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Science Education for Sustainability: Strengthening Children's Science Engagement through Climate Change Learning and Action

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Abstract: Scientists and sustainability scholars continue to make urgent calls for rapid societal transformation to sustainability. Science education is a key venue for this transformation. In this manuscript, we argue that by positioning children as critical actors for sustainability in science education contexts, they may begin to reimagine what science means to them and to society. This multi-site, mixed-methods study examined how children's climate change learning and action influenced their science engagement along cognitive, affective, and behavioral dimensions. For fifteen weeks, ten- to twelve-year-olds participated in an after-school program that combined on-site interactive educational activities (e.g., greenhouse gas tag) with off-site digital photography (i.e., photovoice process), and culminated in youth-led climate action in family and community settings. Participants were 55 children (M = 11.1 years), the majority from groups underrepresented in science (52.7% girls; 43.6% youth of color; 61.8% low-income). Combined survey and focus group analyses showed that, after the program, science became more relevant to children's lives, and their attitudes towards science (i.e., in school, careers, and in society) improved significantly. Children explained that understanding the scientific and social dimensions of climate change expanded their views of science: Who does it, how, and why—that it is more than scientists inside laboratories. Perhaps most notably, the urgency of climate change solutions made science more interesting and important to children, and many reported greater confidence, participation, and achievement in school science. The vast majority of the children (88.5%) reported that the program helped them to like science more, and following the program, more than half (52.7%) aspired to a STEM career. Lastly, more than a third (37%) reported improved grades in school science, which many attributed to their program participation. Towards strengthening children's science engagement, the importance of climate change learning and action—particularly place-based, participatory, and action-focused pedagogies—are discussed.

Keywords: children; climate change education; participatory action research; photovoice; science attitudes; sustainability

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1. Introduction

Promoting children's science engagement is often framed as a means to address the world's most pressing problems over the decades to come [1]. For example, by shoring up children's science interest and achievement today, young people may go on to become leaders and agents of change in addressing the major scientific and technological challenges of tomorrow [2,3]. From a sustainability perspective, however, this is a problematic starting point. Current global crises—including climate change and biodiversity loss—demand rapid societal transformation towards social and ecological sustainability beginning now, not in the abstract future when today's children have reached adulthood [4]. Indeed, climate change is already wreaking havoc on a global scale in the form of more frequent and more intense extreme weather events and causing unprecedented environmental, societal, and economic disruption [5]. Reimagining the very purpose of science education—beyond honing the "potential" of young people to take decisive action in the future—has become a necessity.

Promoting children's science engagement is also commonly framed in the language of global dominance. A persistent narrative is that, by feeding the STEM "pipeline" today, the U.S. may remain competitive in the global marketplace of the future by remaining a leader in technology and innovation [6,7] This narrative is clear in federal STEM education reports and initiatives, which have for decades emphasized the connection between intensifying STEM education and regaining or maintaining the U.S. position on the frontiers of discovery [8–11]. Again, from a sustainability perspective, this worldview is misaligned with the kinds of societal transformation that are required to avert catastrophic ecological and societal consequences. Specifically, the modes of transformation required to adequately address sustainability challenges are those that force us to rethink, reinvent, and restructure our institutions (e.g., global economies, the scientific enterprise) in ways that shift away from the non-sustainable modes of interaction (e.g., competition, consumerism, individualism) that have delivered us into the present moment [12]. The prevailing neoliberal ideology of limitless growth and perpetual global competition has locked us onto the current crisis-bound trajectory [13,14]. Rethinking the very purpose of the STEM pipeline—beyond the language of global competition—is required for course correction.

In sum, there is a need for rapid societal transformation to sustainability in ways that substantively involve children and young people in climate change learning and action as well as a need to redefine science not as a "competitive edge" to safeguard against the threat of future subordination, but as a collaborative process to envision and enact sustainable futures today. Moreover, given the overwhelming nature of sustainability challenges, there is a need to encourage children's informed actions on sustainability topics in ways that promote their sustained interest and engagement. What if, rather than attempting to shore up children's science engagement today to ensure their status as capable actors in the future, we positioned children as critical actors for sustainability today as a means to simultaneously strengthen and reimagine children's science engagement for the well-being of people and planet?

This article is the third in a series of manuscripts exploring what constitutes, and how to facilitate, children's constructive climate change engagement through the lens of *Science, Camera, Action!*, an afterschool program that combined educational activities with digital photography to facilitate children's individual and collaborative climate change action [15,16]. The present article examines how children's agentic experiences in the program influenced their thoughts (i.e., perceptions of), feelings (i.e., attitudes toward), and behaviors (i.e., engagement) related to science as a school subject, potential career, and societal force. Findings suggest that children's climate change engagement can be a vehicle not only for supporting children's science interest, but for opening up pathways to a sustainable future by positioning children as agents of change today.

2. Literature Review

Today's most urgent challenges are increasingly those that call upon broad sectors of society to understand and practice sustainability. Sustainability is defined as "meeting the needs of the present without compromising the ability of future generations to meet their needs" [17], and is commonly acknowledged to have environmental, social, and economic dimensions. High-stakes sustainability challenges (e.g., climate change and biodiversity loss) are understood to be the consequence of decisions and actions by humans. The conclusion that human activity has had such a massive impact on the global environment has prompted scientists to refer to our current geological age as the Anthropocene—*anthropo* meaning "human" and *-cene* referring to a geological period [18]. To avert catastrophic ecological and societal consequences, what is needed now are broad shifts in how societies operate and how people live their everyday lives to reduce future threats to people and planet. In the sections that follow, we review the current state of sustainability science education in the U.S., and make the case that what is needed now are empowering and transformative pedagogies that encourage children's sustained interest and participation in sustainability action. Doing so, we argue, could redefine the very purpose of science education while strengthening children's science engagement as they reinterpret what science means to them and to society.

2.1. Science Education for a Sustainable Future

Science education must play a pivotal role in promoting sustainability, in particular through facilitating climate change learning and action. To date, however, climate change education is not a national priority in the U.S., and many science teachers report feeling unsupported in teaching about climate change in the classroom [8]. For example, many teachers feel under-prepared due to a lack of training on the subject, and there is no national policy mandate requiring that they include climate change topics in their curriculum [8,19]. Consequently, most teachers spend a limited amount of time teaching about climate change, if at all, and students sometimes receive "mixed messages" about the topic that do not align with accepted science [8,20]. Even still, demanding that teachers teach according to the scientific evidence may not be enough. Research critiquing the "information deficit" approach to climate change communication has shown that merely learning facts about a problem does not necessarily lead to action [21]. Moreover, young learners can feel overwhelmed by the issue, causing them to disengage [22]. What is needed, rather, are agency- and action-focused engagement strategies that empower learners to feel capable of addressing the issue in meaningful ways, particularly by working together in local settings [15,16,23].

Within and beyond the U.S., sustainability education has been criticized for being 'depoliticised' [24,25]. The Next Generation Science Standards (NGSS), which shape P-12 science education and teacher education in the U.S., position the environment as entirely separate from living organisms, humans in particular [26]. Further, sustainability challenges are often framed as having physical properties and primarily technological solutions, which overlooks their complex human elements (e.g., cultural, social, and political) [26–29]. In the U.S. classroom, for example, the siloed, discipline-based approach to teaching climate change as science tends to ignore the social dimensions of climate change, and the political dimension is likely to be omitted [30]. Further, the individualism that drives—and is perpetuated by—the competitive orientation of STEM education has been linked to a renunciation of pro-environmental thought and behavior, and the rejection of human behavior as a contributor to environmental problems [28]. Consequently, sustainability learning from the formal classroom is focused on individualistic learning of scientific facts rarely paired with opportunities for action, especially collaborative action within local communities.

Positioning young people as capable actors today could promote their science engagement and redefine the role of science in society—for promoting the stability of ecosystems that support human life on this planet. To accomplish this, we must rethink the nature of science education as well as the purpose of the "STEM pipeline". Students need opportunities to see how the science they learn matters to their lives and that of other living beings, to spread their knowledge across their networks of families and friends, and to transform the world around them as they engage collaboratively to translate their knowledge into action.

2.2. Sustainability Science Education for Children's Sociopolitical Inclusion

Explanations for the depoliticization of sustainability education can be found at multiple levels. Beyond the institutional level (e.g., policy, school), discussed earlier, a less apparent reason is the broader cultural issue of children's exclusion from the socio-political domain. Put differently, children are viewed not as "human beings", but rather as "human becomings" whose political participation and engagement is not yet considered an age-appropriate behavior [31]. Dominant constructions of childhood, including *children as innocent* and *children as becoming*, regard early life as fundamentally a period of preparation and socialization leading toward the full citizenship of adulthood [32]. Such images of young people in primarily Western societies, including the U.S., render adult-youth relations as inherently paternalistic, whereby young people are often neither consulted as competent citizens nor invited as capable actors with rights to participate in civil society [33]. Politics is an "adult-only" domain, and children are asked to learn and observe from society's margins [34]. This state of affairs inevitably leaves young people without a voice in important matters that impact their lives. More generally, the disjuncture between science and society has given rise to critical dialogue about promoting public engagement through "scientific citizenship" [35] and redefining the meaning of "science literacy" [36,37].

Given children's general lack of engagement with critical societal issues in the classroom, researchers have argued that the formal education system has failed to empower young people as citizens [38,39]. Relative to other societal issues, this accusation is especially severe in the context of sustainability education, given that today's children are the "future generations" whose health and well-being will be increasingly harmed as the stability of social and ecological systems continues to unravel [40]. Towards building sustainable futures in collaboration with youth—and towards developing empowering pedagogies in the process—inviting young people to learn about the scientific and social dimensions of sustainability is critical, as is encouraging their action [4,41].

2.3. Sustainability Science Education for Collaborative Action

To date, most classroom-based climate change learning is not paired with an action component of any kind [30]. When opportunities for action are incorporated into environmental programming, within and beyond the classroom, a key criticism is their emphasis on individual rather than collective action. Underscoring individualized behavior change implicitly frames sustainability challenges as a matter of personal responsibility rather than large-scale structural change, or the kinds of change that require communication, coordination, and collaboration [28,42]. This trend is rooted in neoliberal ideology, as the implied message is that sustainability challenges can be overcome through aggregated, freely taken individual actions (e.g., consumer choices) that need not involve coordinated efforts or policy-level decisions that may prompt state interference in the marketplace. A key distinction here is between individual actions taken *within* existing systems (i.e., behavior change) versus collaborative actions taken to *transform* existing systems (e.g., via collective action).

Of great significance for sustainability learning is that such a micro-level framing misrepresents the macro-level (i.e., policy, infrastructure) changes that must occur in order to adequately address sustainability challenges, thus hindering learners' ability to imagine alternative futures and the kinds of decisions and actions necessary to realize them. As noted by Hayward,

> ... the psychological lens inadvertently narrows our vision of citizenship, reducing the potential of political agency to the aggregation of personal value choices, aspirations and psycho-social interactions with the natural world, obscuring the political potential of citizens collaborating and reasoning together to create alternative pathways and forms of public life. [42] (pp. 7–8)

In a sustainability education context, then, "fight(ing) post-political representations of the present" is a first step towards building a sustainable future [43] (p. 148).

To be transformative for learners, pedagogies must move beyond *instrumental* (i.e., prescriptive) modes and towards *emancipatory* engagement, as the former "stifles creativity, homogenises thinking, narrows choices and limits autonomous thinking and degrees of self-determination" [44] (p. 180). For example, engaging young people using participatory approaches—in which they are treated as decision-makers and collaborators throughout the process of learning and action—can cultivate a sense of agency that combats climate change anxiety and withdrawal [15,16,41]. Moreover, engaging young people in collaborative approaches to education and action have the potential to promote pro-environmental thoughts and behaviors that may lead to a more interdependent (rather than independent) ways of thinking and solving problems [28]. Positioning young people as radical visionaries and capable actors for sustainable transformation demands that educators cultivate their critical awareness and invite them to envision preferable futures, dialogue about and develop their own plans for action, and then act on them collaboratively within communities [15,16,45–48].

2.4. Science Engagement for Societal Transformation

Societal transformation to sustainability requires widespread shifts in modes of thinking, being, and interacting in the world as a way of preventing the worst effects of environmental degradation. Science education is critical to this transition. Not only do students need deep knowledge and understanding of disciplinary concepts and processes, they also must have extensive scientific literacy to use disciplinary knowledge to make evidence-based decisions that simultaneously consider environment, social, and economic dimensions. In the U.S., children and youth are most likely to learn about today's most urgent sustainability challenges, including climate change, in the science classroom. It is therefore imperative not only to support learners' fact-based understanding of sustainability challenges, but to cultivate their sustained interest and participation in addressing these challenges through empowering and transformative pedagogies that position children as critical actors for a sustainable future.

Transformative sustainability learning theory holds that profound changes in learners' thinking and action can result from pedagogical modes that encompass cognitive, affective, and behavioral engagement [49]. By cultivating critical awareness and collaborative action, sustainability science education can lead to increased pro-environmental knowledge, more positive attitudes, and greater behavioral engagement. What if, beyond transforming learners' perspectives on sustainability, such modes had the capacity to transform learners' perspectives on science? For example, could transformative sustainability pedagogies also influence science learning, attitudes, and behavioral engagement? Doing so could begin to reframe what science means to children and their understanding of the role of science in society. Using mixed-methods data collected through a collaborative, multi-site research study, the present research examines how children's climate change learning and action influenced their science interest and engagement. An earlier manuscript in this series [16] examined children's knowledge gains through the program, and showed that after the program, children knew more about climate change than they did before, and—on average—more than the average U.S. teenager or adult. The present research moves beyond climate change learning to examine how the program impacted children's cognitive, affective, and behavioral science engagement.

3. Program Description, Community Partner, Research Context

The present study was carried out in partnership with three Boys and Girls Club (BGC) units in the Mountain West Region of the U.S. The BGC is one of the longest-standing and largest community-based youth development organizations in the U.S., founded in 1860 and currently serving over 4 million youth annually across 4600 clubs in urban and rural areas, in public housing communities, and on Native lands [50]. As a non-profit organization funded by government grants as well as corporate donations and private philanthropy, the BGC offers out-of-school youth services year-round, with annual membership fees as low as five U.S. dollars [51]. As an approximation of members' socio-economic status, 61% of BGC youth receive free or reduced-price school lunches, for which eligibility is based on federal poverty guidelines. To achieve their mission to enable young people to "reach their full potential as productive, caring, responsible citizens", BGC provides positive and safe places to learn, be with friends, and develop relationships with caring adults. The BGC offers "unstructured, drop-in, recreational" activities [52] (p. 52) as well as structured programming aligned with its five focal areas: character/leadership, education/career, health/life skills, the arts, and sports/fitness/recreation [51].

Science, Camera, Action! (SCA) was an after-school program that aligned with BGC structured education-oriented programming by pairing climate change science education with photovoice methodology. Throughout the program, participants engaged with topics of global climate change (e.g., ecosystems; the greenhouse effect) and sustainable solutions (e.g., energy use; teamwork and leadership) as well as digital photography (i.e., photovoice), while being encouraged and assisted as they developed and implemented action plans in their families and communities. The present research aligned with regional BGC efforts to integrate "STEAM" programming into their clubs. STEAM is science, technology, engineering, and mathematics (STEM) combined with the arts.

Designed and implemented by the first author, SCA took place for one hour weekly over a period of 15 weeks in 2016 (January to May). Program content and activities were shaped by the 'Head, Hands, and Heart' model for sustainability education, which underscores the transformative potential of simultaneous cognitive, behavioral, and affective engagement [49]. Using these dimensions, key program components are described below.

3.1. Science: Cognitive Engagement

SCA's educational program content consisted of six activities integrating the scientific and social dimensions of climate change by demonstrating the relationships between Earth's changing climate, the functioning of local ecosystems, and the actions of individuals and communities. In the framework of 'Head, Hands, and Heart,' SCA's *Science* component encouraged children to think critically and systematically ("Head") about the problem of climate change (e.g., causes and consequences) and its many solutions through human action. Hands-on activities also introduced children to relevant STEM fields (e.g., ecology, climatology) and communicated how various STEM careers affect communities and improve lives.

3.2. Camera: Affective Enablement

Digital cameras were distributed at the conclusion of each of the six educational activities (one per week), and children were prompted to photograph images conveying their views of and connections with the week's topic. Three subsequent photovoice sessions, scheduled at regular intervals across the 15-week program, allowed children to reflect on what they learned and the connections represented in the images, to narrate their photos, and to discuss the connections between their own and others' photographs and experiences. The final photovoice session involved identifying common themes discussed during photovoice sessions and translating themes into action plans [15]. In this way, the photovoice methodology bridged educational activities with children's action projects [53].

Photovoice is typically employed as a participatory action research method but has also been adopted as an equity- and empowerment-oriented pedagogical technique [54]. When used as a pedagogical technique, photovoice has the potential to support learners to make personal connections to disciplinary content (e.g., [55]), to recognize the value of their subjective experiences, and empower them to conceptualize "new and reflective ways to perceive their own world and the science around them, as well as the potential to generate change in their own community" [56] (p. 340). Regardless of its application, photovoice is a powerful tool that promotes critical and reflexive group dialogue. Participants use photographs as representations of important issues to reflect on community strengths and concerns and collaborate to engage in action to advance social change [57]. In the framework of 'Head, Hands, and Heart,' the photovoice method encouraged participants to experience connection ("Heart") to their surroundings through deeper awareness of the interconnected nature of ecological systems and their own place in them. Moreover, photovoice was intended to facilitate children's ability to make connections between their own lives and SCA's science content, which served both to make seemingly distant and abstract science concepts feel more personally relevant and concrete.

3.3. Action: Behavioral Enactment

Youth-led action projects included: (1) *Family action plans*, crafted by each child in response to personalized carbon footprint feedback, emphasizing behavior change toward sustainability; and (2) *Community action projects*, planned and implemented by each group of children, towards advancing sustainability through community advocacy and action. In the framework of 'Head, Hands, and Heart', these family action plans and community action projects each enabled children to deeply and actively engage with the learned climate change concepts ("Hands") through everyday practices and innovative projects.

For each of the three community action projects, there are outcomes that continue to be felt nearly four years later. Children in a small politically conservative agricultural community prepared a speech that described climate change and some of its global and local impacts. This speech, presented to 60 officials and community members at a city council meeting, included an appeal for permission to begin a tree planting campaign. Not only were they given approval, when trees were planted in a local park, they were accompanied by a plaque commemorating the children's environmental stewardship [15]. Children attending at another site created an education- and action-oriented website designed to raise awareness about climate change and inspire action within their community and beyond. At a gallery event to launch the website, a selection of children's photographs—matted and mounted with titles and short narrative descriptions—were put on display to convey participants' personal connections to climate change topics. Children served as docents to over 100 visitors, discussing the meaning of photographs and directing them to the newly unveiled website to learn more. At the third SCA site, children revitalized an abandoned and overgrown garden on the BCG property. After preparing the garden site (e.g., weeding, turning the soil, spreading compost), children planted more than 100 fruit and vegetable plants. At harvest time, not only did BCG member families and the community have access to fresh local produce, the older children used the produce in educational healthy-eating activities for younger BCG members. In planning for the future, SCA participants created a BCG garden club for all ages to ensure the ongoing maintenance and use of the restored garden space [15]. Inspired by the SCA garden, at least four additional at-home gardens were established that summer by participants' families.

4. The Present Study

This mixed-methods study used surveys and focus groups to explore the impact of SCA on children's science engagement. Learner engagement is a multidimensional construct comprised of interrelated cognitive, affective, and behavioral dimensions [58,59]. For the purposes of this study, "science engagement" encompassed children's perceptions, attitudes, and behaviors related to science. Children's *perceptions* of science included how they thought about science (and scientists) before and after the program as well as their general regard for science. Children's *attitudes* towards science included the extent to which they viewed science as interesting, appealing, and important in school, career, and societal contexts. Conceptually, children's perceptions and attitudes differ in the sense that perceptions encompass mostly knowledge and beliefs, whereas attitudes entail evaluative judgments and feelings. Finally, the behavioral dimension of science engagement was explored through children's narratives of school-based science participation and achievement. The present study was guided by three research questions:

1. How did SCA influence children's perceptions of science?
2. How did children's attitudes towards science change following SCA?
3. How did children describe the influence of SCA on their behavioral engagement with science?

5. Methods

5.1. Participants

Participants were 55 children (52.7% girls; $n = 29$), ages 10 to 12 ($M = 11.1$), who attended one of the three partnering BGC units. For socio-demographic characteristics by research site, see Table 1. Participants were recruited during BGC site visits, through flyers, and via letters to parents. Participation in both SCA and this study were voluntary, and parental consent and youth assent were obtained for all participants. This study was approved by the university's institutional review board.

Table 1. Socio-demographic characteristics by research site.

		Town (*n* = 9)		City (*n* = 19)		Suburb (*n* = 27)		Total (*n* = 55)	
Characteristic		**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
Gender	Girls	7	77.78	12	63.16	10	37.04	29	52.73
	Boys	2	22.22	7	36.84	17	62.96	26	47.27
Age	10	4	44.44	6	31.58	13	48.15	23	41.82
	11	1	11.11	3	15.79	7	25.93	11	20.00
	12	3	33.33	7	36.84	6	22.22	16	29.09
	13	1	11.11	3	15.79	1	3.70	5	9.09
Average Age		11.11 years		11.37 years		10.81 years		11.05 years	
School Grade	4	2	22.22	4	21.05	12	44.44	18	32.73
	5	2	22.22	7	36.84	6	22.22	15	27.27
	6	5	55.56	4	21.05	8	29.63	17	30.91
	7	0	0.00	4	21.05	1	3.70	5	9.09
Race/Ethnicity	White	3	33.33	9	47.37	19	70.37	31	56.36
	Hispanic/Latino	3	33.33	6	31.58	5	18.52	14	25.45
	Multiple Ethnicities	3	33.33	4	21.05	1	3.70	8	14.55
	Other	0	0.00	0	0.00	2	7.41	2	3.64
Free/Reduced Price Lunch		4	44.44	17	89.47	13	48.15	34	61.82
Single Parent Household		3	33.33	10	52.63	11	40.74	24	43.64

5.2. Data Sources and Analysis Procedures

To explore the impact of the program on children's science engagement, pre- and post-program surveys included scales measuring children's attitudes towards school science, attitudes towards the societal implications of science, and attitudes towards careers in science [60], as well as one prompt that asked children to report their most recent overall grade in science class. In the post-survey, children were asked to respond, yes or no, to whether SCA helped them to "like science more", and to write about why. Also in the post-survey, one open-ended item explored children's career aspirations.

Post-program focus groups were conducted to further explore this study's research questions, as well as to clarify and expand on survey findings [61,62]. Specifically, a portion of the focus group guide examined children's thoughts and feelings about science before and after their program participation. In total, 11 focus groups were conducted, averaging four to five children each and lasting an average of 38 min. Focus groups were audio-recorded, transcribed verbatim, edited for accuracy, and then entered into NVivo 10 software [63] for analysis following the process and rules of thematic analysis [64].

6. Results

Findings are organized into three sections aligning with this study's research questions. The first section explores the cognitive dimension of children's science engagement by examining children's perceptions of science (i.e., thoughts, beliefs) before and after the program, including how and why SCA helped them to like science more. The second section explores the primarily affective dimension of children's science engagement by examining differences in their attitudes towards science. Lastly, the third section examines the behavioral dimension of children's science engagement by assessing differences in children's school science achievement as well as their self-reported classroom behavior and career choices. Each section begins with quantitative survey results, followed by focus group findings, which serve to clarify and expand the survey results.

6.1. Children's Perceptions of Science

This study's first research question aimed to explore children's general *perceptions of science*, or "the way[s] in which [science] is regarded, understood, or interpreted" by children [65]. Perceptions of science encompassed general thoughts and beliefs about what science entails, who needs science and why, and the relevance of science to their own lives.

6.1.1. Survey Results

Recognizing that children's general perceptions of science may have influenced whether or not they participated in the program, one open-ended survey item asked children about their motivations for joining SCA. The most common response category was SCA's digital photography component (n = 23, 41.8%), followed closely by participants' fondness for science (n = 21; 38.2%). Other reasons for joining SCA included children's: Belief that SCA would be fun or interesting (n = 15; 27.3%), love for nature (n = 5; 9.1%), eagerness to learn (n = 5; 9.1%), interest in action (n = 3; 5.6%), and desire to be around friends (n = 3; 5.6%).

After the program, children were asked "Did *Science, Camera, Action!* help you to like science more?" and were then prompted to provide an open-ended explanation of their response. Separate thematic analyses [64] were conducted for "Yes" and "No" groups. Most children (n = 46; 88.5%) indicated that SCA did, in fact, have a positive impact on how they regard science. Among the remaining participants (n = 6; 11.5%), several described their love of science as a motivator for joining SCA. Consistent with pre-survey findings, these children perceived SCA to be a venue for engaging in science programming aligned with their existing interests. Of the children who reported that SCA helped them to like science more, most said it was because: (1) SCA was fun and they learned science could be fun; (2) they learned new things in SCA; and (3) they gained a better understanding of the applicability of science to real-world problems. A summary of thematic analyses of children's explanations, along with representative quotations, is provided in Table 2.

6.1.2. Focus Group Findings

Focus group discussions explored children's perceptions of science before and after the program. Before SCA, children's knowledge about, and images of, science and scientists ranged widely. While some valued science as important to know and relevant to their lives, others expressed less familiarity with science. Miguel described his limited exposure to science at school, and Theo reported not knowing a lot about science, while Gabe viewed it as extremely important to society.

> I don't do science at school.
>
> —Miguel (12)

> I don't know much about science.
>
> —Theo (10)

> Overall, I think science is a big help to the human race, and without it, we'd not be where we are now.
>
> —Gabe (12)

A few children explained that SCA expanded their perspectives on science, particularly which types of problems are dealt with by science and how scientists do their work. Some began with simplified impressions of science. To Theo, science was about "making rockets fly". Without having a class in school dedicated explicitly to science, Miguel perceived science to be "all about experiments". Olivia and Nora had similar impressions, sharing that before participating in SCA, they understood science to take place "indoors", such as in laboratories, and focus on "inside" things rather than the environment.

> I thought that science was just like an indoors thing ... Like science experiments and stuff? I didn't know it had anything to do with the outdoors or anything ... We don't need to mix stuff together to make science.
>
> —Olivia (12)

> I thought it was like ... I didn't know that science was like outside things. I thought that was social studies. Social studies and science are two different things. It confused me at the beginning of the program, but I kind of get it now.
>
> —Nora (12)

By including nature in their concept of science, both Olivia and Nora gained more expansive views of what science entails. Olivia remarked that, "Science is actually all around the world". Nora said, "Science opened my mind ... Science is a bigger topic than [I thought]". In the following exchange, three additional participants, all girls, agree that anyone can do science, and that science is much more than "chemicals and labs".

Riley (10): At first, I just thought *scientists* could do science and you had to be a scientist or grow up to be one. But now I know that you don't have to be a scientist, you can be anyone [and do science].
Aubrey (11): Like Riley said, it doesn't matter if someone is a scientist or not because, at the beginning, I thought, like Riley, "You have to be a scientist to know what you're doing". But I learned that if you have enough experience, you don't have to be a scientist ... You can do all this stuff.
Charlotte (10): When I hear the word "science", I think of like chemicals and like labs, but then we're going through this program and it's not just chemicals and labs. It's the Earth and it can be—
Riley: Anything!
Charlotte: —It could be plants, the sky. It could be ... *That* can be science.
Riley: Climate change ... Inventions. It's so magical.

For some, science was interesting because scientific innovation was understood to have a significant impact on people's lives, including the need for science in addressing climate change.

> I think science makes Earth cool because, with science, people can change a lot of things, like how we do this or how we do that.
>
> —James (11)

> [SCA] changed how I felt because now I know that science is all around us and we can do science stuff to help the environment and to help the Earth be healthy and for us to be able to live without any of this bad stuff. Also, that sometimes science can do bad things to the Earth, but if you do more science then it will help fix it, too.
>
> —Olivia (12)

Eleven-year-old Grace explained that SCA enhanced her views of the importance of science. As she put it, "I used to think that science wasn't that important and now I know it's really important and that we can help". Not everyone's views of science changed. For example, 10-year-old Ben said he "[didn't] really think of science differently" because, as he put it, "scientific studies ... can be about anything really".

Table 2. Thematic analysis of *Science, Camera, Action!* (SCA)'s impact on participants' perceptions of science.

Thematic Categories & Representative Quotations †	n ‡ (%)
The program helped me to like science more because . . .	**46 (88.46)**
SCA was fun and I learned that science can be fun. "Because I now know science can be FUN!"—Ali, 12 "Because we did fun activities." —Riley, 10	11 (21.15)
I learned new things in SCA. "I learned things I never knew!"—George, 11 "Because I had learned more about my subjects in school."—Lexi, 11	10 (19.23)
SCA helped me understand the applicability of science. "Yes, because science can help the world."—Gabe, 12 "Yes, because I like helping other people, and science helps people."—Maria, 10	9 (17.31)
It gave me ideas for action-taking to benefit the environment. "[SCA] helped me learn what I could do to help."—Tim, 11 "Because we can save our ecosystem."—Henry, 10	6 (11.54)
SCA made science more interesting. "Because I slept through class in school. Now I don"t."—Nora, 12 "[SCA] helped me like science more because I know there is a point to it."—Noah, 10	4 (7.69)
It built on my existing enjoyment of science. "It allowed me to do a lot of science."—Owen, 12 "Because it made me enjoy the science even more than I did."—Bill, 13	4 (7.69)
It helped me to understand science as a career. "Because it taught about science. Now I kind of want to be a scientist."—Carlos, 10 "Because it helps to know what to do if you become a scientist."—Olivia, 12	2 (3.85)
The program did not help me to like science more because . . .	**6 (11.54)**
I already liked science. "I liked science already too much to add to."—Abigail, 12 "SCA is great, but my love for science is too strong already."—Scarlett, 12	4 (7.69)
The program could be improved. "It didn"t really have interesting activities."—Ben, 10	1 (1.92)
I just don"t like science. "Not really. I still hate science!!"—Kelly, 12	1 (1.92)

Note: n = 52; † Categories appear in order of descending prevalence. Participant responses could be categorized into more than one response type; Bold headings indicate whether perception change occurred; Italics indicate thematic category, followed by direct quotes. ‡ n (%) = number of participant responses corresponding with each thematic category, followed by the percentage of full sample coverage.

6.2. Children's Attitudes Towards Science

This study's second research question explored how the program influenced children's attitudes towards science. Attitudes are simultaneously cognitive and affective in nature and refer to a "general evaluation of an object, person, group, issue, or concept on a dimension ranging from negative to positive" [66]. Attitudes are "feelings" towards the attitude object that are grounded in perceptions (see previous section) and lead to behavior (see next section).

6.2.1. Survey Results

A combined 15 items on the pre-post questionnaire asked children about their attitudes towards school science, science careers, and the societal implications of science. On all constructs, responses ranged from 1 ("Strongly Disagree") to 5 ("Strongly Agree"), with higher scores indicating more positive attitudes.

Attitudes Towards School Science

The "Attitudes Towards School Science" (ATSS) scale [60] consists of seven items (α_{pre} = 0.88; α_{post} = 0.82). Children's school science attitudes were very positive overall, though they were more positive following program participation (*M* = 4.41, *SD* = 0.54), compared to before (*M* = 4.25, *SD* = 0.70). A paired-samples *t*-test was conducted to assess changes in ATSS following program participation. Results of the *t*-test revealed that the mean increase of 0.16 in children's ATSS, 95% CI [0.02, 0.30], was statistically significant, t(52) = 2.22, *p* = 0.031, *d* = 0.30 (see Table 3).

Table 3. Summary of paired-samples *t*-tests for science attitudes and grades.

Variable	Pre	Post					95% CI		Cohen's
	M (SD)	*M (SD)*	*MD*	*t*	*df*	*p*	*LL*	*UL*	*d*
Attitudes Towards School Science	4.25 (0.70)	4.41 (0.54)	+0.16	2.22	52	0.031 *	0.01	0.30	0.30
Attitudes Towards Careers in Science	3.73 (0.78)	4.02 (0.71)	+0.29	2.96	51	0.005 **	0.09	0.49	0.41
Attitudes Towards Societal Implications of Science	4.12 (0.70)	4.33 (0.56)	+0.20	2.13	53	0.038 *	0.01	0.40	0.29
Science Grades	7.20 (2.48)	8.02 (2.10)	+0.81	2.19	53	0.033 *	0.07	1.56	0.30

Note: * $p < 0.05$; ** $p < 0.01$.

Attitudes Towards Science Careers

Five items assessed children's "Attitudes Towards Careers in Science" [60]. Internal consistency correlations were acceptable to good (α_{pre} = 0.73; α_{post} = 0.60). Children's attitudes towards science careers were more favorable after the program (*M* = 4.02, *SD* = 0.71), compared to before (*M* = 3.73, *SD* = 0.78). A paired-samples *t*-test was conducted to assess differences in children's attitudes towards science careers prior to and following their participation in the program. The mean increase of 0.29 in children's attitudes towards science careers, 95% CI [0.09, 0.49], was statistically significant, t(51) = 2.96, *p* = 0.005, *d* = 0.41. Differences in children's science attitudes by research site are summarized in Table 4.

Table 4. Summary of descriptive statistics for children's science engagement.

Variable (Number of Items)	Town (*n* = 9)			City (*n* = 19)			Suburb (*n* = 27)		
	Pre-Survey *M (SD)*	Post-Survey *M (SD)*	*MD*	Pre-Survey *M (SD)*	Post-Survey *M (SD)*	*MD*	Pre-Survey *M (SD)*	Post-Survey *M (SD)*	*MD*
Attitudes Towards School Science (7) [a]	4.08 (0.76)	4.40 (0.40)	+0.32	4.21 (0.72)	4.29 (0.80)	+0.08	4.29 (0.79)	4.43 (0.53)	+0.14
Attitudes Towards Societal Implications of Science (3) [a]	4.33 (0.76)	4.30 (0.72)	−0.04	4.11 (0.75)	4.37 (0.59)	+0.26	4.01 (0.69)	4.33 (0.51)	+0.32
Attitudes Towards Careers in Science (5) [a]	3.87 (0.85)	4.00 (0.81)	+0.13	3.47 (0.86)	3.74 (0.71)	+0.26	3.85 (0.68)	4.12 (0.84)	+0.27
Science Grades (1) [b]	3.56 (0.53)	3.78 (0.44)	+0.22	2.89 (1.24)	3.50 (0.71)	+0.61	3.30 (0.72)	3.63 (0.74)	+0.33
Science Career Aspirations (1, post only) [c]		66.67 (*n* = 6)			42.11 (*n* = 8)			55.56 (*n* = 15)	.

Note: [a] Response range: 1–5, where higher scores indicate more positive attitudes; [b] Response range: 0–4, where scores are coded as grade point averages (0 = F; 4 = A); [c] Response range: 0–100% of participants within each group aspiring to a science career.

Attitudes Towards Societal Implications of Science

Three items assessed children's "Attitudes Towards Societal Implications of Science" [60]. Internal consistency correlations were high (α_{pre} = 0.79; α_{post} = 0.81. Children's attitudes in this domain were very positive overall, though they were more positive following program participation (*M* = 4.33, *SD* = 0.56), compared to before (*M* = 4.12, *SD* = 0.70). A paired-samples *t*-test was conducted to assess pre- and post-program differences in children's attitudes towards the societal implications of science.

The mean increase of 0.21 in children's attitudes towards the societal implications of science, 95% CI [0.01, 0.40], was statistically significant, t(53) = 2.13, $p = 0.038$, $d = 0.29$.

6.2.2. Focus Group Findings

A portion of the focus group guide explored children's generalized attitudes towards science. When asked about their feelings towards science, several children said they viewed science favorably prior to their participation in SCA. For example, 10-year-old Noah said he "always liked" science, while 13-year-old Matthew said he "already liked science". More commonly, children reported that SCA enhanced their interest in, and enjoyment of science. As 10-year-old Lexi put it, "I kind of did not like science before. I do like it now". Girls and boys across ethnicities, age groups, and research sites explained that SCA either deepened their appreciation or changed their attitudes in favor of science. This came about through their enjoyment of SCA activities, viewing science as more accessible, interesting, or valuable.

> I didn't really like science until I actually started to learn more about [it in] the program.
>
> —Bryan (10)

> What I feel about science now is I like it more than I did before.
>
> —Michael (11)

> I enjoy science a lot now. It's one of my favorite subjects now actually.
>
> —Sydney (12)

> I mean, I liked science but I didn't like science *too* much. I didn't think it was very interesting. I can tell you this much, I like my Geo classes a lot more!
>
> —Ali (12)

Some children suggested that SCA captured their interest and held their attention more than school science sometimes did.

> At my school, if there's a topic that we're talking about that doesn't interest me ... science is not actually fun for me. But [SCA] made me care a lot about global warming.
>
> —Athena (10)

> I've been learning about [climate change] in class, but I wasn't paying attention much ... So now I really know what it means and ... how it is.
>
> —Luke (11)

When asked to explain whether his views on science had changed overall, Luke added, "Well, I thought that science was kind of boring and you didn't really have to do it. But when I came here and I knew that it was about climate change and how the world is, I thought of it differently". Climate change made science relevant. Grace expressed a similar view, saying, "I didn't really like [science] before, and I wasn't interested in it. But now I know that you really need to know about it and you can't just ignore the changes happening in the world". For Arie, science went from "not really that interesting" to absolutely essential. As she explained, "Before [SCA], I had thought of [science] as just something to do and something that's not really that interesting. But now ... I'd rather do science now than pretty much anything else".

6.3. Children's Behavioral Engagement with Science

This study's final research question explored how SCA influenced children's science-relevant behaviors. Children's perceptions of, and attitudes towards, science can lead to changes in behavior and behavioral intentions [67]. In this study, children's behavioral engagement with science before and after the program was assessed in the survey and focus group by asking children about their academic performance in school science and their career goals.

6.3.1. Survey Results

To assess the behavioral dimension of children's science engagement, children were also to report their most recent letter grade in science class before the program (i.e., from the fall term) and after the program (i.e., from the spring term). The pre-survey was administered in January, closely following winter break, and the post-survey was administered in May, closely following the end of the school year. In the post-survey, children were also asked about their career aspirations.

Science Grades

For exploratory purposes, children's grades in science class, measured before and after the program, were treated as a proxy measure of children's behavioral science engagement. On the pre-survey, most children reported receiving A's (n = 24, 44.4%) and Bs (n = 22, 40.7%) in science class the previous fall. In the post-survey, 70.4% (n = 38) reported receiving an A grade in science class in the spring term, while 22.2% (n = 12) reported receiving a B. Of the 54 children who completed these items, 20 (37.0%) received improved science grades after the program compared to before, seven (13.0%) received a lower grade, and 27 (50.0%) received the same grade. Scores ranging from 0 (F) to 10 (A+) were subjected to a dependent samples t-test to determine pre- and post-program differences. Results of the t-test revealed that children's science grades improved from the fall term (M = 7.20, SD = 2.48) to the spring term (M = 8.02, SD = 2.10), a statistically significant mean increase of 0.82, 95% CI [0.07, 1.56], t(53) = 2.19, p = 0.033, d = 0.30.

Career Choice

In the post-survey, one open-ended item asked children about their career aspirations. The 55 responses were categorized into major career fields. More than half (52.73%) aspired to a STEM career (see Figure 1). These included careers in physical science (e.g., physicist), earth science (e.g., geologist), space science (e.g., astronomer), and life science (e.g., biologist) careers, as well as applied science careers in engineering, computer science, and medicine.

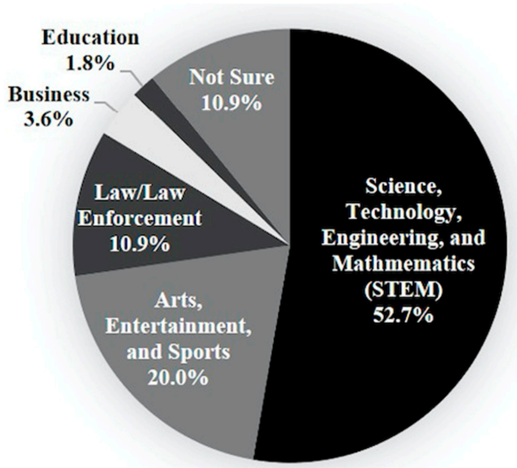

Figure 1. Children's career aspirations by major career category.

6.3.2. Focus Group Results

During focus groups, several children reported that their participation in SCA had a positive impact on their achievement in school science. For some, doing better in school was attributed to their enjoyment of SCA. Ten-year-old Lexi said, "I liked ... learning all this stuff and plus I'm ahead in my class". Others attributed their improved school science performance to an enhanced interest in science, which they gained through SCA.

> [After SCA], I enjoy science *so* much more. Before, I thought science was just one of those things we had to learn and so I wasn't really interested. I did what I had to do to get a good grade. Before I started *Science, Camera, Action!*, I started falling behind in science, but after I started the program it helped me catch up [in school].
>
> —Sydney (12)

A number of children reported that SCA content mapped onto current school science topics. As Scarlett, age 12, explained, "[SCA] helped me out in class because we're kind of learning about the same things at the same times and so I could put more input into my science class because I knew more from here". Children across the age spectrum identified connections between SCA and school science, which made them feel knowledgeable and better able to learn new things in the classroom.

> It helped me learn what we're actually doing in school.
>
> —Daniel (10)

> In science, sometimes I don't know the answers, and now I know a lot more answers about carbon dioxide and that stuff.
>
> —Jack (11)

> With all that ... I've learned here, I feel like it's kind of helped me with my learning ... Because the time that I'm here ... I had time to really understand what I need to in science or social studies.
>
> —Wayne (12)

Several children described feeling more confident in science, which made them more likely to actively participate in science class. As Wayne continued, "I feel like it was easier for me to open up [and say] what I learned [here] at my school and stuff". When asked whether SCA influenced her self-confidence, 10-year-old Peyton said, "When we read books [in science class], they would ask us questions on the side of the books. And I was usually the one that would be most confident to raise my hand and tell them what I know about". After participating in SCA, Scarlett and Arie also felt more confident communicating about science.

> Every year ... we do the school science fair. SCA gave me more ideas for the science fair and gave me more confidence in myself so I could present it to everyone.
>
> —Arie (10)

> I learned how to better communicate what I meant ... because, when we were learning about [climate change] in school, I didn't know to say certain terms. Or how to [choose] my words so that it made sense or got my point clear. I felt like this program really helped me realize how to tell better on what I learned and what I know. How to put that into real life.
>
> —Scarlett (12)

A couple of children explained that their increased interest and confidence in science, gained through SCA, helped them to feel better on school science tests and standardized tests.

> Well, I wasn't really into science [before the program]. But after I got more into science, it actually made me feel better on my tests when I had to take tests.
>
> —Bryan (10)

> I thought [the program] did help because ... we had TCAP [the Transitional Colorado Assessment Program test], and doing this program actually helped me feel more confident on one of the tests. Some people were like, "I don't want to take the test because I don't know a lot about science". But I was ... excited because I know about it.
>
> —Peyton (10)

Others reported getting better grades in science. For Cristy, it was a matter of paying more attention in science class. Jimmy thought joining SCA may help boost his science grades. After the program, he said his science performance had improved a full letter grade.

Cristy (11): I pay attention to class now. I'm getting an A.

Ali (12): I'm getting a B.

Jimmy (10): Before the program, I would usually get C-pluses or C-minuses and now I'm getting either B-pluses or A-minuses.

7. Discussion

The present study explored whether and how SCA—an after-school program focused on climate change learning and action—impacted children's science engagement along cognitive, affective, and behavioral dimensions. SCA combined hands-on climate change educational activities with digital photography (i.e., photovoice methodology) to simultaneously explore and expand children's role as change agents for sustainability in both family and community contexts. Prior to SCA, children's survey-based attitudes towards science were, on average, generally positive. For more than a third of participants, joining SCA was at least partially due to their fondness for science. However, not everyone favored science prior to the program. Although few articulated an explicit dislike for science during focus groups, many discussed their previous indifference or narrow definitions of science. Some children described inattention and poor performance in school science, while others said they completed class requirements satisfactorily, but with little enthusiasm. Following SCA, children's perceptions of science had expanded beyond indoor laboratory-based science to include the outdoors and their everyday environments. Through SCA, science became relevant to their lives, and their attitudes towards science (i.e., in school, careers, and in society) improved significantly. In short, climate change made science interesting and important. The vast majority of the children reported that SCA helped them to like science more, and following the program, more than half aspired to a STEM career. In sum, climate change learning and action became an avenue towards children's increased science engagement.

7.1. Strengthening Children's Science Engagement through Climate Change Learning and Real-World Action

One reason for SCA's positive impact on children's science engagement—even among those who already liked science—could be that the program's content and format diverged from traditional school science in important ways. In particular, SCA emphasized the connections between science and everyday life through place-based, participatory, and action-focused programming. In formal classroom settings, science topics can often be perceived as disconnected from real-world issues [68]. Learning about socio-scientific issues such as climate change, however, can crystallize the connection between what children are learning in the science classroom and their own everyday lived realities [39]. After teaching about atmospheric processes (i.e., the greenhouse effect), SCA brought climate change "down to Earth" through activities focused on people, plants, and animals. Further, SCA brought science content into children's everyday environments through place-based content focused on local ecosystem impacts. A previous article in this series showed that not only did children demonstrate significant knowledge gains through their participation in SCA, they also felt motivated to act on this knowledge and doing so strengthened children's sense of agency to make a difference on climate change [16]. School-based science curriculum is not often associated with action-taking on learned concepts, particularly in U.S. science classrooms [67,68]. An exclusive focus on the cognitive dimensions of science learning without connecting science topics to students' civic engagement, "isolates scientific knowledge and practices from individuals' lived experiences and the immediacy of community life" [69] (pp. 287–288). These researchers have advanced the concept of educated action in science, which "requires both knowing and doing . . . the capacity to leverage scientific knowledge and practices to inform actions(s) taken" (p. 287). Beyond SCA's place-based content, it was likely this pairing of knowing with doing that strengthened children's science engagement. They understood how climate change—and thereby science—was important and relevant to their own everyday lives and behaviors.

Implementing programming like SCA in the formal science classroom, however, is impeded by a number of factors. Some students in this study shared that they did not have school science. While many elementary-aged students receive the recommended 30 min per day [70], infrequent classroom science instruction is not uncommon. This is particularly true in schools not meeting benchmarks on high stakes tests, where instructional time has been shifted away from science in favor of literacy and mathematics [71–73]. Further, science teachers who want to implement projects or link learning to action may face an uphill battle. Teachers face demands to teach in certain ways, to cover certain topics, and—implicitly or explicitly—are discouraged from slowing down to dive deeply into topics or do open-ended projects. Indeed, "implementing project-based science curriculum is challenging in the context of standardized tests, 45-min class periods, large class sizes, and the emphasis on individual grades" [74] (p. 455).

The SCA program—having taken place outside the formal classroom—undoubtedly benefited from increased flexibility on these dimensions, which have been associated with successful science learning outcomes in informal contexts [75–77]. At present, school science policies and practices emphasize the role of education in preparing "future citizens", rather than creating opportunities for children's educated action now. This focus on preparation (e.g., via testing) is a barrier to children's full science engagement. While informal learning spaces that can offer children empowering and constructive ways to learn about climate change are paramount [15], informal and after-school programming alone is not the answer. To adequately address sustainability challenges and to make engaged science the norm, there is a need for larger-scale policy change focused on school reform recognizing children's capacities to be change agents in their communities. Such policies would support teachers in evidence-based instruction and real-world action, making science relevant to the lived realities of learners and their families. Deliberately inviting young people to think about and act on critical societal and global issues—beyond advancing children's sociopolitical inclusion—is a first step towards repositioning science education at the heart of necessary societal transformation to sustainability.

7.2. Promoting Diversity in Science through Climate Change Learning and Collaborative Action

Findings of the present study suggest that, through their participation in SCA, children came to view science as more interesting, accessible, and important. For many, this was due to an expanded view of the scope of science inquiry, who can be a scientist, and how science connects to their lives. Perspectives shifted beyond stereotypical views of scientists in the laboratory or building rockets to scientists whose work takes place in the outdoors and deals with environmental aspects of everyday life. After SCA, some children saw science all around them. This enlarged view of science made it fascinating, and its role in understanding and addressing climate change made it valuable. Although connections between science attitudes and attitudes towards climate change are under-studied, they have been shown to have weak but positive correlations [60]. In this study, knowing about climate change made science important, a finding that resonates with previous studies documenting the expanded significance of science topics when implications are considered beyond the confines of the classroom [39,78]. Viewing science as more approachable and appealing translated into youths' increased confidence and performance in school science. They reported being more engaged. For some children, greater self-confidence and enthusiasm made active participation in science class less effortful, and science tests less daunting. A few participants attributed better grades in science to their participation in SCA, while surveys showed significantly improved science grades by participants overall. Most children left the program aspiring to a science career of some kind, representing a variety of subfields.

These findings are encouraging given the socio-demographic composition of children in SCA, many of whom were from groups underrepresented in science. SCA's participants were mostly girls (52%), nearly half youth of color (44%), and a majority were from low-income households (61%). Issues of equity, access, identity, and confidence still impede the science engagement of underrepresented groups such as girls, racial and ethnic minorities, and economically disadvantaged students [79–81]. From early adolescence, girls express less interest in math and science careers compared to boys [82], with gender differences in STEM self-confidence beginning to emerge in middle school [83]. This makes upper elementary and early middle school, the age of SCA participants, a critical stage for girls' science interest and confidence. Youth of color, despite showing increased interest in science at earlier educational stages, continue to be underrepresented in higher education and careers [84]. Finally, low-income youth often have less access to science enrichment opportunities and after-school activities, and are more likely to attend schools with insufficient resources to support science learning [80,85]. To date, most research on diversifying the sciences looks at marginalized groups based on single identities (e.g., girls or youth of color). It is worth noting that many SCA participants had multiple marginalized identities (e.g., low-income girls of color) and face a combination of barriers to their interest and pursuit of science higher education and careers [86]. In this context, climate change learning and action became an avenue through which to markedly strengthen their overall science engagement.

It is possible that a critical element supporting children's science engagement, in this study, was its collaborative action component. Research on goal congruity in STEM education contends that students' educational and career choices are affected by how much they perceive a career path to align (or dis-align) with their life goals [87]. For example, to the extent that STEM careers are viewed as fulfilling communal goals—of working alongside or helping other people—they are more appealing to girls and many first-generation college students whose socialization emphasizes a communal orientation [87,88]. Similarly, altruistic goals are associated with STEM career interest by underrepresented minority students [85]. Similarly in SCA, children's recognition that science was relevant to their everyday lives supported their overall engagement in the program, and their full-cycle participation provided opportunities for individual and collaborative climate change action, which further emphasized the connections between science learning and addressing real-world challenges. In particular, SCA's collaborative action component was framed in terms of community service and action, which may have contributed to the shift in children's perceptions about the importance of science in society.

To date, when climate change education is paired with an action component, most often it is focused on individual behavior change rather than collaborative sustainability action [42]. In action-focused climate change programming, offering children opportunities to engage in collaborative community-focused action is important because—compared to promoting individual behavior change, which is often framed in terms of personal responsibility—it more accurately frames climate change as a complex, global issue requiring collective, coordinated action region by region. As this study suggests, collaborative action may also play a critical role in helping children from groups underrepresented in science to reimagine science as fitting with their other-oriented goals (i.e., to be communal, altruistic). Through climate change learning and informed action, children were able to see how science permeates every aspect of their daily experience, and many were able to view themselves as future scientists. Inviting children to participate as co-researchers and collaborators in making sense of and acting on sustainability challenges is an additional step towards their full sociopolitical inclusion. Importantly, through SCA, climate change became a portal through which children were able to rethink who can do science, how, and why.

7.3. Transforming Science Education through Climate Change Learning and Action

So far, we have discussed the transformative potential of action-focused climate change programming in terms of its capacity to deepen students' engagement with science. Resonating with previous research [39,68], this study's results show that when children perceive science as relevant to their lives and connected to social change action, its value and attraction grow. As mentioned, this may be especially appealing to children from backgrounds underrepresented in science, an effect which itself could transform the discipline [85,87]. Beyond transforming children's views of science, on a much broader level, action-focused climate change learning has the potential to transform science education in terms of its role in society. Rather than focusing on the STEM "pipeline" and children's "potential" futures, science education could be a societal force for positive social change and building cultures of sustainability today. Doing so would mean making visible the inherent interconnectedness across disciplinary 'subjects' in addressing sustainability challenges and emphasizing children's participatory action in addressing sustainability challenges in local settings.

Sustainability has long been a key site of disciplinary re-integration [12]. Findings of the present study suggest that action-oriented climate change learning can help learners draw linkages across fields framed in the classroom as disparate or disconnected, helping them to better understand and act on sustainability challenges in meaningful ways. Despite having been enculturated into the world of disciplinary silos in the form of school subjects, through SCA, children made connections between, for example, science and social studies through the lens of climate change. Advocates and scholars of scientific literacy have argued for years that traditional disciplinary boundaries are not only arbitrary, but also impede deep understanding of complex socioscientific issues like those related to sustainability [36,37,89]. That SCA participants were seeing the socio-ecological complexity of climate change and the interconnectedness between the sciences and other fields was a key strength of the program [23,24]. Adequately addressing sustainability challenges will require the participation of diverse fields, and appreciating these connections is critical [90,91]. Towards positioning children as agents of change, action-oriented climate change learning can prompt children's awareness of the inseparability of school subjects when focusing on complex environmental problems.

Finally, by taking action on learned concepts, children were reframing the meaning of science education for themselves as well as their families and communities. The SCA program allowed children to engage with science on their own terms through voluntary participation, digital photography, and youth-designed action projects. Importantly, children designed and implemented their own community-focused sustainability projects. Following the program, children reported that they had fun during SCA activities, which made science enjoyable and approachable, rather than boring or intimidating. According to Riemer and colleagues [92], the most successful non-formal youth-based environmental engagement programs tend to provide youth the opportunity to "define the context of their participation" and "act as co-creators or partners" in projects that bring about meaningful change to the youth as individuals or to the communities to which they belong (p. 570).

To their families and communities who were impacted by children's projects, SCA represented a "science program" that had a tangible impact beyond children's learning. By working to address sustainability challenges in locally meaningful ways, SCA became an example of *educated action in science* [69]; children's science knowledge opened up the possibility for their informed action. Rather than framing science education as a pathway to a "competitive edge" grounded in neoliberal logic, this approach to learning positions science education at the center of a broader, more inclusive and collaborative process of cultural transformation to sustainability—one that opens up the possibility of supporting human life and the health of ecosystems amidst unprecedented environmental degradation [5].

8. Limitations

Findings of the present study should be viewed within the context of its limitations. First, this study's non-experimental research design calls into question whether the effects attributed to SCA were, in actuality, due to the influence of the program. A strength of this study's mixed-methods design, however, was that qualitative analyses of focus group discussions clarified the diverse ways that children's perceptual, attitude, and behavior change were directly tied to program content.

Another limitation is this study's small sample size, which precludes robust analyses of effects by sub-group (e.g., demographic characteristics). A further limitation is that, because children self-selected into the program, most already held positive attitudes towards science. As stated previously, children's enjoyment of science was a main reason for enrolling in the program. Children's voluntary participation was a strength of the program, and future research might explore whether children with less positive views of science show similar gains in science engagement. Relatedly, children's preexisting positive views of science may be a reason for their high science grades both before and after the program. As with all findings in this non-experimental study, it is not possible to say with confidence that changes over time are attributable to children's program participation. In future similar studies, data that could otherwise be obtained from primary sources (e.g., report cards) should be sought. Further, more comprehensive documentation of the content of children's school-based learning should be both acquired and accounted for in analyses.

9. Conclusions

As climate change continues to destabilize ecosystems, economies, and societies around the globe, climate scientists and sustainability scholars have continued to make urgent calls, as they have for decades, for rapid societal transformation to sustainability. In this paper, we argue that science education is a key venue for this transformation. Specifically, science education could address the need to substantively involve children and young people in climate change learning and action towards redefining science not as a pathway towards endless competition and domination, but as a collaborative process to envision and enact sustainable futures today. Reimagining science, we argue, begins with forms of engagement that allow children to think about science—and science education—in new ways. The present research explored participatory and action-focused pedagogies that, by positioning children as critical actors for sustainability, simultaneously sought to strengthen and reimagine children's science engagement for the well-being of people and planet.

Findings of the present study suggest that climate change learning and action can support children's engagement with science by emphasizing its real-world significance and by connecting learning with collaborative, community-based action. Making such practices accessible to students in the formal science classroom, we have argued, would require broad shifts in school science policy and practices. Doing so, however, would be worth the effort as the stakes could not be higher [5]. Climate change is increasingly referred to in terms of "crisis" and "chaos". Whereas "crisis" means a *turning point*, the point after which things get better or worse, "chaos" refers to an *opening* or empty space. Some have argued that our position on the precipice of irreversible changes to the climate system is a window of opportunity for transformative change—the kind that promotes the flourishing of human societies and ecosystems. A science education that rises to today's challenges by opening up space for children to be critical actors for sustainability in their communities could be decisive in creating the future that is to be.

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References

1. Schreiner, C.; Henriksen, E.K.; Kirkeby Hansen, P.J. Climate education: Empowering today's youth to meet tomorrow's challenges. *Stud. Sci. Educ.* **2005**, *41*, 3–49. [CrossRef]
2. National Science and Technology Council: Charting a Course for Success, America's Strategy for STEM Education. Available online: https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf (accessed on 22 June 2020).
3. National Academies of Sciences, Engineering, and Medicine. *Developing a National STEM Workforce Strategy: A Workshop Summary*; The National Academies Press: Washington, DC, USA, 2016.
4. Hodson, D. Time for action: Science education for an alternative future. *Int. J. Sci. Educ.* **2003**, *25*, 645–670. [CrossRef]
5. Intergovernmental Panel on Climate Change: Special Report on Global Warming of 1.5 °C. Available online: https://www.ipcc.ch/sr15/ (accessed on 22 June 2020).
6. DeBoer, G. *A History of Ideas in Science Education*; Teachers College Press: New York, NY, USA, 1991.
7. National Science Board: Our Nation's Future Competitiveness Relies on Building a STEM-Capable U.S. Workforce. Available online: https://www.nsf.gov/nsb/sei/companion-brief/NSB-2018-7.pdf (accessed on 22 June 2020).
8. Plutzer, E.; Hannah, A.L.; Rosenau, J.; McCaffrey, M.S.; Berbeco, M.; Reid, A.H. Mixed Messages: How Climate Is Taught in America's Schools. National Center for Science Education. Available online: http://ncse.com/files/MixedMessages.pdf (accessed on 22 June 2020).
9. Domestic Policy Council: American Competitiveness Initiative: Leading the World in Innovation. Available online: https://georgewbush-whitehouse.archives.gov/stateoftheunion/2006/aci/aci06-booklet.pdf (accessed on 22 June 2020).
10. National Commission on Excellence in Education: A Nation at Risk: The Imperative for Educational Reform. Available online: https://www2.ed.gov/pubs/NatAtRisk/index.html (accessed on 22 June 2020).
11. National Defense Education Act Pub. L. No. 85–864, 72 Stat. 1580. Available online: https://www.govinfo.gov/content/pkg/STATUTE-72/pdf/STATUTE-72-Pg1580.pdf (accessed on 22 June 2020).
12. Cook, J.W. (Ed.) *Sustainability, Human Well-Being, and the Future of Education*; Palgrave Macmillan: London, UK, 2019.
13. Meadows, D.; Randers, J. *The Limits to Growth: The 30-Year Update*; Routledge: London, UK, 2012.
14. MacLellan, M. The tragedy of limitless growth: Re-interpreting the tragedy of the commons for a century of climate change. *Environ. Humanit.* **2016**, *7*, 41–58. [CrossRef]
15. Trott, C.D. Reshaping our world: Collaborating with children for community-based climate change. *Action Res.* **2019**, *17*, 42–62. [CrossRef]
16. Trott, C.D. Children's constructive climate change engagement: Empowering awareness, agency, and action. *Environ. Educ. Res.* **2020**, *26*, 532–554. [CrossRef]
17. World Commission on Environment and Development. *The Brundtland Report: Our Common Future*; Oxford University Press: Oxford, UK, 1987.
18. Lewis, S.L.; Maslin, M.A. Defining the anthropocene. *Nature* **2015**, *519*, 171–180. [CrossRef]
19. Wise, S.B. Climate change in the classroom: Patterns, motivations, and barriers to instruction among Colorado science teachers. *J. Geosci. Educ.* **2010**, *58*, 297–309. [CrossRef]
20. Branch, G.; Rosenau, J.; Berbeco, M. Climate education in the classroom: Cloudy with a chance of confusion. *Bull. Atom. Sci.* **2016**, *72*, 89–96. [CrossRef]
21. Hart, P.S.; Nisbet, E.C. Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Commun. Res.* **2012**, *39*, 701–723. [CrossRef]
22. Ojala, M. Regulating worry, promoting hope: How do children, adolescents, and young adults cope with climate change? *Int. J. Environ. Sci. Res.* **2012**, *7*, 537–561.
23. Rousell, D.; Cutter-Mackenzie-Knowles, A. A systematic review of climate change education: Giving children and young people a 'voice' and a 'hand' in redressing climate change. *Child. Geogr.* **2020**, *18*, 191–208. [CrossRef]
24. Feinstein, N.W.; Kirchgasler, K.L. Sustainability in science education? How the Next Generation Science Standards approach sustainability, and why it matters. *Sci. Educ.* **2015**, *99*, 121–144. [CrossRef]

25. Håkansson, M.; Kronlid, D.O.O.; Östman, L. Searching for the political dimension in education for sustainable development: Socially critical, social learning and radical democratic approaches. *Environ. Educ. Res.* **2019**, *25*, 6–32. [CrossRef]
26. Hufnagel, E.; Kelly, G.J.; Henderson, J.A. How the environment is positioned in the Next Generation Science Standards: A critical discourse analysis. *Environ. Educ. Res.* **2019**, *25*, 731–753.
27. Boström, M.; Andersson, E.; Berg, M.; Gustafsson, K.; Gustavsson, E.; Hysing, E.; Lidskog RLöfmarck, E.; Ojala, M.; Olsson JSingleton, B.; Svenberg, S.; et al. Conditions for transformative learning for sustainable development: A theoretical review and approach. *Sustainability* **2018**, *10*, 4479. [CrossRef]
28. Komatsu, H.; Rappleye, J.; Silova, I. Culture and the independent self: Obstacles to environmental sustainability? *Anthropocene* **2019**, *26*, 100198. [CrossRef]
29. Knappe, H.; Holfelder, A.K.; Beer, D.L.; Nanz, P. The politics of making and un-making (sustainable) futures. *Sustain. Sci.* **2018**, *13*, 273–274. [CrossRef]
30. Monroe, M.C.; Plate, R.R.; Oxarart, A.; Bowers, A.; Chaves, W.A. Identifying effective climate change education strategies: A systematic review of the research. *Environ. Educ. Res.* **2019**, *25*, 791–812. [CrossRef]
31. Qvortrup, J. Are children human beings or human becomings? A critical assessment of outcome thinking. *Riv. Internazionale di Sci. Soc.* **2009**, *17*, 631–653.
32. Kellett, M.; Robinson, C.; Burr, R. Images of childhood. In *Doing Research with Children and Young People*; Fraser, S., Lewis, V., Ding, S., Kellett, M., Robinson, C., Eds.; Sage: Thousand Oaks, CA, USA, 2004; pp. 27–42.
33. Mitra, D.; Serriere, S.; Kirshner, B. Youth participation in US contexts: Student voice without a national mandate. *Child. Soc.* **2014**, *28*, 292–304.
34. Wyness, M.; Harrison, L.; Buchanan, I. Childhood, politics and ambiguity: Towards an agenda for children's political inclusion. *Sociology* **2004**, *38*, 81–99. [CrossRef]
35. Elam, M.; Bertilsson, M. Consuming, engaging and confronting science: The emerging dimensions of scientific citizenship. *Eur. J. Soc. Theory* **2003**, *6*, 233–251. [CrossRef]
36. Liu, X. Beyond science literacy: Science and the public. *Int. J. Environ. Sci. Educ.* **2009**, *4*, 301–311.
37. Roth, W.M. Scientific literacy as an emergent feature of collective human praxis. *J. Curric. Stud.* **2003**, *35*, 9–23. [CrossRef]
38. Freire, P. *Pedagogy of the Oppressed*; Penguin: London, UK, 1972.
39. Sadler, T.D. Situated learning in science education: Socio-scientific issues as contexts for practice. *Stud. Sci. Educ.* **2009**, *45*, 1–42. [CrossRef]
40. Barry, B. Sustainability and intergenerational justice. *Theoria* **1997**, *44*, 43–64. [CrossRef]
41. Cutter-Mackenzie, A.; Rousell, D. Education for what? Shaping the field of climate change education with children and young people as co-researchers. *Child. Geog.* **2019**, *17*, 90–104. [CrossRef]
42. Hayward, B. *Children, Citizenship and Environment: Nurturing a Democratic Imagination in a Changing World*; Routledge: London, UK, 2012.
43. Kenis, A.; Mathijs, E. Climate change and post-politics: Repoliticizing the present by imagining the future? *Geoforum* **2014**, *52*, 148–156. [CrossRef]
44. Wals, A.E. Learning our way to sustainability. *J. Educ. Sustain. Dev.* **2011**, *5*, 177–186. [CrossRef]
45. D'Amato, L.G.; Krasny, M.E. Outdoor adventure education: Applying transformative learning theory to understanding instrumental learning and personal growth in environmental education. *J. Environ. Educ.* **2011**, *42*, 237–254. [CrossRef]
46. Hicks, D. *Educating for Hope in Troubled Times: Climate Change and the Transition to a Post-Carbon Future*; Trentham Books Limited: Staffordshire, UK, 2014.
47. Ojala, M. Hope and anticipation in education for a sustainable future. *Futures* **2017**, *94*, 76–84. [CrossRef]
48. Wals, A.E.; Jickling, B. "Sustainability" in higher education: From doublethink and newspeak to critical thinking and meaningful learning. *High Educ. Policy* **2002**, *15*, 221–232. [CrossRef]
49. Sipos, Y.; Battisti, B.; Grimm, K. Achieving transformative sustainability learning: Engaging head, hands and heart. *Int. J. Sustain. High Educ.* **2008**, *9*, 68–86. [CrossRef]
50. Boys and Girls Clubs of America: 2018 Annual Report. Available online: http://www.bgca.org/ (accessed on 22 June 2020).
51. Anderson-Butcher, D.; Newsome, W.S.; Ferrari, T.M. Participation in boys and girls clubs and relationships to youth outcomes. *J. Community Psychol.* **2003**, *31*, 39–55. [CrossRef]

52. Fredricks, J.A.; Hackett, K.; Bregman, A. Participation in Boys and Girls Clubs: Motivation and stage environment fit. *J. Community Psychol.* **2010**, *38*, 369–385. [CrossRef]
53. Cook, K. Grappling with wicked problems: Exploring photovoice as a decolonizing methodology in science education. *Cult. Stud. High Educ.* **2015**, *10*, 581–592. [CrossRef]
54. Derr, V.; Simons, J. A review of photovoice applications in environment, sustainability, and conservation contexts: Is the method maintaining its emancipatory intents? Environmental Education Research. *Environ. Educ. Res.* **2019**, *26*, 1–22.
55. Schell, K.; Ferguson, A.; Hamoline, R.; Shea, J.; Thomas-Maclean, R. Photovoice as a teaching tool: Learning by doing with visual methods. *Int. J. Teach. Learn. High Educ.* **2009**, *21*, 340–352.
56. Cook, K.; Quigley, C.F. Connecting to our community: Utilizing photovoice as a pedagogical tool to connect college students to science. *Int. J. Environ. Sci. Educ.* **2013**, *8*, 339–357. [CrossRef]
57. Wang, C.C.; Morrel-Samuels, S.; Hutchison, P.M.; Bell, L.; Pestronk, R.M. Flint photovoice: Community building among youths, adults, and policymakers. *Am. J. Public Health* **2004**, *94*, 911–913. [CrossRef]
58. Ben-Eliyahu, A. Academic Emotional Learning: A critical component of self-regulated learning in the emotional learning cycle. *Educ. Psychol.* **2019**, *54*, 84–105.
59. Fredricks, J.A.; Blumenfeld, P.C.; Paris, A.H. School engagement: Potential of the concept, state of the evidence. *Rev. Educ. Res.* **2004**, *74*, 59–109. [CrossRef]
60. Dijkstra, E.; Goedhart, M. Development and validation of the ACSI: Measuring students' science attitudes, pro-environmental behaviour, climate change attitudes and knowledge. *Environ. Educ. Res.* **2012**, *18*, 733–749. [CrossRef]
61. Gibson, F. Conducting focus groups with children and young people: Strategies for success. *J. Res. Nurs.* **2007**, *12*, 473–483. [CrossRef]
62. Millward, L. Focus groups. In *Research Methods in Psychology*, 4th ed.; Breakwell, G.M., Smith, J.A., Wright, D.B., Eds.; Sage: Thousand Oaks, CA, USA, 2012; pp. 412–437.
63. QSR International Pty Ltd. NVivo (Released in March 2020). Available online: https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home (accessed on 27 January 2020).
64. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
65. Oxford Dictionaries, s.v. "Perception". Available online: https://en.oxforddictionaries.com/definition/perception (accessed on 27 January 2020).
66. American Psychological Association, s.v. "Attitude". Available online: https://dictionary.apa.org/attitude (accessed on 27 January 2020).
67. Lester, B.T.; Ma, L.; Lee, O.; Lambert, J. Social activism in elementary science education: A science, technology, and society approach to teach global warming. *Int. J. Sci. Educ.* **2006**, *28*, 315–339. [CrossRef]
68. Roth, W.M.; Lee, S. Science education as/for participation in the community. *Sci. Educ.* **2004**, *88*, 263–291. [CrossRef]
69. Birmingham, D.; Calabrese Barton, A. Putting on a green carnival: Youth taking educated action on socioscientific issues. *J. Res. Sci. Teach.* **2014**, *51*, 286–314. [CrossRef]
70. NGSS Lead States. *Next Generation Science Standards: For States, by States*; The National Academies Press: Washington, DC, USA, 2013.
71. Center on Educational Policy Public School Facts and History. Available online: https://www.cep-dc.org/CEP-Publications-Database.cfm (accessed on 27 January 2020).
72. Dougherty, C.; Moore, R. *Educators' Beliefs about Teaching Science and Social Studies in K-3*; ACT: Iowa City, IA, USA, 2019.
73. Milner, A.R.; Sondergeld, T.A.; Demir, A.; Johnson, C.C.; Czerniak, C.M. Elementary teachers' beliefs about teaching science and classroom practice: An examination of pre/post NCLB testing in science. *J. Sci. Teach. Educ.* **2012**, *23*, 111–132. [CrossRef]
74. Barab, S.A.; Luehmann, A.L. Building sustainable science curriculum: Acknowledging and accommodating local adaptation. *Sci. Educ.* **2003**, *87*, 454–467. [CrossRef]
75. Blythe, C.; Harré, N. Inspiring youth sustainability leadership: Six elements of a transformative youth eco-retreat. *Ecopsychology* **2012**, *4*, 336–344. [CrossRef]

76. Hall, C.; Easley, R.; Howard, J.; Halfhide, T. The role of authentic science research and education outreach in increasing community resilience: Case studies using informal education to address ocean acidification and healthy soils. In *Cases on the Diffusion and Adoption of Sustainable Development Practices*; Muga, H.E., Thomas, K.E., Eds.; IGI Global: Pennsylvania, PN, USA, 2013; pp. 376–402.
77. Tan, E.; Calabrese Barton, A.; Kang, H.; O'Neill, T. Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *J. Res. Sci. Teach.* **2013**, *50*, 1143–1179. [CrossRef]
78. Karpudewan, M.; Roth, W.M.; Abdullah, M.N.S.B. Enhancing primary school students' knowledge about global warming and environmental attitude using climate change activities. *Int. J. Sci. Educ.* **2015**, *37*, 31–54. [CrossRef]
79. Brotman, J.S.; Moore, F.M. Girls and science: A review of four themes in the science education literature. *J. Res. Sci. Teach.* **2008**, *445*, 971–1002. [CrossRef]
80. Lee, O.; Buxton, C.A. *Diversity and Equity in Science Education: Theory, Research, and Practice*; Teachers College Press: New York, NY, USA, 2010.
81. National Science Foundation: Women, Minorities, and Persons with Disabilities in Science and Engineering. Available online: https://ncses.nsf.gov/pubs/nsf19304/digest/field-of-degree-minorities (accessed on 22 June 2020).
82. Hill, C.; Corbett, C.; St Rose, A. Why so Few? Women in Science, Technology, Engineering, and Mathematics. 2010. Available online: http://www.aauw.org/learn/research/upload/whysofew.pdf (accessed on 22 June 2020).
83. Lapan, R.T.; Adams, A.; Turner, S.; Hinkelman, J.M. Seventh graders' vocational interest and efficacy expectation patterns. *J. Career Dev.* **2000**, *26*, 215–229. [CrossRef]
84. Thoman, D.B.; Brown, E.R.; Mason, A.Z.; Harmsen, A.G.; Smith, J.L. The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience* **2015**, *65*, 183–188. [CrossRef]
85. Steinberg, D.B.; Simon, V.A. A comparison of gobbies and organized activities among low income urban adolescents. *J. Child. Fam. Stud.* **2019**, *28*, 1182–1195. [CrossRef]
86. Joseph, N.M.; Hailu, M.; Boston, D. Black Women's and Girls' Persistence in the P–20 Mathematics Pipeline: Two Decades of Children, Youth, and Adult Education Research. *Rev. Res. Educ.* **2017**, *41*, 203–227. [CrossRef]
87. Diekman, A.B.; Clark, E.K.; Johnston, A.M.; Brown, E.R.; Steinberg, M. Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for a goal congruity perspective. *J. Pers. Soc. Psychol.* **2011**, *101*, 902–918. [CrossRef]
88. Allen, J.M.; Muragishi, G.A.; Smith, J.L.; Thoman, D.B.; Brown, E.R. To grab and to hold: Cultivating communal goals to overcome cultural and structural barriers in first-generation college students' science interest. *Transl. Issues Psychol. Sci.* **2015**, *14*, 331–341. [CrossRef]
89. Ratcliffe, M.; Grace, M. *Science Education for Citizenship: Teaching Socio-Scientific Issues*; McGraw-Hill Education: New York, NY, USA, 2003.
90. Weinberg, A.E.; Trott, C.D.; McMeeking, L.B.S. Who produces knowledge? Transforming undergraduate students' views of science through participatory action research. *Sci. Educ.* **2018**, *102*, 1155–1175. [CrossRef]
91. Colucci-Gray, L.; Perazzone, A.; Dodman, M.; Camino, E. Science education for sustainability, epistemological reflections and educational practices: From natural sciences to trans-disciplinarity. *Cult. Stu. Sci. Educ.* **2013**, *10*, 127–183. [CrossRef]
92. Riemer, M.; Lynes, J.; Hickman, G. A model for developing and assessing youth-based environmental engagement programmes. *Environ. Educ. Res.* **2014**, *20*, 552–574. [CrossRef]