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Accelerating high school students' science career trajectories through non-formal science volunteer programs

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ABSTRACT

Extensive research shows that non-formal science education programs effectively build and sustain long-term interest and persistence in science careers. Framed by expectancy-value theory, this study examined the academic and career outcomes of students who participated in a multi-year volunteer program at a science museum. Twenty-one participants were interviewed about their motivations for volunteering and the impact of participation on their science career trajectories. Data were coded for factors related to expectancy-value including goals, motivations, previous non-formal science experiences, and family attitudes towards science and STEM. Results showed participants of the volunteer program pursued science careers at higher rates than the national average, adding evidence to show how non-formal science education programs extend the longevity of science career interests. This study also documented a newly emergent phenomenon of acceleration of participant science career trajectories. Museum volunteer programs such as the one studied may help high school students gain knowledge and skills central to science career development earlier than is typical. The implications of this type of program for students with already established science interests and science career motivations is discussed from an equity perspective.

Keywords
Non-formal science education; career persistence; expectancy- value theory

Dwindling numbers of students seeking careers in science has driven investigations and interventions designed to mitigate student disengagement and divergence from the pathways that lead to career persistence (DeWitt et al., 2013). The decline of both interest and positive attitudes towards science and mathematics at key educational transition points have been cited as driving the loss of desire to pursue science careers (Young et al., 2016). Within formal mathematics and science education, the focus on high-stakes testing and lack of personally and socially relevant curricula are also thought to contribute to declining interest in science starting as early as elementary school (Stuckey et al., 2013). One commonly suggested solution for retention includes engaging students in non- formal science education programs that offer more expansive and authentic science experiences, which can serve to bridge the interest gaps for school-based learning (Philip & Azevedo, 2017). The proposed action focuses on 'theories of change' and posits that through immersion in authentic science engagement, students come away from non-formal experiences with increased interest, knowledge, and 'pursuits of science practice' (Philip & Azevedo, 2017, p. 528). However, these theories have the potential to underemphasize the role students' pre-existing interests play in the selection of non-formal science experiences and how that relates to subsequent career outcomes.

Hidi and Renninger (2006) defined interest as an individual's 'predisposition to re-engage with particular content' (p. 111). Patterns of re-engagement with science content outside of school have been shown to be positively related to the decision to enroll in formal science courses or electives in high school and college (Caspi et al., 2019). By high school, students are typically establishing college and career goals (Eccles & Wigfield, 2020) and exhibit greater levels of autonomy in deciding how they spend their time (Deschenes et al., 2010). In their analysis of out-of-school programs for middle and high school students, Deschenes et al. (2010) reported that students who participated in non-formal education programs were highly motivated and sought educational opportunities that allowed for exploration of their career interests. Contrary to studies that situate non-formal science experiences as interest-building contexts that ultimately lead to career persistence, science interest may already be a persistent factor for high school students who seek formal and non-formal science opportunities. Thus, if participating in non-formal science experiences during high school is an intentional choice for students with established affinities and interest in science, it follows that students who take part in these experiences may already be predisposed to persistence in science careers and may receive the added benefit of early career development as a result of program participation. In this paper, we examined how students' interests, values, senses of usefulness, and priorities influenced their decisions to participate in a volunteer program at a natural science museum. Further, we explored how participation in non-formal experiences can sustain science career interests and offer unique opportunities to accelerate youth career trajectories. We use the term non-for- mal over informal to indicate purposeful learning activities that take place outside of school but within an organizational framework (Ainsworth & Eaton, 2010).

Research questions

In this exploratory case study (Creswell & Poth, 2016), qualitative data were collected on students' motivations for engaging in non-formal science programs, career aspirations, and career choice outcomes. A primary area of focus was the perceived values and benefits associated with the volunteer experience. The following research questions guided this study:

(1) What motivations do youth report for participating in science museum volunteer programs while in high school?
(2) How does participating in science museum volunteer programs impact students' career and college major choices?
(3) What knowledge, skills, and benefits do youth report gaining because of participating in science museum volunteer programs?

Theoretical framework

Exploring participation in non-formal science volunteer programs through the *expectancy-value theory* (EVT) framework (Eccles & Wigfield, 2020) offers insight into how students' motivation to engage in volunteer programs is related to their career goals and outcomes. EVT theorizes that students' academic, or achievement-related choices, are determined by two motivational con- structs: 1) subjective task value, and 2) self-concept and expectations for success. Subjective task value has four components: *intrinsic value*, *attainment value*, *utility value,* and *perceived cost* (Eccles & Wigfield, 2020). This study additionally examined contributing factors that can influence motivation and science career trajectories (see Figure 1) that include: prior experiences in structured non- formal science programs (Goff et al., 2020) and environmental factors such as perceptions of parents' and teachers' beliefs and behaviors (Archer et al., 2012).

Prior participation in out-of-school science experiences

Participating in non-formal science activities influences students' interest and ability-related beliefs, which impact students' academic and career choice (Goff et al., 2020). Though understudied, early and repetitive participation in non-formal science experiences that build interest, identity, and self- efficacy may significantly accelerate participant career trajectories.

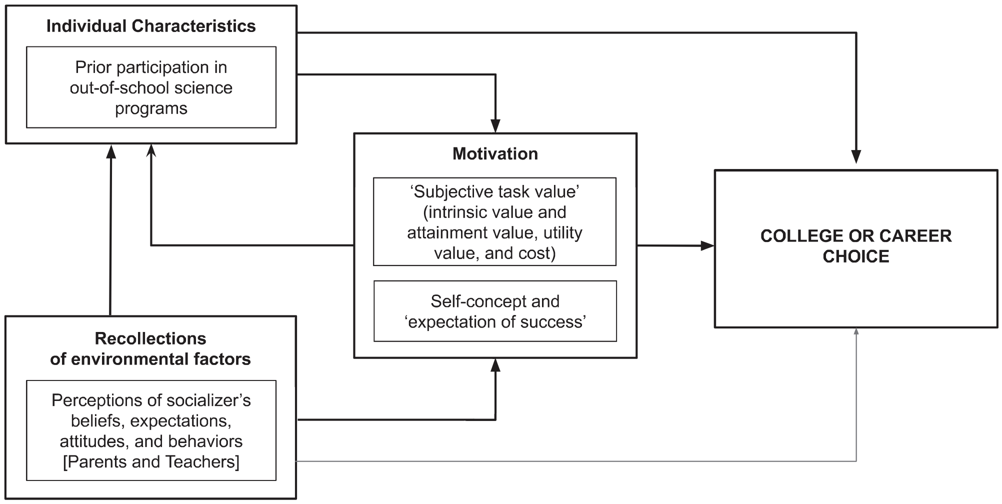

Figure 1 . Reduced expectancy-value theory model for achievement-related engagement. *Note*. Modified from Caspi, A., Gorsky, P., Nitzani-Hendel, R., Zacharia, Z., Rosenfeld, S., Berman, S., & Shildhouse, B. (2019). Ninth-grade students' perceptions of the factors that led them to major in high school science, technology, engineering, and mathematics disciplines. Science Education, 103(5), 1176–1205.

Perceptions of parent and teacher beliefs and expectations

When their science interests are encouraged, students develop high self-efficacy and outcome expectancies which significantly predict their goal orientations for science disciplines (Nugent et al., 2015). There is also a transfer of utility value perceptions when the importance of science careers is regularly communicated by parents and teachers (Archer et al., 2012). In addition, teachers' expectations are a driver of student engagement (Nugent et al., 2015) and teacher support has a positive impact on students' selections of college majors after high school (Sahin et al., 2018).

Self-concept and 'expectation of success'

An individual's expectation for success in undertaking a task is related to how well they believe they will fare when completing that task in either the immediate or long-term future (Eccles & Wigfield, 2020). These personal expectations for success are related to self-concept theories (e.g. Hazari et al., 2010) and describe the positive relationship between high science self-concept (e.g. recognizing oneself, and being recognized by others as a 'science person'), science self-efficacy, and high levels of persistence in science (Hazari et al., 2010).

Subjective task value

Intrinsic value and attainment value

Two related categories, intrinsic value and attainment value, are concerned with intrinsic motivational orientations. Eccles and Wigfield (2020) define intrinsic value as personal enjoyment from performing an activity. Such personal sense of value supports one's motivation and persistence. Attainment value is the perceived importance of an activity as it relates to an individual's self- image (Eccles & Wigfield, 2020). High attainment values for particular activities identify experiences that individuals perceive as being central to their sense of self. As motivational factors, intrinsic and attainment values for tasks associated with specific science disciplines are strong predictors of academic choice and career trajectories (Hazari et al., 2010).

Utility value

The usefulness, or utility value, of a task is how well experiences contribute to one's achieving cur- rent or future goals. This variable has been shown to be important to high school students in choosing coursework and experiences that will help them to reach their college or career aspirations (Eccles & Wigfield, 2020). Utility value is linked to extrinsic motivational orientation as some activities may be perceived as means to an end (Ryan & Deci, 2016).

Perceived cost

In EVT, perceived cost is the negative aspects associated with a task or activity, and includes the effort required to undertake the task as well as sacrifices made in order to participate (Eccles & Wigfield, 2020) such as giving up extracurricular activities or having less time to see friends or do homework. In this study, we examine students' perceptions of the costs related to being a museum volunteer.

Methods

Study sample

Study participants were recruited from a pool of former youth volunteers at a large science museum in the southeastern United States. Through convenience sampling, former youth volunteers were contacted using the museum's alumni email lists or on alumni-managed social media pages. A second list of students who had identified working at the museum on their college applications was obtained from the admissions office of a nearby university and used in targeted emailing. The first 21 respondents were accepted into the study (61.9%, $n = 13$ women and 38.1%, $n = 8$ men). Additionally, 71.4% ($n = 15$) self-identified as White/Non-Hispanic, 23.8% ($n = 5$) as Asian, and 4.7% ($n = 1$) as Black or African American. Participants were required to be no longer active in the program, a high school graduate, and over the age of eighteen. Fifty-seven percent ($n = 12$) of participants were undergraduate university students at the time of the study, 14.3% ($n = 3$) were currently enrolled in a Ph.D. or post-degree program, and (28.6%, $n = 6$) were currently employed. All of the currently employed participants were working in STEM fields as research scientists (9.5%, n = 2) or in education/outreach at various environmental institutions or wildlife agencies (19.0%, n = 4).

Study context

The volunteer program had several discipline-based tracks that varied in focus but were consistent in approach and level of engagement. Tracks were structured around a common set of elements, including 1) a career exploration component (e.g. meeting with scientists to learn about career paths), 2) public outreach and science communication opportunities (e.g. hosting Science Cafés, volunteering at public events, or teaching from carts on the museum floor), 3) authentic science experiences with museum researchers (e.g. working in museum collections doing specimen preparation and cataloging) and 4) field trips that encouraged exploration of science careers and topics of interest (e.g. conducting fieldwork or visiting science labs outside of the museum). Youth volunteers entered as rising 9th-11th graders and were encouraged to apply to programs matching their personal areas of interest. Students were required to complete an application, submit letters of recommendation, and attend admission interviews. At the end of each program year, invitations to return to the program were extended to individuals who performed well in their volunteer roles. Participation through all four years of high school was encouraged, but not required.

Interview and coding protocol

A semi-structured interview guided exploration of factors related to career aspirations and individuals' motivations for engaging in non-formal science programs. Participants were asked series of questions about their childhood experiences with volunteerism and non-formal science, what motivated them to want to serve as a museum volunteer, their perceptions of the benefits, costs, and utility of service, and their actual/intended post-museum career trajectories. Questions were reviewed for clarity and validity by a panel of educators including the museum's youth programs coordinator, a former museum youth programs educator, and two non-formal science education researchers. Interviews were conducted in-person and were tape recorded. Interviews were then transcribed, and transcripts were open coded through the process of memoing to identify common themes (Creswell & Poth, 2016). After a codebook was developed, relationships between the data were identified through axial coding

(Creswell & Poth, 2016) to provide additional insight on how student perceptions of their volunteer experiences impacted whether they chose to pursue a science major or career. From this data, a phenomenon of acceleration for academic and career trajectories emerged. To link the themes to established educational theories (Creswell & Poth, 2016), selective coding was applied, which led to identification of EVT (Eccles & Wigfield, 2020) as a framework. The final codes included prior participation in non-formal science programs, perceptions of parent and teacher beliefs and expectations, science self-concept, intrinsic and attainment value, utility value, and cost.

Validation and reliability

After development of the codebook, a secondary independent coder was trained and provided with 20% of the interview transcript data for analysis. Reliability across coders was assessed for consistency using Krippendorf's alpha coefficient to calculate an intercoder agreement of 0.83 (Krippendorff, 2011). The remaining transcripts were independently coded by the two researchers.

Results

Prior participation in out-of-school science experiences

Eighty-one percent of participants reported participating in non-formal science experiences prior to applying to the volunteer program. Many cited persistent interests in science and knowledge of the volunteer programs as being relevant to their decision to apply. Eighty percent of the women in the study had previously participated in a middle school program for young women at the same museum, suggesting a high rate of transfer for these students. Gloria (pseudonyms are used to protect participant privacy) described participating in the middle school program as being highly influential in her decision to serve as a high school volunteer: 'When it was time to apply for [the high school program] I already was familiar with it and knew that it existed from [the middle school program] and so then I decided to apply.'

Perceptions of parent and teacher beliefs and expectations

Two emergent factors related to motivation to engage in museum volunteer programs were having close family members in science or STEM (80.9%) and visiting museums during childhood (61.9%).

Having a close family member in science or STEM was often discussed as the source of value and utility judgments related to participation. When prompted to reflect on family beliefs about science and personal goal orientations, Valerie stated, ‘my whole family is just super STEM-oriented … and so their passion for science and passion for learning and the value [they place on] education … just got me into learning more.’ For David, another volunteer, ‘the museum is the place where I made some of my earliest memories.’ After meeting a museum volunteer at an event, David recalled thinking, ‘I promised myself that if I was ever allowed to, I would volunteer for the museum.’ Parental involvement in the form of advocacy and encouragement for non-formal science engagement was also discussed with relation to accessibility of science experiences. Alex recalled, ‘I was super lucky to have [my mom] as an advocate at that age because many people’s parents don’t have time to do that,’ referencing the time and transportation costs associated with long-term program participation.

When asked about program recruitment and encouragement, more participants (42.8%) were encouraged to apply to the program by a teacher than by a parent (28.5%). When probed, some students mentioned that without teacher encouragement, they would not have known non-formal science education programs were available. ‘I would say my decision to apply really stemmed from the science teacher that I had and getting plugged in in sixth grade,’ Gloria recalled. Others focused heavily on teacher recognition of student science interests as being important in the decision to engage in non-formal science experiences. Janine recalled,

> The sixth-grade science teacher who told me to apply for [the middle school program for girls] was sort of a mentor in that she was reaching out and saying - oh you’re a kid who likes science you should apply for this.

Self-concept and ‘expectation of success’

During the interview process, participants were asked to reflect on their identities as a ‘science per- son.’ Seventy-one percent of participants self-identified as being a ‘science person’ before entering the program. For participants like Alex, being a science person was something innate to their identity: ‘I’ve never known what it would be like to not have that abiding interest … I think there was just always something inside me.’ The remaining 28.5% of participants generally agreed that although they had interests in science prior to entering the program, they did not yet see themselves as science people or potentially becoming scientists in the future. When asked about the impacts of the program on their science identity, 100% of the volunteers agreed that by the conclusion of the program they saw themselves as science people, as did their families and peers.

All participants entered the program with clearly developed interests in science and cited personal enjoyment of things like 'getting to work with animals,' 'being able to do real science,' and getting to go behind the scenes at an institution they held in esteem as being integral to the decision to apply. Other students noted a desire to participate in the program as it related to their identities and ideal self-images. Janine said that wanting to 'be the person who asks the scientists really good science questions' during program meetings was a significant motivator in her desire to participate and to do well. David referred to the structure of the program as being the embodiment of life's 'most noble pursuits': to learn new information and to share it with others.

Subjective task value

The interviews revealed that utility value was the most frequently cited factor (43.9%) of the subjective task value factors mentioned (see Table 1). For example, in addition to wanting to participate for altruistic reasons, David indicated the value in the program was 'not just about helping other people,' but was a way for him to gain new skills and experiences that would help him achieve future success. Nelson reflected that the program 'helped me become a better student and has given me marketable skills.' In many cases, reflections indicated a blended perception of both the personal values and the utility value of engaging in the program. Sam initially wanted to participate in the program to show prospective colleges his capabilities and evidence of extracurricular engagement, but the experience taught him 'to see how you can do better for yourself and your community.'

Table 1. Participant Reports of Intrinsic and Attainment Value, Utility Value, and Cost.

Factor	Examples	Frequency	Percent
Intrinsic & Attainment Value	'I love working with animals.' 'I wanted to be the student that asks the smart questions about science.'	87	40.7%
Utility Value	'This will help me to build skills and get a job in a field I love.'	94	43.9%
Cost	'I was too busy to join a sports team.'	33	15.4%
Total		214	100%

References to program benefits outweighed references to program costs, which were generally associated with the time and financial commitments required for long-term participation (see Table 1). Participants reported that program participation did not allow for time to engage in other activities like an after-school club or playing a school sport. Another cost reported was the financial capital to participate in the program, including a required annual fee and a variety of optional field experiences ranging from local to international trips. Participants who joined these excursions cited them as being hugely beneficial to advancing their knowledge of science, providing them with authentic science experiences, helping them to develop real world skills like being able to travel and work in challenging environments, and exposing them to new career opportunities in science. However, cost was a significant barrier to many individuals. Betty recalled holding bake sales to help raise money for her trips, while Alex took on paid work at the museum in order to raise money,

Evolution of career interests

Emergent in the data were themes of persistence in already established science career trajectories. Thirty-eight percent of the study participants reported they entered the volunteer program with a desire to pursue a specific major and career and left the program feeling confirmed in that choice. Another 28.5% were able to focus a broadly existing interest to one with more specificity. For example, Charlie knew he wanted to pursue a career studying fish, and after working in one of the museum's research labs was able to narrow his interest to a particular branch of ichthyology. For others (14.2%), meeting scientists from a variety of fields exposed them to areas of interest beyond well-known careers like medicine and ultimately influenced their career decisions. As Anna explained,

> I think it definitely impacted my career choice because as I've said there is a misconception that if you're good at science and you enjoy science that you're going to be a researcher, or a doctor, and go to medical school.

A small number of students (*n* = 2, 9.5%) reported that the program helped them realize they did not want to pursue a career in their expected discipline. For example, Betty realized that she no longer wanted to be a research scientist and instead chose to become a science museum educator. The two participants (9.5%) who reported no change to their career trajectories during high school either cited having unfocused career goals throughout the program duration or noted that any changes in their career trajectory were made due to outside influences.

Science career trajectories

Analyses also revealed that 85.7% (*n* = 18) of the former volunteers were currently enrolled in a science major or had graduated with a science degree, which is much higher than the national aver- age of 18% (de Brey et al., 2000). Every one of these eighteen participants cited pursuing the science major or career they had chosen while serving as a volunteer. When collapsed into overarching fields of study (Ginder et al., 2019), the majors and intended majors most heavily represented were 1) biological sciences (50%, n = 9), 2) agricultural sciences (22.2%, n = 4), 3) chemistry or chemical engineering (11.1%, n = 2), 4) computer science or computer engineering (11.1%, n = 2), and 5) psychology (5.5%, n = 1).

The accelerative effect of program participation on science career trajectories

Interview analyses revealed the theme of acceleration for academic and career trajectories as a result of program participation. Betty, (who was previously referenced as changing her career trajectory as a result of program participation), noted that the program not only offered a direct pathway to achieving her academic and career goals, but also provided her with skills and knowledge that set her ahead of peers who did not participate in the same kinds of non-formal education experiences.

> You know the 'what are you gonna do when you grow up?' game- [it is a decision] that people are having to make earlier and earlier. Since I knew what I wanted to do relatively early, I was able to tailor my learning and path towards what I wanted to do. So, I feel like [the program] gave me a head start. My volunteer experience was something that I put on resumes and things like that to get jobs and college internships and all of those sorts of things. So that definitely gave me a leg up on getting into the field.

Axial coding of the utility value data for relationships to the theme of acceleration highlighted the various ways participants perceived the usefulness of the program as it related to current or future goals (see Table 2). The frequencies refer to the number of times each theme was represented in the interview data. For example, the participants collectively referred to the utility of college/career exposure 27 times. The reported percentage provides insight into how often the themes were rep- resented in comparison to each other. For example, the theme of prestige accounted for 18.6% of the coded themes related to utility.

Exposure to previously unknown college and career options was most frequently discussed as many students decided on colleges, specific majors, or research foci because of meeting scientists in fields of interest. Equally represented was the theme of *prestige*, defined in this study as the recognition participants gained from others' perceptions of their achievements. An example from one participant, Janine: '[The program] was central to all my college applications because it wasn't some flashy award, it was real authentic experiences I was able to write about.' Many noted that the pro- gram provided them with tangible evidence of science experiences, interest, and motivation to pre- sent to college boards, professors, and hiring managers. *Authentic experiences and opportunities* like working with scientists, participating in fieldwork, and communicating with the public were also reported as being useful in deciding whether or not participants would find these particular tasks enjoyable in the future. *Networking* helped several participants find placements in research labs and internships immediately upon graduation from high school, via the connections they made with scientists, researchers, and academics during the program. Participants also noted *preparedness*, defined in the context of this study as gaining skills or knowledge for a not yet established purpose. Evan expressed that he was motivated to participate in the program as a means 'to cultivate an interest I already have or an interest I might have which over the years might end up leading somewhere for myself.' *Interpersonal skills* included perceptions of communication, leadership, and teamwork, and how having these skills could benefit the individual in the future. Many volunteers, including Judy, described how giving presentations to audiences at the museum positioned them as educational leaders and allowed them to 'develop effective public speaking skills.' *Technical skills* like 'gill-netting' or 'making field observations' were coded as anything specific to the practice of doing science that would aid in future academic or career success. The *science knowledge* gained as a result of the program was the least referenced benefit in terms of future career success. Knowledge was often discussed in the context of the volunteer's ability to understand the world scientifically and included knowing the Latin names for animals and being able to identify a variety of plant and animal species during fieldwork exercises.

Table 2. Frequencies for Identified Themes Related to Usefulness or Utility Value.

Theme	Frequency	% frequency
Career/college choice exposure	27	18.6%
Prestige	27	18.6%
Authentic experiences and opportunities	26	17.9%
Networking	18	12.4%
Preparedness	15	10.3%
Interpersonal skills	13	8.9%
Technical skills	12	8.5%
Science knowledge	7	4.8%

Limitations

Investigating the impacts of competitive non-formal science programs has its challenges. By nature, programs such as the one studied have application processes designed to attract, and ultimately select for, academically talented students who display high aptitudes and interest for science. As the study sample only included participants selected for program participation at this museum, care should be taken when generalizing these results.

Discussion

Examining the expectancy values for non-formal science program participation of highly interested and motivated students is an important aspect of science career development and persistence that is missing from the literature on the role of non-formal science programs on persistence in science. Evidence from this study suggests that students who are accepted into application-based non-for- mal science volunteer programs at the high school level may have established science interests and career goals and hold expectations for the benefits they will receive as a result of participation. The results of this study support previous findings within the literature regarding the role that non-formal science programs play in promoting science interest and persistence (e.g. Carpi et al., 2017; Caspi et al., 2019) but offer new evidence that programs such as these have the added benefit of accelerating students towards their academic and career goals.

Science career trajectories and evolution of career interests

Participants viewed their time in the program as central to the development of their science identities, sense of self, and motivation to pursue a science career. Consistent with prior research (e.g. Goff et al., 2020), this identity development and sustainability appears to be a predictor of sub- sequent persistence in majors and careers. Data analysis also revealed that the volunteers entered the program with highly specific and well-established science career goals in disciplines like limnology, ichthyology, biogeochemistry, and conservation biology. This level of specificity may indicate that many of these students already had a significant breadth of understanding of potential careers. This also provides evidence that motivated students' career decisions could begin in middle school or even earlier, and that career-focused high school non-formal science programs provide a secondary layer of career trajectory development. Practical experience within specific science disciplines is not common for typical high school students (see Carpi et al., 2017; Griswold, 2019), and those who are afforded such specialized opportunities may be able to make career decisions earlier than their peers. Though it is difficult to extrapolate pre-program levels of awareness for how participation would be a useful step towards a future career, participant responses indicated a high degree of knowledge in hindsight of how non-formal science education programs offer students both personal and professional advantages.

Benefits of the program were perceived as outweighing the extensive time and financial requirements associated with the program. Costs were often discussed in relation to the family unit and not to the volunteers themselves, with references to parents' willingness to provide regular transportation to the museum and the reality of high costs for field trips and experiences. Future work should be conducted to evaluate the perceived value of program participation by parents and guardians, as parental availability and perceived utility values towards science programming are known to be highly influential on student motivation and choice.

Compounding factors related to perceived value of non-formal science program participation

As noted by Caspi et al. (2019), a student's motivation to pursue a science-related career trajectory is impacted by compounding environmental factors. From the data, a pattern of factors emerged as influencing the decision to pursue non-formal science experiences during high school including 1) having a family member in science or STEM (80.9%), 2) previous participation in structured non-formal science programming before high school (80.9%), 3) attending museums with parents or families during childhood (61.9%), and 4) receiving encouragement to apply to the program by a teacher (42.8%) or parent (28.5%). These results appear to indicate that the decision to pursue a science career, and the choices made in that pursuit (such as participation in non-formal science programs), are formed by factors that occur over a person's lifetime and that these factors may contribute to early identification of science career goals and interests (Goff et al., 2020). It is well established that having a parent in science or STEM and doing science activities or hobbies as a family is enormously influential in a student's decision to pursue a science career (Jones et al., 2021; Refvem et al., 2022). What is newly documented in this study and what warrants more investigation is how parent and teacher expectancy values for non-formal science programming shape student participation in programs of this kind.

However, there are limitations in conjecturing the impacts of competitive non-formal science programming on career persistence. The students who were admitted to these programs displayed high levels of science interest and motivation upon entering the program and it is likely these demonstrations aided in their selection. Therefore, it is difficult to ascertain the influence of the volunteer program on career outcomes for students who already possess numerous factors related to science career persistence. What is clear, however, is that the students who participate in these pro- grams receive a variety of benefits that prepare them for academic and career success and accelerate their career development at a rate atypical for many teenagers (Carpi et al., 2017; Griswold, 2019).

Conclusion and recommendations

The evidence from this study suggests that for these former teen museum volunteers, their science career interests persisted during and after program participation, and that their participation was not only related to interest in science but was an intentional choice that accelerated them toward academic and career goals. As one volunteer summarized, 'I both had access to more opportunities and had a greater impetus to engage and create my own opportunities.' However, programs such as the ones discussed in the study must be assessed with some level of scrutiny regarding which students have access to these programs and who is able to take advantage of the accelerative benefits of participation. Despite numerous attempts to increase participation and inclusion of underrepresented racial, ethnic, and socioeconomic groups, non-formal science education continues to be a field that is 'marked by privilege' (DeWitt & Archer, 2017, p. 356), and generally caters to students of more privileged backgrounds. Like many non-formal science programs that lack targeted recruitment strategies, the demographic makeup of participants in this study was highly reflective of the majority groups typically seen in the natural sciences. The participants in the program surveyed were predominantly white women (42.8%) and men (23.8%). Without targeted recruitment, competitive non-formal science education programs run the risk of continuing to serve only majority groups and those students who have the time, money, and familial support to take part in these programs. Given that teacher awareness and encouragement were cited as heavily impacting students' decisions to apply to competitive non-formal science programs, we suggest that non- formal science centers may be more inclusive if targeted recruiting is implemented through relationship-building with community partners and teachers at schools with diverse populations.

It is also recommended that future research be conducted to explore any confounding factors or introductions of bias that may be obscuring the impacts of non-formal science program participation on career trajectories. While the results of this study suggest that the participants demonstrated sustained science interest, what is unclear is how institutional selection bias may have favored students with already well-developed factors that influence science career persistence. How non-selected youth would have benefitted from inclusion in the program, or how the students who were selected to participate would have persisted in science careers unaided, is unknown. We therefore offer for consideration that, by design, competitive applications are inherently exclusive both in terms of attracting youth participants and selecting for them. We suggest that care should be taken to foster equitable experiences, beginning with a critical look at the exclusive nature of application processes. In summary, youth volunteer programs have the potential to impact science career persistence and accelerate students' career development trajectories. Because the benefits of participation are great, non-formal science programs must give more attention to issues of inequity to ensure that they are not privileging a select few students to enter science careers.

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Ethical statement

This study was granted exempt status by the NC State Institutional Review Board under protocol number 14318.

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