distributed, as assessed by Shapiro–Wilk’s test ( $p = 0.12$ ) and visual inspection of a histogram and a Normal Q-Q Plot. Difference scores were also determined to be normally distributed by examining skewness  $-0.38$  ( $SE = 0.35$ ) and kurtosis  $-0.78$  ( $SE = 0.69$ ). Carbon footprint scores were converted into the metric of pounds (lbs.) of carbon dioxide equivalent (CO<sub>2</sub>e) emitted over the course of a year corresponding with children’s self-reported behaviors. The minimum possible CO<sub>2</sub>e score was 805 lbs./year and the maximum was 10,475 lbs./year. Since participation in this phase of the program required attendance on specific program weeks, not every child was able to complete the carbon footprint surveys at pre and post. In total, 46 participants completed both surveys. Results of the *t*-test revealed that participants’ carbon footprints were lower ( $M = 4514.03$ ,  $SD = 1525.29$ ) in the post-survey, compared to the pre-survey ( $M = 5162.25$ ,  $SD = 1374.23$ ). This was a statistically significant mean decrease of 648.22 lbs. of CO<sub>2</sub>e, 95%

CI [−972.64, −323.80],  $t(45) = -4.02$ ,  $p < 0.001$ ,  $d = 0.59$ . A summary of  $t$ -tests for children's climate change behaviors is provided in Table 5.

**Table 3.** Descriptive Statistics for Climate Change Behaviors.

Attitude Statements	Pre-Survey	Post-Survey	MD
	M (SD)	M (SD)	
<i>Pro-Environmental Behavior and Environmental Stewardship</i>	$a = 0.81$ *	$a = 0.82$	
I am careful not to waste water. <sup>a</sup>	4.11 (0.88)	4.45 (0.69)	+0.35
I am careful not to waste food. <sup>a</sup>	4.09 (0.95)	4.36 (0.78)	+0.27
I separate most of my waste for recycling. <sup>b</sup>	4.16 (0.94)	4.25 (0.97)	+0.09
I prefer to use public transport or bicycle over car. <sup>b</sup>	3.67 (1.17)	4.05 (1.06)	+0.38
I always switch off the lights when I leave a room. <sup>a</sup>	4.02 (1.11)	4.33 (0.88)	+0.31
I always turn off the computer when I do not use it. <sup>b</sup>	4.36 (0.93)	4.22 (1.12)	−0.15
I try to save energy. <sup>b</sup>	4.45 (0.81)	4.53 (0.69)	+0.08
I talk to my friends and family about the environment. <sup>c</sup>	3.25 (1.17)	3.67 (1.33)	+0.42
I feel it's important to take good care of the environment. <sup>a</sup>	4.69 (0.60)	4.76 (0.54)	+0.07
It's important to protect as wide a variety of animals and plants as we possibly can. <sup>c</sup>	4.64 (0.65)	4.64 (0.73)	0.00

Note. \* Chronbach's alpha ( $a$ ) is provided for the scale at pre and post. Both alpha values are considered strong (Taber, 2018). <sup>a</sup> Item from Pro-environmental Behaviors scale only; <sup>b</sup> Item from both Pro-environmental Behaviors scale and Environmental Stewardship scale; <sup>c</sup> Item from Environmental Stewardship scale only.

**Table 4.** Descriptive Statistics for Carbon Footprint.

Questionnaire Item (Response Range)	Pre-Survey ( $n = 49$ ) Item Response	Post-Survey ( $n = 46$ ) Item Response	MD	Pre-Survey ( $n = 49$ ) Avg. CO <sub>2</sub> e/Year	Post-Survey ( $n = 46$ ) Avg. CO <sub>2</sub> e/Year	MD
	M (SD)	M (SD)		M (SD)	M (SD)	
<i>How many days per week do you:</i> (0–5 days)						
Walk or ride your bike to school?	1.20 (1.74)	1.13 (1.61)	−0.07	0.00 (0.00)	0.00 (0.00)	0.00
Ride the bus to school?	1.71 (2.25)	1.37 (2.10)	−0.34	32.72 (46.78)	27.37 (42.86)	−5.35
Share a ride (carpool) to school?	0.59 (1.46)	1.04 (1.76)	+0.45	29.61 (70.51)	72.46 (130.33)	+42.85
Get a ride to school?	2.98 (2.19)	2.52 (2.16)	−0.46	562.10 (459.54)	512.29 (473.13)	−49.81
<i>How often do you:</i> (1–5) <sup>a</sup>						
Turn off lights when you leave a room?	4.16 (1.01)	4.59 (0.88)	+0.42	161.24 (33.99)	146.94 (29.83)	−14.30
Unplug chargers when you're not using them?	3.12 (1.44)	3.93 (1.36)	+0.81	13.22 (3.24)	11.40 (3.05)	−1.83
Hang clothes to dry instead of using the dryer?	1.69 (1.12)	1.98 (1.44)	+0.28	619.90 (210.34)	566.58 (269.52)	−53.32
Turn off the water when brushing your teeth?	4.59 (0.91)	4.78 (0.76)	+0.19	54.33 (49.24)	44.83 (40.66)	−9.50
Turn off the TV when you're not watching it?	4.10 (1.33)	4.50 (1.19)	+0.40	64.55 (29.10)	51.53 (19.43)	−13.02
Turn off your video game system when you're not using it?	4.27 (1.58)	4.02 (1.79)	−0.24	29.46 (13.75)	30.19 (17.67)	+0.73
Put the computer in "sleep" mode when you're not using it?	3.41 (1.85)	3.63 (1.98)	+0.22	126.81 (62.97)	117.85 (61.96)	−8.96
<i>How often do you recycle:</i> (1–5) <sup>a</sup>						
Magazines?	2.84 (1.77)	3.61 (1.53)	+0.77	8.11 (6.64)	5.22 (5.73)	−2.89
Newspaper?	2.96 (1.79)	3.76 (1.51)	+0.80	45.92 (40.29)	27.88 (33.94)	−18.04
Glass?	3.08 (1.78)	3.87 (1.50)	+0.79	3.36 (3.11)	1.98 (2.62)	−1.38
Plastic?	3.80 (1.59)	4.26 (1.12)	+0.46	5.72 (7.57)	3.51 (5.34)	−2.21
Aluminum and steel cans?	3.69 (1.64)	4.15 (1.19)	+0.46	28.08 (35.17)	18.23 (25.63)	−9.85
<i>How many days per week do you:</i> (0–7 days)						
Eat meat?	4.92 (1.88)	3.89 (2.40)	−1.03	1692.62 (647.03)	1310.67 (838.81)	−381.95
Drink from a reusable water bottle?	5.00 (2.59)	4.83 (2.77)	−0.17	40.30 (52.19)	45.87 (56.95)	+5.57
<i>For dinner, how often do you:</i> (1–5) <sup>b</sup>						
Eat out (Fast Food, Delivery, Restaurant)?	2.02 (0.88)	1.83 (0.74)	−0.19	1153.23 (907.52)	998.51 (930.87)	−154.72
Eat home cooked food?	4.06 (0.85)	4.11 (1.02)	+0.05	480.58 (116.38)	498.64 (121.53)	+18.06
Total				5156.04 (1352.63)	4514.03 (1525.29)	−648.22

Note. <sup>a</sup> Response range: 1 = "Never"; 2 = "Hardly Ever"; 3 = "Half the Time"; 4 = "Most of the Time"; 5 = "Always". <sup>b</sup> Response range: 1 = "0 (Never)"; 2 = "1–2 days per week"; 3 = "3–4 days per week (Half the Time)"; 4 = "5–6 days per week"; 5 = "7 (Every day)".

**Table 5.** Summary of Paired-Samples t-Tests for Climate Change Behavior.

Variable	Pre	Post	MD	t	df	p	95% CI		Cohen's
	M (SD)	M (SD)					LL	UL	d
Pro-Environmental Behaviors and Environmental Stewardship <sup>a</sup>	4.14 (0.58)	4.35 (0.53)	+0.21	3.06	53	0.003 **	0.07	0.35	0.42
Carbon Footprint <sup>b</sup>	5162.25 (1372.40)	4514.03 (1525.29)	−648.22	−4.02	45	<0.001 ***	−972.64	−323.80	0.59

Note. \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; <sup>a</sup> Response range: 1–5, with higher scores indicating more pro-environmental behavior; <sup>b</sup> Response range: 805–10,475 lbs. of CO<sub>2</sub>e/year (carbon dioxide emissions equivalent), with lower scores indicating more pro-environmental behavior.

### 3.1.2. Focus Groups

During focus groups, children reported numerous ways the program impacted their climate relevant behaviors. For some, a deeper sense of urgency to address climate change prompted self-reflection. Specifically, children's heightened awareness of the importance of human action to address climate change was understood by many participants to reflect on their own behaviors. As Lexi, age 10, put it, "SCA made me care more about what I do." Children's increased climate change awareness [36], combined with their enhanced pro-environmental attitudes through SCA, fueled children's enthusiastic engagement in pro-environmental behaviors. A desire to help the environment was behind children's informed actions.

SCA made me think about . . . what I was doing to help or hurt the environment. It made me think about what I could do to help the environment, so I made sure that I [had] good habits so I didn't hurt it.—Scarlett (12)

Before SCA, I didn't on a constant basis help the environment, but now I'll do it four times a week—a school week. Then over the weekend, too.—Gabe (12)

During focus groups, children reported regularly engaging in behaviors that were aimed at saving energy and reducing waste. Energy-saving behaviors in particular led several participants to become more physically active by turning off the television and leaving behind videogames to ride bikes and play outdoors. Behavior change was described as a direct result of specific program activities that heightened their awareness and rewarded their efforts, particularly the Carbon Footprint Contest.

*Carbon Footprint Contest.* Prior to SCA, few participants thought about the environmental impact of their behaviors, and no one had heard of a "carbon footprint." However, the idea of tackling climate change through behavior change was met with interest and excitement. Participants were motivated to make a difference. As Athena (10) put it, "I never cared about my carbon footprint until I went through this club." Throughout the process, participants reported having fun, while feeling challenged. What Gabe, age 12, enjoyed "about the Carbon Footprint Contest . . . was that we saw how we were living originally, and then we tried to go home and change it." A number of participants had pre-existing low-impact lifestyles, particularly those from low-income households. As Nora put it, "[Having a low] carbon footprint was easy for me because I didn't really have to change much . . . I just had to change what I eat which was really easy." At the end of the contest, participants were rewarded with certificates on a number of dimensions, including having a low carbon footprint to begin with. As a winner, Nora reflected on how the contest made her feel, saying, "I liked the Carbon Footprint Contest . . . [My small footprint] made me open my eyes and see that, 'Oh, I'm doing really great' instead of doing really poorly in my life." Receiving rewards was viewed positively by a number of participants. For Peyton, it was about being recognized. Lucy enjoyed the constructive atmosphere. Despite being a competition, people were friendly and supportive of one another.

I liked that people actually got noticed when they did something [in *Program*], like in the Carbon Footprint Contest, they actually got rewards.—Peyton (10)



[I liked] the Carbon Footprint Contest [and] that some people won, and some people didn't, but nobody got too upset.—Lucy (10)

It could be that participants' positive attitudes about the contest were rooted in some level of awareness that what they were doing had meaning beyond the contest itself. As Sydney explained, the contest was not her only motivation to change her behaviors.

We did the Carbon Footprint Contest. Maybe instead of having a contest, it should be a daily routine now. People need to know that we need to save energy because . . . power plants . . . pollute the air and it really does us no good.—Sydney (12)

Overall, the process was illuminating for many participants and left them feeling encouraged. Some were surprised by their own success.

I started with a big carbon footprint that went down lower and [I] found out that I can actually lower my footprint.—Lexi (10)

*Minimizing waste.* Following the program, many participants reported that their daily routines had changed. A common theme in children's newly-adopted habits was minimizing waste through recycling and reusing things, as well as reducing their contributions to the quantity of single-use items that end up in the landfill. For example, several participants described beginning to recycle, or recycling more often than they did before. Grace (11) said, "I used to not recycle a lot and now I've gotten a lot better about recycling cans and plastic." Katherine (12) added, "If we recycle more, then they can reuse it, and it wouldn't cause as much pollution." Beyond recycling, some participants discussed the value of trying to minimize waste by not throwing things away in the first place. According to them, single-use items—especially those that do not biodegrade, such as Styrofoam and plastic—should be replaced by durable products, as captured in the following exchange:

Nora (12): I think it's good to use reusable bottles because you're not just getting a Styrofoam cup and just throwing it out.

Abigail (13): I think that if people do use Styrofoam cups and stuff that they should use them like they would their actual dishes and just reuse them until it breaks.

Rose (13): Honestly, I think that people should just get durable things so they could just keep washing it and then use it over and over until it breaks.

Abigail (13): Or use paper bags and not plastic bags . . .

Tim (11): There's a bunch of pollution in the ocean.

*Saving energy.* Another theme in children's newly-adopted behaviors was the goal to reduce the amount of energy consumption associated with their daily habits. As Lucy, age 10, explained, "SCA introduced me [to the goal] to not waste energy." To save energy, children reported using less electricity (e.g., by turning off lights) and unplugging 'vampire' appliances that use energy even when not in use (e.g., cell phone chargers). Under the energy-saving umbrella, decreasing water consumption was seen as important, given its relationship to the energy needed to supply, treat, and use (e.g., heat) water for daily necessities, such as for hydration and hygiene.

I would try to use less water at home and everywhere. We should bring a water bottle because water fountains, when you drink out of them, most of the water falls out.—Luke (11)

I have done a lot more stuff, like I've been unplugging my chargers when I'm not using them.—Bill (13)

In the following exchange, pairs of family members (Isabella and Carlos; Grace and Katherine) discuss their energy saving efforts, while seeming to hold one another to account.

Isabella (12): I would never turn off the lights that much when I don't use them, so now I do.

- Grace (11): I've gotten better at [turning off the lights].  
 Carlos (10): I use less videogames.  
 Isabella (12): Oh yeah, and water.  
 Carlos (10): Because [Isabella] knows me. I always just play games.  
 Katherine (12): Grace never turned off the lights either.  
 Grace (11): I've gotten better at that.  
 Katherine (12): Yeah, she's gotten better at it.

*Increased physical activity.* An unexpected theme was that, in reducing their energy use, several children said they became more physically active in their free time. These children reported walking, biking, and playing outside more often, rather than watching television or playing videogames. Carlos, age 10, who in the above exchange mentioned playing fewer videogames, said, "Now I like to stop pollution, like ride a bike or walk more." As Bill put it, "SCA changed my daily life by having me ride my bike a lot again." Beyond riding his bike for fun, he said he uses it to get places, replacing vehicle transport.

I have been riding my bike more often to school. I'm going to be hopefully riding my bike to the Boys and Girls Club if I'm bored at home, don't want to play videogames, stuff like that, because I'm bored and lonely. I come over here because I can ride my bike here and it doesn't pollute anything and I'm safe.—Bill (13)

Other participants described leaving behind the electronics to play outside more often. Riley said she "decided instead of watching TV all the time," that she "can just go outside and play with [her] neighbor." She and others explained being similarly influenced by SCA.

Before we started actually talking about "you can change the world" in this program, at first me and my neighbor just were going inside playing the videogame at my mom's house. Now we're walking around hiking by this house that's still being built and going up dirt hills and going anywhere pretty much.—Riley (10)

I learn[ed] to be outside more. Take more advantage of the outside world, such as planting.—Michael (11)

First when I got here, I was watching cartoons at the house and then watching TV and then now it changed me. We can play outside and, instead of TV, I can play with my bike and plant plants.—Dominic (10)

As Bill summed up, "running around outside a lot more" has led to "[being] more active." He added, "I've just been relaxed."

*Other pro-environmental behaviors.* Concerned about pollution, several participants explained that they engaged in behaviors aiming to protect the environment and maintain Earth's beauty. Though these behaviors are less directly relevant to climate change in that they do not reduce carbon emissions, they were nevertheless rooted in a desire to help the planet. Grace and Lucy described regularly cleaning up trash that others had left behind, while Alexis—inspired by her understanding of ecosystems—reported growing flowers to help honeybees and animals.

Around the school, people just drop wrappers and stuff on the ground and whenever I see it, I pick it up and throw it away.—Grace (11)

[I learned that] I love to plant. I even have my own flowers at home to help the animals . . . SCA made me feel like I could make a difference because I could plant random seeds around me or I could start making flowers for the bees to make honey and all that stuff.—Alexis (10)

*Action builds confidence.* Several participants said that taking action helped build their confidence that they could make a difference. Aubrey, age 11, said, "At the beginning, I wasn't very confident in helping the environment. Until we went through the little things that [we could change], I started becoming more confident." In describing overcoming

self-doubt, Luke and Olivia seemed to realize that what is challenging can also sometimes be rewarding.

I thought I was doing badly [with my carbon footprint] and that I needed some help with stuff, like to recycle more and that I don't recycle enough. And that I eat too much meat or I waste too much water or stuff. [The contest] helped me find out that I can make a difference.—Luke (11)

I also liked it when we did the... Carbon Footprint [Contest] because it helps us to [understand] better . . . that we can actually save energy. People that thought that they would do really poorly like [Luke] . . . and they succeeded, they knew that they could do more than what they thought they could.—Olivia (12)

A couple of participants felt good that, in taking steps to reduce their environmental impact, they were also doing more with less. For Charlotte, saving energy was helpful to her family. Lucy said that cutting back on energy consumption made her feel more satisfied with what she has in her life.

I became more confident about helping my family start recycling and saving the power and stuff. It's helped my family go longer with whatever. It helps.—Charlotte (10)

[The program] made me confident that I could do something that I [thought] I couldn't. SCA motivated me to be stronger, and to just be more pleased with what I got, not . . . what I want.—Lucy (10)

Referring to her confidence level and feeling a part of a broader community, Lucy added later, "[I learned that] I could really change the environment, and that I'm not just one person." Working collectively with others added a sense of meaning to her actions, that she was a part of a broader community of people working to address climate change however they are able.

### 3.2. RQ2: Multi-Level Impacts of Children's Climate Learning and Action

This study's second research question examined the multi-level impacts of children's program-based experiences. Specifically, focus group analyses explored whether and how children's program participation may have had ripple effects beyond the immediate program context and into family and community settings.

#### Focus Groups

Beyond engaging in personal pro-environmental behaviors, children in this study provided abundant examples of sharing knowledge and inspiring action by others. As agents of change, they spread information and awareness to the adults and children in their lives, especially family members and friends. Through their collaborative action projects, they also engaged members of their communities. For some participants, SCA led to opportunities for their increased influence in school and community settings.

*Sharing knowledge.* Upon learning about the causes and consequences of climate change, as well as its solutions through individual and collaborative action, youth participants reported feeling motivated to share their knowledge. Having had limited knowledge of climate change prior to SCA, they recognized that other people, like themselves in the recent past, may not be informed. Participants felt it was important for others to know about climate change. As Katherine (12) explained, "It could really make a difference because if [people] didn't know a lot . . . you could teach other people." Peyton reported that she had already taught others things learned in SCA, while Olivia saw the potential for having a wide impact because, by telling others, information can spread.

So, some people have even [learned] what I learned from here. I've taught some other people stuff that you guys taught me.—Peyton (10)

To change the environment, we can just tell people what we know and they could tell other people.—Olivia (12)

Informing other people about climate change was viewed by children as a prosocial act. Telling people meant helping them, and SCA strengthened their confidence to do so. When asked what he learned about himself in the program, Gabe (12) said, “I have the power to help people, and not just help myself.” Nora (12) felt similarly, saying, “SCA inspired me to help out others and inspire them to look at the environment differently”.

Beyond the goal of helping others, the motivation to share information learned in SCA was explained as a strategy for change. Telling people meant spurring shifts in their perspectives and actions. When asked whether she felt like she could make a difference in her community, Annie (13) responded affirmatively because, “Now you know the bad stuff that’s going on in nature and the good stuff. And you could help . . . by telling people.” For Arie, urging change meant engaging with the opposition.

[We could influence] people who would rather . . . keep the greenhouse gases than get rid of them. If you got together a few people, that would make a real impact and maybe even get them to change.—Arie (10)

Olivia said that even though climate change can be an overwhelming problem, spreading hope and inspiring others could be a matter of simply telling them about children’s accomplishments in SCA.

We could influence people to help save the environment . . . to try to make people . . . see that things can seem rough, but then at the end it ends up okay. Because you can influence people by saying, “You can do stuff” when they think that they can’t do it or they can’t make it through something. You can influence people to help save the environment by telling them what we did in the program.—Olivia (12)

*Sharing knowledge with family.* Participants provided numerous examples of engaging their family members on SCA content. Theo (10), referring to an activity about ecosystems, said, “I told my little sister about the thing that we were doing with the yarn.” More often, participants told others about climate change, including Melanie and Kelly, who taught their younger family members.

I taught my little cousin about global warming. She is seven.—Melanie (10)

I taught my [younger] brother . . . [about] global warming.—Kelly (12)

Abigail and Nora discussed the program with additional family members, including parents. Nora’s conversations reached through her parents to their co-workers and her grandparents. In one instance, she found herself teaching an adult about climate change.

I had talked to [my niece] about [the program] . . . I told my parents and my little sister and everyone.—Abigail (13)

I talked to my parents and they talked to their parents and their co-workers and everything. I actually had one of [the] workers come up to me and talk to me about what the program was like. “Hey, what have they taught you about global warming and everything?” I talked to him and he kept talking to me.—Nora (12)

*Sharing knowledge with friends.* Participants also told of teaching their friends and schoolmates about program content. Examples ranged from telling friends about program activities and explaining specific concepts to inspiring their motivation and concern about climate change. In referring to an SCA activity about energy-saving behaviors, Miguel, age 12, said, “I taught one of my friends a lot about the [energy] bingo.” Later, he added, “[I taught] the greenhouse [effect] to one of my friends, [who’s in] the same grade.” Jack (11) said, “My friend . . . didn’t know what carbon dioxide was and I helped him recognize what it was.” Daniel viewed SCA as “basically an extra class,” which made him feel capable of sharing his knowledge about climate change with his friends.

I definitely think I can influence my friends. Most of my friends at school don’t really know about this stuff yet. Since I’m doing this [program] . . . I’m learning . . . and they’re learning from me. I’m teaching other people.—Daniel (10)

Other participants discussed the potential to inspire or bond with friends over climate change. For Rose, friendships could be strengthened through shared concerns about climate change.

If you tell people that you're actually worrying about [climate change], then they might agree and then you might be better friends when you get to talk about it.—Rose (13)

*Inspiring action.* In addition to sharing knowledge gained in SCA, children were committed to encouraging action by others around them. Most commonly, they spread information about everyday behavior change, rather than collaborative climate change action requiring coordination by groups. For example, children advocated behaviors that save energy, minimize waste, or otherwise protect the environment. They said SCA helped them to better understand their own environmental impact and how to make choices to benefit the environment, which was information they wanted to share. As Grace (11) put it, "SCA taught me how to change the environment . . . [and] how to help other people to [do so]." Arie (10) said, "I started looking around for people who kept doing things that would hurt the world and I would go and talk to them and try to get them influenced to help to save the world."

*Inspiring family action.* Participants across age groups and research sites gave examples of influencing family members' action. Some described raising others' awareness, like Melanie (10), who said, "I taught my little cousin and my entire family, 'You need to cut down on the energy and stuff, man!'" Others reported that family members had begun to adopt energy-saving behaviors. For example, Cecelia (10) said, "I got my big sister and my big brother to turn off the lights more." Gabe (12) said, "I feel like I influenced some of my cousins, because they have started using less, being on the TV less, and playing outside more." Tim engaged multiple family members during the Carbon Footprint Contest. As he explained, their help was important to reaching his carbon-savings goals.

When I talked to people, my cousins . . . they helped me with stuff I needed to do [for the Carbon Footprint Contest] and how I could do it and stuff. It helped me make a real difference because . . . I had like five other people who helped me . . . I planted my tree already. They helped with gardening.—Tim (11)

Encouraging action by family members could spread to additional people as well. As Sydney explained, once her mom was on board, so was her mom's partner.

I told my mom about it and she knows how important it is to me. She got her boyfriend to start saving energy by turning off the lights after he leaves, and unplugging the charger cords whenever they're not in use. Anything like that.—Sydney (12)

*Inspiring action with friends.* Some children talked about engaging friends in climate change action, though less often than with family. Engaging other young people was seen by many as an effective strategy for spreading climate change awareness and promoting action. In the following exchange, participants explain that involving youth is important because, that way, information can spread across generations and allow more people to help the environment.

Katherine (12): You could teach [other kids] all you learned from this [program] and then they could teach other people and then those people could teach other people and it could just be ongoing.

Carlos (10): Generation to generation.

Isabella (12): I was going to say some kids don't know what climate change is . . .

Facilitator: Do you think it's important for them to know about that?

Group: Yes!

Carlos (10): Yes, because I think they can make a change in the world, too.

Grace (11): I was going to say “yes” because if we can go around teaching them, then they can go around teaching others and it can start spreading and soon lots of people would be able to help out.

Grace offered an example of influencing a friend’s behavior, saying, “I talked to my friend and told her about climate change . . . and she’s starting to help the environment.” Later, she told of conversations with friends about how to save energy and minimize waste.

I talked to my friend about how we’re making a website and how she can go on to help change her behaviors... And another one of my friends didn’t really know how to recycle, and so I gave her one of the recycling papers [from the program] and now she understands.—Grace (11)

*Collaborative community action projects.* In addition to engaging family and friends, participants discussed their ability to make a difference in the wider community through their collaborative action projects. Children’s action projects included a city council presentation, tree-planting, a photo gallery event, a website to inspire action, and a community garden [24,37]. Reflecting on their participation in SCA, many viewed the action project as the program’s most influential component. Sydney (12) spoke at her city council meeting to urge climate action. At first, speaking in public initially provoked anxiety, but afterward she said, “I love speaking. I love having the thought of speaking in front of people and being confident.” For children across research sites, making a difference in their community meant raising awareness about climate change and inspiring action by community members. At a community event to raise awareness about climate change through children’s photography, Nora reported engaging both adults and children.

I also liked the photo gallery because I helped set it up and I got to see how parents interacted with it and when kids walked by, they interacted differently. It showed me different views . . . The kids would just walk by and just be like, “Eh.” They would not even pay attention . . . but parents would stop and read them and talk to you . . . about it and wonder what we were doing in SCA and what the [program] is all about. We would explain it to them and they would keep looking and ask more questions.—Nora (12)

To Tim and Nora, influencing the community most effectively required ensuring the website’s visibility.

Another way we can help is by spreading it around, like the website. We could tell people, like if you like to help your community, go to this website.—Tim (11)

Going around just even over the Internet [promoting] the website... [or] going around telling your friends about it could inspire them to tell more friends.—Nora (12)

For the children who started a community garden, they enjoyed themselves while making an impact in their community. Bill (13) said, “[I learned] that I love to hang out with people and pull weeds and stuff.” Some started new gardens at home, inspired by SCA.

We started our garden [at home after] I talked to my family about it. We went on a shopping spree for garden stuff and we got a box so we can plant flowers, watermelon, cantaloupe . . . —Bryan (10)

I’ve been telling my mom about the garden and she likes the idea so we’re going to start [one]... We even pulled out all the weeds from the sides and we’re going to start a garden because the inspiration of our garden.—Peyton (10)

To influence others in the community, children were enthusiastic about informing others about gardening. Bryan said, “I feel like I could make a difference by telling others that they should start growing a garden.” Peyton considered volunteering with the garden at her neighborhood church. She said, “How I felt like I could make a difference is by the garden. Also, I live right next to a church and they’re growing a garden, and maybe in

my free time, I could go to the church and help them with the garden from stuff I learned. Maybe I could give them tips.”

*Community engagement beyond SCA.* Through their participation in SCA, a number of participants took advantage of additional opportunities to be influential in school and community settings. Scarlett’s ideas were taken up by teachers for Earth Day celebrations, Andrew discussed climate change with his teacher, and Daniel successfully persuaded his teacher to cover the carbon cycle with his science class.

On Earth Day at school, we were talking about stuff like this and since I have this background information, I put that into my schoolwork and the teachers were really impressed and took some of my ideas and now we’re trying to help.—Scarlett (12)

When I started coming here, I mostly told my teacher what was happening. Like people using bad stuff like gases and they can ruin the planet and kill a lot of things in the ecosystem.—Andrew (11)

At school, we’re now doing plants right now and how the sun beats down and all the CO<sub>2</sub> and this goes in the air and helps it grow. We’re now learning about it because I gave my teacher the idea to see if we could do that.—Daniel (10)

In addition, four participants—Abigail, Rose, Nora, and Tim—reported having joined a youth advisory committee to weigh in on the development of a park in their community. According to Abigail, she may not have considered joining if not for her participation in SCA.

Me, Nora, and Rose, we got into this committee thing. And it’s so that we can work on what goes back there in that field. I think that me personally being in this program made me want to actually participate in that more than I would have before . . . We’re the committee who is going to decide what’s going to go in there. [It’s] just a big field.—Abigail (13)

#### 4. Discussion

This mixed-methods study used surveys and focus groups to examine how an after-school action-focused CCE program impacted ten- to twelve-year-old children’s climate change-relevant behaviors as well as whether and how these shifts had ripple effects in family and community settings. Children attributed to their program participation numerous behavioral shifts, including actions aimed at reducing their energy use and waste as well as becoming more physically active as they left behind television and videogames to ride bikes and play outside more often. Children also reported sharing information and inspiring action among family and friends, as well as being influential in school and community settings. Findings of the present study shed light on the importance of action opportunities in CCE, not only for its positive impacts on children’s mental and physical health but for its transformative potential through children’s intra- and intergenerational influence.

##### 4.1. Children’s Climate Change Action: Micro-Level Benefits

Echoing previous articles in this series [24,36,38] and consistent with the growing literature on children’s climate change engagement [45–48], findings of the present study show that children can engage positively and meaningfully with climate change in educational settings, particularly when given action opportunities. In the present study, ten- to twelve-year-olds engaged in a range of individual and collaborative actions intended to actively mitigate or raise awareness of climate change. Beyond making modifications to their own daily habits and choices, children in this study viewed sharing their knowledge and encouraging others’ action as a prosocial and pro-environmental act. They cared about the issue, took action in multiple forms, and gained a sense of agency that they could make a difference. Importantly, rather than feeling “hopeless”—a common sentiment among adolescents [3]—the children in this study were motivated, engaged, and confident that

their collective actions mattered. Given that children's ages in this study correspond to late childhood (just before adolescence), it is possible that action-focused CCE can play a role in preventing or managing negative feelings in a way that can support children's sustained and constructive climate change engagement [13].

A chief reason that CCE research is limited with younger age groups (e.g., primary school learners) is that questions abound as to what is considered age appropriate for the youngest of audiences [49]. For learners of all ages, climate change can be an intellectually challenging topic, and its consequences for ecosystems and societies around the globe can be unsettling, especially if fully grasped. What the present study's findings suggest is that it is possible to engage younger audiences in empowering ways that educate, motivate, and activate young learners [5,7,13,16]. As mentioned in previous articles in this series [24,36], engaging children in youth-led, action-focused CCE requires that we first confront and surmount dominant cultural narratives that undervalue children's capacities and limit their active participation in addressing collective challenges [15]. Action-focused CCE then requires framing considerations, with aims of cultivating children's positive dispositions (e.g., creativity, empathy, and cooperation) towards CCE from an early age [5]. Far from framing climate change as a tragedy of unprecedented proportions, SCA's curriculum focused on local ecosystem impacts and the role of people in addressing these challenges—collectively and collaboratively—through a range of actions to prevent further harms (see Table 2). In short, rather than emphasizing what makes climate change a crisis or catastrophe, SCA's approach to CCE was to invite children to use their imagination and problem-solving skills to address a key problem affecting people, plants, and animals in their communities and around the globe. Finally, action-focused CCE requires making choices about the scope of youth-led action that is possible in a particular context. In SCA, it was possible to facilitate children's individual and collaborative, site-based actions [24], with the message that a range of "sustainable solutions" at multiple levels is needed. Rather than diminishing the significance of children's individual action-taking, by weaving smaller, cumulative actions into the meshwork of larger, higher-order transformations (e.g., policy change), children derived a sense of agency from playing an active role in the change process within their sphere of influence.

Although relatively few CCE research studies have documented action-focused pedagogies and their impacts on young learners [5], findings of the present study take on expanded significance in the context of increasingly apparent mental health impacts linked with climate change [29], including among young people [1,2]. An unexpected finding in this study was that, in addition to its psychological benefits, children's climate action may have conferred additional mental and physical health benefits through children's increased outdoor activity. This unanticipated finding is directly tied to the participatory nature of the program: Children were not prescribed specific climate-protective actions to take through their program participation. Rather, they designed plans for action in family and community settings that were specific to their interests and goals [21]. It is possible that children's deep engagement with program activities as well as their increased post-program sense of competence were rooted in their sense of ownership over actions taken. This finding resonates with the work of Chadborn and colleagues that children's agency can be supported by inviting them to consider their own active role in "low-carbon healthy lifestyles" (e.g., via walking or biking to school) [50] (p. 271). This finding is also significant given that childhood nature experiences are critical in forming environmental attitudes and behaviors that can last into adulthood [51,52].

The micro-level transformative potential of children's actions can be understood through reflexivity theory as well as transformative (sustainability) learning theory [40,52,53]. Reflexivity theory holds that learners may undergo a process of self-confrontation in response to new knowledge and seek to take "constructive steps toward sustainability" that reflect their newly acquired understanding [53] (p. 6). A similar action-focused process is central to transformative learning theory [54], which states unequivocally that "a transformative learning experience *requires* that the learner makes an informed and reflective *decision* to



act" [55] (pp. 163–164) [emphasis added]. Findings of the present study suggest that, through SCA, children were questioning their own past behavior, altering their daily habits, and feeling energized to spread the word and "save the world." These findings resonate with the literature on action competence in environmental education [30].

#### 4.2. Children's Climate Change Action: Multi-Level Benefits

A critical debate worth mentioning here is the question of whether lifestyle modifications can have any measurable effect towards addressing climate change [56]. Such debates pit the assumed futility of "behavior change" (in the raw metric of pounds of CO<sub>2</sub> sequestered or saved) against the clear necessity for structural and policy change. However, this is a false dichotomy because transformation at all levels—from the political to the cultural—are critical to building a sustainable future [7]. Learning and practicing modes of living more sustainably may contribute to cultural transformation, or 'change from below' that may facilitate top-down (e.g., policy) shifts as well as encourage horizontal action before policies are in place [17]. Importantly, cultural transformation involves recognizing, rethinking, and replacing deeply unsustainable worldviews (e.g., of extraction and exploitation) that underlie all thinking and action [57]. Evidence in this study of children's shifting perspectives is published elsewhere [36,38] and expanded upon in this study, for example, in children's reports of greater life satisfaction through deriving meaning in their low-carbon lifestyles. Modifying everyday climate-relevant behaviors, especially at the household level, is particularly significant in countries such as the U.S. where per capita fossil fuel emissions are among the highest in the world [58] and where consumption practices must change to avert further socio-environmental injustice [59].

Children's intra- and intergenerational influence must also be considered when estimating the practical significance of children's behavior changes. Findings of the present study contribute to the growing evidence base that children can be effective climate change communicators and change agents in their families and communities and across generations [11,12,35,60–64]. A finding worth noting is that the largest single-item shift on the post-program survey was, "I talk to my friends and family about the environment" (see Table 3). Talking about climate change and climate action can be among the most impactful forms of "individual" behavior change because, as one child explained in focus groups, this information can "start spreading and soon lots of people would be able to help out." In short, the significance of youth-led actions lies not necessarily in their cumulative carbon savings, but in their central role in supporting children's learning and agency as well as their potential influence on the attitudes and actions of the people around them. These multi-level effects have the potential to originate in after-school settings, as in the present research, as well as in the formal classroom, where recent research has found teachers are "ready and willing to move forward with radical, action-oriented CCE programmes that can help drive change rather just respond to it" [65] (p. 21). The duration of SCA was fifteen weeks, however, as has been recommended elsewhere [5,37], sustainability is a cross-cutting topic that should be addressed over the longer term and across school subjects.

#### 4.3. Limitations and Strengths

An important limitation of the present research is its non-experimental design, which makes it less clear whether changes in children's behaviors were due to their program participation. A further limitation, given this study's research questions, is that data collection took place only with children and, consequently, the ripple effects of the program are limited to what children perceived. It is also worth recognizing that, in all forms of data collection, children may have been motivated to respond in socially desirable ways. Future research should more systematically examine program impacts beyond children's self-report measures and outside the immediate program context, for example with children's family members or friends. A strength of the present research is the mixed-methods approach, which allowed for measuring program impacts in multiple ways. Focus groups served to clarify and elaborate on survey findings, while allowing children

to make clear attributions to behavioral changes arising from their program participation. Focus groups also generated insights that could not have been predicted in advance and which survey measures alone would likely have missed. An additional limitation is that post-program focus groups took place soon after the program ended, so the long-term impacts of the program are unknown, including whether and to what extent children's behavioral shifts were sustained over time. It is recommended that future studies into the multi-level effects of children's program- or school-based climate change action assess impacts both immediate and over the longer term, with particular attention to the broader socio-cultural context and built environmental factors that may promote or impede action for sustainability.

## 5. Conclusions

This study explored the multi-level impacts of youth-led climate action on children, their families, and their communities. First, enabled by this study's participatory design, children reported a wide range of self-selected climate-relevant actions that supported their constructive engagement and well-being. Further, emboldened by their climate change awareness, children were sharing knowledge and inspiring action by others around them, including among friends and family as well as in school and community settings. Given the cumulative impact of children's actions and their ripple effects into a range of socio-spatial contexts, findings of the present study urge us to rethink the significance of children's actions from the atmosphere to the ground. That is, we must shift our gaze from the emissions-lowering impacts of children's actions to their psychosocial impacts on Earth's most consequential species whose thoughts, values, and actions must shift towards sustainability for any possibility of a viable future.

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