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Lasting Conservation and Science-Related Outcomes Associated with Science Education, Environmental Education, and Outdoor Science Education

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Abstract
Science and environmental education may promote life-long engagement in science and environmental conservation. We used hierarchical multiple linear regression to investigate how childhood participation in science education, environmental education, and outdoor science education interact to encourage long-term participation in science and support for local environments. Our survey of 231 high school students in North Carolina suggests outdoor science education is positively associated with enjoying time outdoors (p = 0.065) and the perception of the value of local natural resources (p = 0.021) four to seven years later. We also found support for science confidence following a science education program (p = 0.004).

Keywords: environmental education, science education, outdoor science education, natural resources, science confidence

To address current environmental challenges, we need citizens who understand the science of complex environmental problems, have the skills to address them, and are motivated to do so. Environmental challenges including biodiversity loss (Cardinale et al., 2012) and climate change (IPCC, 2018) represent pressing global issues with potentially devastating repercussions. These are complex problems requiring a scientifically and environmentally literate citizenry. Scientific literacy includes scientific knowledge, dispositions, skills, and behaviors (Laugksch, 2000; OECD, 2014). Environmental literacy includes parallel constructs, but emphasizes affective (e.g., pro-environmental attitudes) and behavioral dimensions (Hollweg et al., 2011), and is often developed through nature-based learning (Ballantyne & Packer, 2002; Kuo, Barnes, & Jordan, 2019). In short, scientific literacy includes what people know and can do about science, and environmental literacy includes a focus on what people know and how people feel and act with regard to the environment.

Perhaps because the fields have developed in parallel, science education (SE) and environmental education (EE) can result in synergistic benefits for learners. These fields have distinct instructional approaches, with SE efforts most often situated in formal settings like classrooms and focusing on outcomes related to knowledge and skills, and EE efforts focusing more on outcomes related to affect and behavior in non-formal and informal settings like the outdoors (Dillon & Scott, 2002; Gough, 2002; Littledyke, 2008; Wals, Brody, Dillon, & Stevenson, 2014). Despite these differences, SE and EE have been intertwined for decades, creating significant overlap (Wals et al., 2014). For instance, SE was presented as the primary tool for solving environmental problems (Gough, 2002), early conceptualizations of EE emphasized science learning (e.g., the *Tbilisi Declaration*; UNESCO, 1977), and, when included in formal settings, EE is typically conducted in conjunction with science instruction rather than other subjects such as social studies, English, or art (Gough, 2002; Rickinson, 2001). Outdoor science education (OSE) explicitly bridges SE and EE by focusing on science content knowledge while simultaneously encouraging pro-environmental attitudes (Carrier et al., 2014; Cronin-Jones, 2000), creating an opportunity to foster both SE- and EE- related outcomes.

When SE and EE approaches are employed in tandem through OSE, they may result in long-term gains for both science and environmental literacy outcomes. Specifically, OSE may boost science learning (Cronin-Jones, 2000; Rios & Brewer, 2014), provide context that reinforces recollection of long-term content knowledge (Carrier et al., 2014; Dillon & Scott, 2002; Falk & Dierking, 2010), and promote pro-environmental attitudes and behaviors (Ballantyne & Packer, 2005; Bogner, 1998). Research suggests that these synergistic benefits of OSE can result in retention of program content knowledge as well as pro-environmental attitudes up to three months after an OSE experience (Dettmann-Easler & Pease, 1999; Stern, Powell, & Ardoin, 2008). Previous qualitative research focused on the persistence of outcomes demonstrates that OSE experiences can generate vivid memories and perceived pro-environmental attitudes that persist up to a year following an intervention (Farmer, Knapp, & Benton, 2007). More recent research focused on the efficacy of outdoor learning highlights its role in improving student scores on academic assessments across multiple disciplines including science (Dillon et al., 2016). Carrier and colleagues (2014) found adults were more likely to recall science lessons from their childhood when the lessons occurred outside. Similarly, although EE traditions often emphasize affective learning (Iozzi, 1989; Littledyke, 2008), knowledge-based SE approaches may reinforce EE outcomes. Knowledge alone does not lead to conservation behaviors, but it does play a role (Kollmuss & Agyeman, 2002). Similarly, knowledge alone is not a direct driver of behavior, but is essential to sound environmental decision-making (Frisk & Larson, 2011). Further, significant life experience research has identified knowledge-based activities including relevant readings and coursework as influential in life-long environmental engagement (Chawla, 1998; Tanner, 1980).

Early interventions are most likely to promote long-term gains in science and environmental literacy. Early learning experiences may change general attitudes and orientations including science interest and motivation (Bruce, Bruce, Conrad, & Huang, 1997; Eshach & Fried, 2005; Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012) and environmental sensitivity (Chawla, 1998; Peterson, 1982), which may lead to life-long patterns in behaviors such as pursuing a STEM major in college (Maltese & Tai, 2010; Prévot, Clayton, & Mathevet, 2018) and environmental action (Lester, Ma, Lee, & Lambert, 2007), respectively. For instance, childhood SE experiences may lead children to develop positive attitudes toward and interest in science (Eshach & Fried, 2005; Randler & Hulde, 2007), which promote long-term engagement with science (Crawley & Black 1992; Maltese & Tai, 2010). Within the context of EE, interventions early in life play an important role in the development of "life-long attitudes, values, and patterns of behavior toward natural environments" (Wilson, 1996, p. 2). Wells and Lekies (2006) suggest participation in nature-based activities as a child leads to pro-environmental attitudes and to some degree, pro-environmental behavior among adults. Heberlein (2012) strengthens the argument for working with children by suggesting that their attitudes are more susceptible to change than those of adults.

What is less understood is the degree to which short-term synergistic benefits of blending SE and EE approaches persist as learners' age. Much of the previous research on long-term impacts of SE and EE has focused on single domains, such as the perceived benefits of childhood outdoor experiences on life-long environmental engagement (Chawla, 1999; Wells & Lekies, 2006) or early science interventions in building science competencies that translate to sustained interest and motivation regarding science (Eshach & Fried, 2005; Tyler-Wood et al., 2012). Research focused on citizen science efforts that include elements of both SE and EE demonstrate the short-term synergistic potential of OSE (Lewandowski & Oberhauser, 2017; Schuttler, Sorensen, Jordan, Cooper, & Shwartz, 2018), but additional research is needed to explore how these relationships may continue to support one another over time. A review of nature-based citizen science literature conducted by Schuttler and colleagues (2018) highlights SE outcomes such as increased science knowledge, and EE outcomes including increased engagement with nature and the development of an emotional connection with nature, but Schuttler et al. found no studies that examine these variables over time. While OSE may simultaneously build science efficacy and connection to nature (Carrier et al., 2014), we do not know the degree to which that experience will continue to lead to long-term outcomes such as interest in science careers or support for conservation. Identifying the degree to which key childhood experiences reinforce both SE and EE outcomes may shed light on how to maximize early interventions to foster a citizenry that has the scientific know-how and deep commitment to addressing environmental challenges.

This study seeks to improve our understanding of the mutualistic and long-term impacts of SE, EE, and OSE through a case study of high school students in western North Carolina. We measured the presence of potential intermediate affect-related outcomes (i.e., science confidence, enjoying time outdoors) and long-term behavioral outcomes (i.e., pursuit of a STEM major in college, support for local natural resources) from differing education programs. This approach differs from the methodology of several retrospective studies, which have asked adult participants to self-identify the linkages between experiences and their commitment to the environment as demonstrated by career choice or specific actions (Chawla, 1999, 2007; James, Bixler, & Vadala, 2010; Palmer, Suggate, Robottom & Hart, 1999; Tanner, 1980). These studies may be subject to recall and selection biases, as long-term retrospective recall has been identified as a poor measurement of actual events (Golden, Wrangham, & Brashares, 2013). The present study reduces recall bias by engaging adolescents, versus adults, who are closer in age to participation in the educational programs. It limits selection bias by engaging a broad sample of high school students who were not chosen based on exhibiting extraordinary interest and engagement with the environment. We tested five hypotheses:

- H_1: Participation in a multi-year long SE program in high school will be positively related to the intention to pursue a STEM major in college, as mediated by individuals' science confidence.
- H_2: Participation in a multi-year long EE program will be positively related to support for local natural resources, which will be mediated by enjoying time outdoors.
- H_3: Participation in a yearlong OSE program in fifth grade will be positively related to the intention to pursue a STEM major in college and support for natural resources in high school, which will be mediated by science confidence and enjoying time outdoors, respectively.
- H_4: Enjoying time outdoors will strengthen the positive relationship between science confidence and the intention to pursue a STEM major in college.
- H_5: Science confidence will strengthen the positive relationship between enjoying time outdoors and support for natural resources.

Methods

Sampling

This study sampled high school students, as this group includes emerging adulthood developmental stages, when identities and worldviews are beginning to solidify and influence life paths and career trajectories (Arnett, 2000; Kroger, Martinussen, & Marcia, 2010). Additionally, the high school years (i.e., ages 14-18) are proximate enough to childhood that the recalled memories of childhood experiences may be more accurate than those of adults (Brewin, Andrews, & Gotlib, 1993; Halverson, 1988; Stevenson et al., 2014). We surveyed students from two high schools in Transylvania County located in western North Carolina through May and June of 2017. The high schools were selected because the students in these schools would have participated in the OSE program included in this study if they lived in the area during fifth grade, as well as had opportunity to participate in the EE and SE programs of interest. The guidance counseling office at each high school emailed their respective student bodies with a request to complete our survey. In addition, a student volunteer at one of the high schools visited individual classes to encourage students to complete the survey. The possible sample included 1,068 students (731 at school A and 337 at school B), with a total of 186 students responding from school A (25% response rate) and 45 students responding from school B (13% response rate) for a total of 231 responses (22% response rate). Our sample included ninth-grade students (n=51), tenth-grade students (n= 55), eleventh-grade students (n=70), and twelfth-grade students (n=55). A majority (64.1%) of the responding students identified as female (n=148), 32.5% identified as male (n=75), and 3.5% identified as other (n=8). The sample was primarily comprised of students identifying as White (n=186, 85.7%), with fewer Hispanic (n=4, 1.8%), Black (n=4, 1.8%), Asian (n=3, 1.4%), Native American (n=2, 0.9%), and mixed ethnicity students (n=17, 12.8%). Due to the small sample size race was broken into two categories in our analysis with students identifying as White being categorized as White and all other students being categorized as non-White. The socio-economic status of the schools was evaluated by determining the percentage of students eligible for free or reduced-price lunch (Nicholson, Slater, Chriqui, & Chaloupka, 2014). School A had 291 students eligible for free or reduced-price lunch, accounting for nearly 40% of the student population, whereas school B had 148 eligible students, accounting for nearly 44% of the student population.

Choice of Activities

For this study, we assessed whether students participated in programs exemplifying SE, EE, and OSE. The three programs we asked students about were Time 4 Real Science (SE), scouting (i.e., Boy Scouts/Girl Scouts; EE), and Muddy Sneakers (OSE) (see Table 1).

Time 4 Real Science is an after-school SE program for high school students, representing a partnership between the local school district and the county 4H Youth Development program. Participants are ninth through twelfth graders who spend 250 hours during and after school conducting scientific research in partnership with teachers and volunteer scientists from the community (Time 4 Real Science, 2019). Participation in the Time 4 Real Science Program varies so some of the students may have been actively involved in the program at the time they completed the survey for this study.

In this study, scouting includes participating in either the Boy Scouts of America or the Girl Scouts of the USA. Individuals can participate in scouting from kindergarten through high school (Boy Scouts of America, 2019; Girl Scouts, 2019). Scouts cover a wide range of topics with emphasis on providing "leadership development experiences" (Girl Scouts, 2019) as well as youth development and character building (Boy Scouts of America, 2019). Both organizations offer several experiences related to enjoying and appreciating natural resources (Boy Scouts of America, 2019; Girl Scouts, 2019). It is possible that participants in this study were actively involved with Scouts at the time they completed the survey, or that their involvement ended several years prior.

Muddy Sneakers teaches fifth-grade science curriculum through experiential learning in local natural settings. The program is integrated into participating fifth-grade public schools in the western and Piedmont regions of the Carolinas. Students participating in the program spend six to ten full school days over the course of the school year in local natural areas engaging in nature-based scientific inquiry focused around the core concepts of the state science curricula (Muddy Sneakers, n.d.). As Muddy Sneakers was operating in all of the Transylvania County elementary schools at the time when the respondents were in fifth grade, our high school study participants likely participated in Muddy Sneakers if they attended one of the county's elementary schools. Participation in the Muddy Sneakers program would have concluded four to seven years before the survey for this study was administered.

Of the three programs, Muddy Sneakers is the only program that is mandatory as it is incorporated into the normal school day. Time 4 Real Science and scouting are both voluntary programs that students can sign up for outside of normal school hours. Though this does represent program variability, it offers an opportunity to contextualize how OSE among a general student population (i.e., not self-selected) may promote SE and EE outcomes as compared with those who self-select, who we might expect to report greater scores on respective outcome variables. Some respondents participated in more than one program; in such instances our study counted them for each program in which they participated.

Table 1. Program descriptions, participation age, duration, and enrollment type

Programs	Program description	Participation age range	Duration	Voluntary/integrated
Time 4 Real Science (SE)	After school research-oriented SE program	14-18 year olds	250 hours	Voluntary opt-in enrollment
Scouting (EE)	After school EE focused program	5-18 year olds	Dependent on individual but typically meet once a week	Voluntary opt-in enrollment
Muddy Sneakers (OSE)	In school OSE in a local natural area	10-11 year olds	6-10 school days	Integrated into school field trips for all fifth graders

We chose these programs for both their availability within the study area as well as their inclusion of approaches linked to our variables of interest. Here, we outline distinctive approaches to which the literature points as emblematic of SE or EE. Note that these approaches are not mutually exclusive (e.g., SE can occur outdoors, EE can employ SE practices), but rather reflect associated emphases from these educational traditions (Gough, 2002; Wals et al., 2014). Time 4 Real Science includes key attributes of impactful SE: starting during childhood (Eshach & Fried, 2005; Maltese & Tai, 2010; Tyler-Wood et al., 2012), allowing for student-directed learning where students can pursue experiences that interest them, and allowing students to make direct connections to their own lives (Carrier & Stevenson, 2017; Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Lawson et al., 2018; Lindemann-Matthies, 2005; Renninger, 2006) (Table 2). Key outcomes of the Time 4 Real Science program are to develop science-related skills and prepare students to become scientists. Time 4 Real Science has been active in the study area since 2006 and partners with the 4H youth development program. Scouting includes key attributes of impactful EE: starting during childhood (Braun & Dierkes, 2017; Wells & Lekies, 2006), using outdoor settings (Braun & Dierkes, 2017; Cronin-Jones, 2000; Martin, 2003), providing opportunities for participants to interact with positive role models (Chawla, 1999; Tanner, 1980), and having longer duration or repeated interventions (Bogner, 1998; Braun & Dierkes, 2017; Cronin-Jones, 2000; Rickinson, 2001; Stern et al., 2008) (Table 2). Scouts have been active in the study area for 100 years (Boy Scouts of America: Daniel Boone Council, 2020). Key outcomes associated with scouting include character development, hands-on learning, and building an appreciation for the natural world. Muddy Sneakers includes all of the attributes listed for both Time 4 Real Science and scouting (Carrier & Stevenson, 2017; Carrier et al., 2014; Priest, 1986) (Table 2). Key outcomes associated with Muddy Sneakers include teaching state science curriculum through outdoor experiences and developing an affective relationship with local natural resources.

Table 2. Key attributes supporting educational approaches

Educational Approaches	Best Practices	Supporting Literature
Science Education	Connection to students' lives	Carrier & Stevenson, 2017
	Childhood experiences	Eshach & Fried, 2005; Maltese & Tai, 2010; Stake & Mares, 2001; Tyler-Wood et al., 2012
	Free-choice learning and learner-centered environments	Ballantyne & Packer, 2005; Carrier & Stevenson, 2017; Dierking et al., 2003; Renninger, 2006
	Longer duration and/or repeated interventions	Carrier & Stevenson, 2017
Environmental Education	Childhood experiences	Braun & Dierkes, 2017; Chawla, 1999; Dillon et al., 2016; Tanner, 1980; Vadala, Bixler, & James, 2007; Wells & Lekies, 2006
	Outdoor settings	Ballantyne & Packer, 2002; Carrier, 2009
	Positive role models	Chawla, 1999; Sivek, 2002; Sward, 1999; Tanner, 1980
	Longer duration and/or repeated interventions	Bogner, 1998; Braun & Dierkes, 2017; Cronin-Jones, 2000; Stern et al., 2008
Outdoor Science Education	All of the above	All of the above

Survey Instrument

The survey instrument included questions focused on conservation and science attitudes, as well as questions about participation in specific SE, EE, and OSE programs. Respondents self-reported participation in Time 4 Real Science (SE), scouting (EE), and Muddy Sneakers (OSE) programming. We measured the intermediate SE outcome "science confidence" with a scale consisting of nine questions previously used with adolescents (Unfried, Faber, Stanhope, & Wiebe, 2015). The scale displayed acceptable reliability (Cronbach's alpha = 0.94) and a principal component factor analysis indicated all items were associated with a single factor with factor loadings > 0.4 (Table 3) (Comrey & Lee, 2013). The scores for the nine questions were added up for a maximum composite score of 45. We used "intention to pursue a science major in college" as a long-term SE outcome. We asked participants to indicate whether they planned to go to college and if so, what was their intended major. Respondents selected from a list of common majors, and we collapsed those choices into STEM (math, physical sciences, biological sciences, and medicine) and non-STEM majors (English, economics, education, psychology, communications, and history). We measured the intermediate EE outcome enjoying time outdoors with a single question: "Are you someone who enjoys spending time in the outdoors?" and respondents indicated their level of agreement by selecting one of five responses on a Likert scale ranging from "not at all" to "very much." The long-term EE outcome was measured by asking individuals "Do you think Transylvania County's natural resources are important to the community?", which was scored using a five-point Likert scale ranging from "not at all" to "very much." We used a single item to measure "enjoying time outdoors" and "support for local natural resources" as they captured what we were interested in and contributed to our goal of a parsimonious survey instrument. Students also self-reported grade level, gender, and race. The final survey instrument drew from previously validated instruments and was subject to expert review, as well as review by high school students to ensure its appropriateness for our target population.

Table 3. Principal component factor analysis of science confidence scale items

Science confidence items	Factor
I am confident in science classes	0.74
I would consider a career in science	0.87
I expect to use science when I graduate from school	0.91
Knowing science will help me earn a living	0.87
I will need science for my future work	0.88
I know I can do well in science	0.79
Science will be important to me in my life's work	0.91
I can handle most subjects well, but I struggle in science	0.48
I am sure I could do advanced work in science	0.85
Chronbach's alpha = 0.94	

Note: These items come from a previously validated scale (Unfried et al., 2015). Response items included: Strongly agree, Agree, Neither agree or disagree, Disagree, Strongly disagree.

Data Analysis

We analyzed the data using STATA software, version 14.2. We tested hypotheses 1-3 using stepwise multiple linear regression to conduct mediation analyses using the Sobel Goodman mediation test, following guidelines laid out by MacKinnon, Warsi and Dwyer (1995). We conducted mediation analyses in three steps: 1) testing in sequence the relationship between each program (Time 4 Real Science, Scouts, and Muddy Sneakers) and its relationship with intermediate outcomes (science confidence, enjoying time outdoors); 2) testing the relationship between each program and long-term outcomes (intention to pursue a STEM major, support for local natural resources); and 3) testing the relationship between each program and long-term outcomes, controlling for intermediate outcomes (Table 4). We first regressed science confidence (Step 1A, Table 6) and enjoying time outdoors (Step 1B, Table 7) on participation in the three programs. Second, we regressed intention to pursue a STEM major (Step 2A, Table 6) and support for local natural resources (Step 2B, Table 7) on participation in the three programs. Third, we regressed intention to pursue a STEM major (Step 3A, Table 6) and support for local natural resources (Step 3B, Table 7) on science confidence, enjoying time outdoors, and participation in the three programs.

We tested hypotheses 4 and 5 using stepwise linear regression to conduct moderation analyses in three steps: 1) testing in sequence the relationship between each program and long-term outcomes, controlling for intermediate outcomes; 2) testing the relationship between each program and long-term outcomes, controlling for both SE and EE intermediate outcomes; and 3) testing the relationship between each program and long-term outcomes, controlling for both SE and EE intermediate outcomes, as well as the interaction between the two intermediate outcomes (Table 5). We first regressed science confidence (Step 1C, Table 8) and enjoying time outdoors (Step 1D, Table 9) on participation in the three programs. Second, we regressed intention to pursue a STEM major (Step 2C, Table 8) and support for local natural resources (Step 2D, Table 9) on science confidence, enjoying time outdoors, and participation in three programs. Third, we regressed intention to pursue a STEM major (Step 3C, Table 8) and support for local natural resources (Step 3D, Table 9) on science confidence, enjoying time outdoors, science confidence*enjoying time outdoors, and participation in the three programs. Examining the moderating effects of intermediary outcomes allows us to explore the moderating potential of SE intermediate outcomes (science confidence) on EE long-term outcomes (support for local natural resources) and EE intermediate outcomes (enjoying time outdoors) on SE long-term outcomes (intention to pursue a STEM major). In all regression models, we controlled for demographics including the high school attended, grade level, gender, and race.

Table 4. Stepwise mediation analysis

	Description of Analysis Steps	**Intent to Pursue STEM Major (Analysis A)**	**Support for Local Natural Resources (Analysis B)**
Mediation Analysis	**Step 1:** Test if program participation predicts intermediary outcome	OSE + SE + EE = Science Confidence	OSE + SE + EE = Enjoying Time Outdoors
	Step 2: Test if intermediate outcome predicts long-term outcome	OSE + SE + EE = Intent to Pursue STEM Major	OSE + SE + EE = Support for Local Natural Resources
	Step 3: Test if program participation predicts long-term outcome when controlling for intermediate outcome	OSE + SE + EE + Science Confidence = Intent to Pursue STEM Major	OSE + SE + EE + Enjoying Time Outdoors = Support for Local Natural Resources

Note: This table provides a step-by-step roadmap of the mediation analyses.

Table 5. Stepwise moderation analysis

	Description of Analysis Steps	Intent to Pursue STEM Major (Analysis C)	Support for local Natural Resources (Analysis D)
Moderation Analysis	**Step 1:** Test if program participation predicts long-term outcome when controlling for intermediate outcome	OSE + SE + EE + Science Confidence = Intent to Pursue STEM Major	OSE + SE + EE + Enjoying Time Outdoors = Support for Local Natural Resources
	Step 2: Test if program participation predicts long-term outcome when controlling for both SE and EE intermediate outcomes	OSE + SE + EE + Science Confidence + Enjoying Time Outdoors = Intent to Pursue STEM Major	OSE + SE + EE + Science Confidence + Enjoying Time Outdoors = Support for Local Natural Resources
	Step 3: Test if program participation predicts long-term outcome when controlling for both SE and EE intermediate outcomes and the interaction between intermediate outcomes	OSE + SE + EE + Science Confidence + Enjoying Time Outdoors + Science Confidence*Enjoying Time Outdoors = Intent to Pursue STEM Major	OSE + SE + EE + Science Confidence + Enjoying Time Outdoors + Science Confidence*Enjoying Time Outdoors = Support for Local Natural Resources

Note: This table provides a step-by-step roadmap of the moderation analyses.

Results

Nearly three-quarters of the students surveyed participated in Muddy Sneakers (OSE program) (n = 170, 73.59%), with fewer Scouts (EE Program) (n = 53, 22.94%) and Time 4 Real Science participants (SE program) (n = 21, 9.09%). There was overlap between the three groups with 16 students participating in both Muddy Sneakers and Time 4 Real Science, 36 students participating in Muddy Sneakers and scouts, one student participating in Time 4 Real Science and scouts, and two students participating in all three programs. Aggregate mean scores for students' enjoyment of time outdoors was 3.85 out of 5.00 (*sd* = 1.11), and confidence in science was 29.40 out of 45.00 (*sd* = 8.18). Few students planned to major in science (n = 71, 32.13%). Support for local natural resources was 4.57 out of 5.00 (*sd* = 0.78).

We found partial support for hypothesis 1, as participation in the SE program Time 4 Real Science predicted the intermediate SE outcome science confidence (B = 5.529; p = 0.004) (Step 1A, Table 6, Figure 1), and science confidence predicted the long-term SE outcome interest in pursuing a STEM major (B = 0.030; $p <$ 0.001) (Step 3A, Table 6, Figure 1). Specifically, students participating in Time 4 Real Science (SE program) were 18.09% more confident on average than those that did not participate (*SE* = 1.908). However, science confidence did not mediate the relationship between Time 4 Real Science and interest in pursuing a STEM major, as there was no relationship between participation in Time 4 Real Science and intention to pursue a STEM major in college (Step 2A, Table 6).

We did not detect support for hypothesis 2, with no relationship between participation in the EE program scouts and the intermediate EE outcome enjoying time outdoors (Step 1B, Table 7, Figure 1) or the long-term EE outcome support for local natural resources (Step 2B, Table 7, Figure 1).

We found partial support for hypothesis 3, as participation in the OSE program Muddy Sneakers served as a weak predictor for the intermediate EE outcome enjoying time outdoors ($B = 0.324$; $p = 0.065$) (Step 1B, Table 7, Figure 1), and enjoying time outdoors predicted the long-term EE outcome appreciation for local natural resources ($B = 0.279$; $p = 0.016$) (Step 3B, Table 7, Figure 1). Specifically, students participating in Muddy Sneakers reported enjoying time outdoors an average of 10.68% ($SE = 0.175$) more than those who did not participate and individuals that enjoyed time outdoors were on average 5.01% ($SE = 0.046$) more supportive of local natural resources. We did not detect a relationship between Muddy Sneakers participation and SE outcomes (Step 1A and 2A, Table 6, Figure 1).

We did not find support for hypothesis 4, as the moderating relationship between enjoying time outdoors and the relationship between science confidence and intention to pursue a STEM major was marginal ($B = 0.005$; $p = 0.091$) (Step 3C, Table 8, Figure 1). We also failed to detect support for hypothesis 5, the moderating effects of science confidence on the relationship between enjoying time outdoors and support for local natural resources (Step 3D, Table 9, Figure 1).

Although we did not have hypotheses associated with demographic control variables, several relationships were detected. Girls expressed a higher level of intention to choose a STEM major in college than boys across models 2A ($B = 0.163$; $p = 0.019$), 3A ($B = 0.126$; $p = 0.035$) (Table 6), and 3C ($B = 0.123$; $p = 0.039$) (Table 8). Students attending high school A and girls were more supportive of local natural resources than boys across model 2B ($B = 0.252$; $p = 0.021$), 3B ($B = 0.241$; $p = 0.027$) (Table 7), and 3D ($B = 0.222$; $p = 0.040$) (Table 9). Given that boys have been shown to demonstrate greater interest and engagement with science than girls during middle school (Catsambis, 1995), and some studies have shown that OSE may be effective at engaging girls (Tyler-Wood et al., 2012), we also tested for an interaction between girls and the OSE intervention. However, we found no moderating relationship of OSE between gender and science confidence ($B = 0.951$; $p = 0.751$) or gender and intention to pursue a STEM major ($B = 0.143$; $p = 0.366$). Although the relationships were weak, younger students expressed greater enjoyment of time outdoors ($B = -0.129$; $p = 0.066$) (Step 1B, Table 7) and students identifying as non-white expressed lower levels of enjoyment of time outdoors and support for local natural resources ($B = -0.264$; $p = 0.086$) (model 3D, Table 7).

Table 6. Mediation Analysis: factors predicting intention to choose a STEM major

	Science Confidence Step 1A			Intention for STEM Major - Step 2A			Intention for STEM Major Step 3A		
	Beta	**Std. Beta**	***p***	**Beta**	**Std. Beta**	***P***	**Beta**	**Std. Beta**	***p***
Muddy Sneakers	1.240	0.067	0.325	-0.009	-0.008	0.909	-0.044	-0.041	0.506
Scouts	1.410	0.072	0.290	0.006	0.005	0.945	-0.034	-0.030	0.628
Time 4 Real Science	5.529	0.196	0.004**	0.081	0.050	0.474	-0.079	-0.049	0.424
Science Confidence							0.030	0.523	<0.001***
High School	0.428	0.021	0.761	-0.034	-0.029	0.694	-0.043	-0.037	0.554
Grade	-0.690	-0.093	0.169	-0.020	-0.046	0.512	-0.002	-0.004	0.947
Gender	1.321	0.077	0.248	0.163	0.164	0.019*	0.126	0.127	0.035*
Race	0.894	0.037	0.585	0.010	0.007	0.920	-0.009	-0.006	0.918
Intercept	27.949		0.000	0.302		0.054	-0.549		0.001
P	0.043*			0.431			<0.001***		
R^2	0.034			<0.001			0.264		
N	223			213			213		

Notes: Gender (Male = 0, Female = 1), Race (White = 0, non-White = 1)
$^+$ $p \leq 0.1$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 7. Mediation Analysis: factors predicting support for local natural resources

	Enjoying Time Outdoors Step 1B			Support for Local NR Step 2B			Support for Local NR Step 3B		
	Beta	**Std. Beta**	***p***	**Beta**	**Std. Beta**	***P***	**Beta**	**Std. Beta**	***p***
Muddy Sneakers	0.324	0.128	0.065$^+$	0.279	0.155	0.021*	0.243	0.135	0.044*
Scouts	-0.003	-0.001	0.986	0.100	0.053	0.431	0.101	0.053	0.424
Time 4 Real Science	0.160	0.041	0.547	0.325	0.118	0.076$^+$	0.307	0.111	0.090$^+$
Enjoy Time Outdoors							0.112	0.157	0.016*
High School	-0.041	-0.015	0.836	-0.334	-0.168	0.014*	-0.329	-0.166	0.014*
Grade	-0.129	-0.126	0.066$^+$	0.027	0.038	0.566	0.042	0.057	0.380
Gender	0.104	0.044	0.514	0.252	0.151	0.021*	0.241	0.144	0.027*
Race	0.105	0.031	0.647	-0.240	-0.101	0.126	-0.251	-0.105	0.105
Intercept	3.905		<0.001	4.485		<0.001	4.049		<0.001
P	0.263			<0.001***			<0.001***		
R^2	0.009			0.081			0.101		
N	223			223			223		

Notes: Gender (Male = 0, Female = 1), Race (White = 0, non-White = 1)
$^+$ $p \leq 0.1$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 8. Moderation Analysis: factors predicting intention to choose a STEM major

	Intention for STEM Major Step 1C			Intention for STEM Major Step 2C			Intention for STEM Major Step 3C		
	Beta	Std. Beta	*p*	Beta	Std. Beta	*p*	Beta	Std. Beta	*p*
Muddy Sneakers	-0.044	-0.041	0.506	-0.045	-0.042	0.500	-0.042	-0.039	0.528
Scouts	-0.034	-0.030	0.628	-0.033	-0.029	0.633	-0.025	-0.022	0.717
Time 4 Real Science	-0.079	-0.049	0.424	-0.079	-0.049	0.425	-0.087	-0.054	0.380
Science Confidence	0.030	0.523	<0.001***	0.030	0.521	0.000***	0.013	0.222	0.236
Enjoy Time Outdoors				0.004	0.009	0.890	-0.126	-0.289	0.121
Science Confidence *Enjoy Time Outdoors							0.005	0.480	0.091+
High School	-0.043	-0.037	0.554	-0.043	-0.037	0.556	-0.032	-0.027	0.660
Grade	-0.002	-0.004	0.947	-0.001	-0.003	0.958	-0.004	-0.010	0.870
Gender	0.126	0.127	0.035*	0.126	0.126	0.036*	0.123	0.124	0.039*
Race	-0.009	-0.006	0.918	-0.009	-0.006	0.917	-0.010	-0.007	0.908
Intercept	-0.549		<0.001	-0.560		0.003**	-0.103		0.752
P	<0.001 ***			<0.001 ***			<0.001 ***		
R^2	0.264			0.260			0.267		
N	213			213			213		

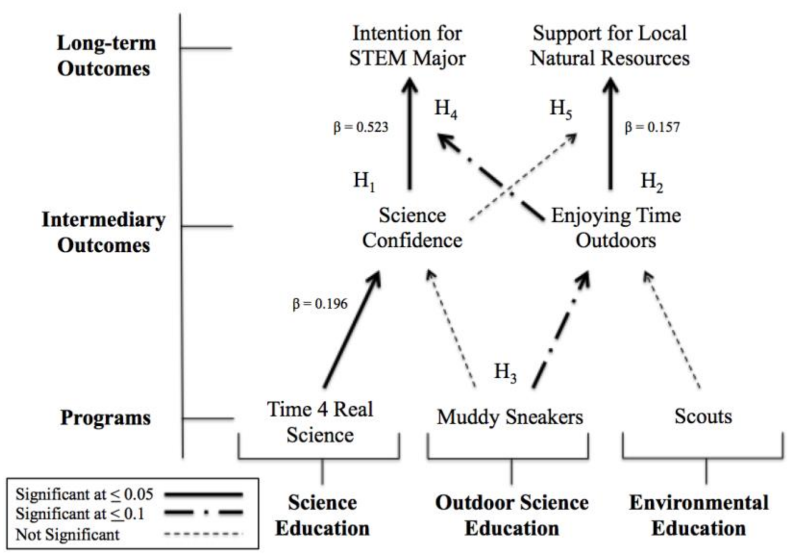
Notes: Gender (Male = 0, Female = 1), Race (White = 0, non-White = 1)
+ $p \leq 0.1$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 9. Moderation Analysis: factors predicting support for local natural resources

	Support for local NR Step 1D			Support for local NR Step 2D			Support for local NR Step 3D		
	Beta	**Std. Beta**	***p***	**Beta**	**Std. Beta**	***p***	**Beta**	**Std. Beta**	***p***
Muddy Sneakers	0.243	0.135	0.044*	0.233	0.129	0.052	0.233	0.130	0.051^{+}
Scouts	0.101	0.053	0.424	0.081	0.043	0.516	0.092	0.048	0.462
Time 4 Real Science	0.307	0.111	0.090^{+}	0.235	0.085	0.199	0.226	0.082	0.217
Enjoy Time Outdoors	0.112	0.157	0.016*	0.090	0.127	0.056	-0.083	-0.117	0.565
Science Confidence				0.014	0.139	0.038*	-0.010	-0.101	0.616
Science Confidence *Enjoy Time Outdoors							0.006	0.390	0.205
High School	-0.329	-0.166	0.014*	-0.366	-0.169	0.012*	-0.320	-0.161	0.017*
Grade	0.042	0.057	0.380	0.049	0.066	0.307	0.045	0.062	0.343
Gender	0.241	0.144	0.027*	0.225	0.135	0.037*	0.222	0.133	0.040*
Race	-0.251	-0.105	0.105	-0.261	-0.110	0.090^{+}	-0.264	-0.111	0.086^{+}
Intercept	4.049		<0.001	3.751		<0.001	4.365		<0.001
P	<0.001***			<0.001***			<0.001***		
R^2	0.101			0.115			0.117		
N	223			223			223		

Notes: Gender (Male = 0, Female = 1), Race (White = 0, non-White = 1);
$^{+}$ $p \leq 0.1$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Figure 1. Programs, outcomes, and their relationships



Note. This figure is a conceptual model of our mediation and moderation findings. Standardized beta coefficient values (β) are provided for significant hypothesized relationships.

Discussion

Local experiences in natural settings, repeated interventions over the course of the school year, and a focus on young students (fifth grade) may explain why Muddy Sneakers participants reported slightly higher enjoyment of time outdoors and greater propensity to consider local natural resources important four to seven years after their OSE experience. A review of research focused on K-12 EE outcomes between 1994-2013 highlighted there were only six studies (18%) collecting follow-up data more than six months post intervention (Ardoin, Bowers, Roth, & Holthuis, 2018). Our results demonstrating the persistence of positive conservation-related attitudes four to seven years after participation in the Muddy Sneakers program align with previous research demonstrating persistence of similar EE outcomes three months after an OSE experience (Dettmann-Easler & Pease, 1999; Stern et al., 2008). Previous research highlights that participating in OSE instills enjoyment of time outdoors (Ewert, Place, & Sibthorp, 2005), which could contribute to the development of an eco-centric versus an anthropocentric worldview and subsequent support for conservation (Ewert et al., 2005; Wells & Lekies, 2006). Some attributes of Muddy Sneakers that likely contribute to the program's effectiveness at generating these long-term EE outcomes include the young age at which the intervention occurs (Braun & Dierkes, 2017; Chawla, 1999; Dillon et al., 2016; Tanner, 1980; Vadala et al., 2007; Wells & Lekies, 2006), the use of local outdoor settings (Martin, 2003; Rios & Brewer, 2014), longer duration and repeated interventions (Bogner, 1998; Braun & Dierkes, 2017; Cronin-Jones, 2000; Rickinson, 2001), and use of small group sizes, which may increase the potential for an instructor to serve as a role model and provide opportunity for deep affective connections to local natural resources (Chawla, 1999; Sivek, 2002; Tanner, 1980).

This study suggests previously identified OSE impacts on interest in science may diminish over time without recurring interventions. Previous studies investigating science outcomes immediately following an OSE experience identified increased science motivation and interest (Dettweiler, Ünlü, Lauterbach, Becker, & Gschrey, 2015; Zoldosova & Prokop, 2006), and increased science content knowledge related to environmental science topics (Cronin-Jones, 2000). While increased interest in science and gains in science knowledge may result in science confidence, maintaining science confidence likely relies on continued interest and regular gains in content knowledge. Previous research demonstrating students' interest and performance in science declines throughout adolescence (Bøe, Henriksen, Lyons, & Schreiner, 2011; Linn, Lewis, Tsuchida, & Songer, 2000) may help explain why we did not find a relationship between participation in OSE and science confidence or interest in pursuing a STEM major several years later. It is possible that any gains in science confidence associated with childhood OSE may have eroded without reinforcement throughout adolescence. Future research should investigate whether repeated OSE interventions may help these outcomes persist over time.

Participation in SE was associated with science confidence, but future research with participants who are not self-selecting and over longer time periods is needed to understand how this may translate to persistent interest and participation in STEM. Additionally, the small sample size for this group (n = 21) makes it difficult to draw any inferences regarding our results. Time 4 Real Science is an after-school program for high school students that is focused on improving students' science-related skills by pairing them with scientists from their community who help them conduct a scientific research project. Because Time 4 Real Science occurs during high school, science confidence effects were still short-term relative to those measured for Muddy Sneakers. As participation in Time 4 Real Science is voluntary, in contrast to Muddy Sneakers, it is possible that higher science confidence among Time 4 Real Science students reflected self-selection bias in addition to effects from the program (Aschbacher, Li, & Roth, 2010). However, the lack of relationship between Time 4 Real Science participation and the choosing of a science major suggests that participation did not translate that confidence towards the intention to pursue a STEM major. Another aspect to consider when comparing potential long-term impacts of OSE on science and environmental engagement is that our measure of engagement with the environment (i.e., support for local natural resources) required less personal commitment than our measure of engagement with science (i.e., choosing a STEM major). Further, the item we used could be interpreted as how much others (i.e., the community) value natural resources rather than self. However, the significant relationship found between participation in OSE and the support for natural resources suggests that aspects of the program likely fostered some sort of lasting connection with local natural resources. Future research should explore how science confidence and interest may relate to long-term science engagement outside of career choice (e.g., science hobbies; Alexander, Johnson & Kelley, 2012; Dabney et al., 2012; Jones, Corin, Andre, Childers, & Stevens, 2017) and seeking scientific evidence in decision making (Bell & Lederman, 2000). Future research should also seek to develop a more nuanced understanding of how OSE in childhood may foster lasting connections with local natural resources.

High variability in scouting programming may explain the surprising lack of relationships between scouting participation and enjoyment of time outdoors or support for local natural resources. Although scouts have key attributes linked to EE, participants can choose a participation approach that spans 135 Boy Scout merit badges (Boy Scouts of America, 2019) and over 230 Girl Scout badges (Girl Scouts, 2019), many of which are not directly related to environmental education. Arguably, scouting does aim to promote substantial experiences with the outdoors (Boy Scouts of America, 2019; Girl Scouts, 2019), but at least in this case, those collective experiences may not be enough to promote enjoyment of time outdoors or appreciation for local natural resources. In contrast, we have a firm understanding of the programmatic attributes of the OSE experience related to this study. Future research should continue to explore impacts of participation in scouts, while accounting for the type of participation individuals choose.

The weak moderating relationships we identified between SE and EE outcomes suggests that future research should continue to explore the potential for long-term moderating benefits of OSE on engagement with both science and the environment. Previous research suggests that OSE can promote both science learning and environmental engagement in the short term (Stern et al., 2008). Some research suggests that these benefits may be synergistic, where learning science content may promote further environmental engagement (Littledyke, 2008; Wals et al., 2014), and learning outdoors may enhance science content knowledge and skills more than learning in settings not explicitly outdoors (Carrier et al., 2014; Cronin-Jones, 2000; Rios & Brewer, 2014). Though the interactions we tested were not significant, similar studies with larger sample sizes may increase the chances of detecting these relationships, supporting the notion that OSE, or other interventions providing opportunity for engagement with science in the outdoors (e.g., nature-based citizen science; Schuttler et al., 2018), may work to strengthen life-long engagement with both science and the environment.

The positive relationship between female gender and commitment to STEM majors demonstrated in our study may be explained by evidence that OSE contributes to female student engagement with science. Studies from diverse fields related to conservation and environmental education have documented more pro-environmental attitudes and behaviors among females as compared to males (Arnocky & Stroink, 2011; Karpiak & Baril, 2008; Zelezny, Chua, & Aldrich, 2000), which our study mirrored. However, research around the gender STEM gap suggests that girls are consistently less interested in science and less likely to pursue majors and careers, particularly as they age (Brotman & Moore, 2008; Tyler-Wood et al., 2012; Wang & Degol, 2017). Our results suggest a shift in female patterns of STEM participation, perhaps brought on by the numerous efforts in recent decades to mitigate a gender gap in STEM fields (Brotman & Moore, 2008; Holman, Stuart-Fox, & Hauser, 2018; Wang & Degol, 2017). Girls may also gain more interest in STEM majors as a result of OSE interventions (Tyler-Wood et al., 2012; Zoldosova & Prokop, 2006), although we did not find that relationship in our study. The unusually high interest in STEM majors among girls in our study is encouraging in light of efforts to mitigate STEM gender gaps, and our study highlights a need to monitor this issue as educational interventions attempt to address it and gender roles shift over time.

Other differences detected based on age and ethnicity are consistent with previous findings, and highlight a need to improve SE and EE curricula for older and more diverse youth. Several studies suggest younger students are more engaged with science (Baram-Tsabari & Yarden, 2009; Potvin & Hasni, 2014; Simpson & Oliver, 1985) and exhibit a greater degree of environmental concern (Buttel, 1979; Liefländer & Bogner, 2014; Stevenson, Peterson, Bondell, Mertig, & Moore, 2013). The parallel findings in our study suggest continued efforts are needed to keep older students engaged in science and the environment. Encouraging efforts with older students include programs like Time 4 Real Science, and our results suggest they do work to boost science confidence. Similarly, non-White people, particularly those identifying as African American, are underrepresented in outdoor recreation (Schwartz & Corkery, 2011), as well as conservation majors (Porter & Umbach, 2006) and careers (Blockstein, 1990; Lawrence, Holland, & Morrin, 1993). Recent boosts in efforts to diversify outdoor recreation and conservation fields are also encouraging (Diversify Outdoors, 2018; Outdoor Afro, 2019), and techniques such as hiring diverse staff who may serve as potential role models (Shin, Levy, & London, 2016) and removing potential barriers (Balcarczyk, Smaldone, Selin, Pierskalla, & Maumbe, 2015; Foster, Blair, Bennett, Bynum, & Sterling, 2014; Tsui, 2007) may help strengthen underrepresented individuals' sense of belonging in recreation, conservation, and STEM fields. Our results suggest that SE and EE communities working with children should employ these strategies to ensure diverse stakeholders are engaged with science, the environment, and building a sustainable and just future.

Conclusion

This study suggests childhood OSE may help build life-long environmental engagement by promoting support for local natural resource protection up to seven years after program participation. Although we did not find parallel long-term outcomes related to science engagement, future research should continue to explore the short-term science-related benefits of OSE and the conditions under which those may persist. Periodic science-based interventions (e.g., Time 4 Real Science or similar programs) may reinforce the short-term gains related to science confidence others have found associated with childhood OSE (Cronin-Jones, 2000; Dettweiler et al., 2015; Zoldosova & Prokop, 2006). Though it should be repeated with larger sample sizes, our analytical approach of quantitatively linking experiences with intended behaviors and commitments provides new support for the notion that such experiences serve as a mechanism for the persistence of OSE outcomes. Future research should explore other SE outcomes such as content knowledge or skills to understand how OSE may impact science engagement over time. Additionally, our findings regarding the synergistic relationship between SE and EE outcomes hint at a potential relationship that may aid in the development of educational interventions that work towards addressing issues associated with the compounding problems of disinterest in science and a disconnection from the natural world.

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