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The Next Generation of Science Educators: Museum Volunteers

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ABSTRACT

There is a growing need for science educators and communicators who can support public understanding of complex science issues. Furthermore, little is known about how to nurture career aspirations for teaching science. This study examined the influence of youth volunteer experiences on career aspirations through a lens of science identity. Twenty-one participants were interviewed about high school volunteer experiences at a science museum. Data were coded for factors related to science identity (recognition, competence, and performance) and career aspirations. Results showed that the museum program contributed to the development of youth volunteers' science identities through experiences that bolstered individuals' science recognition, science competence, and science performance. Further analyses revealed the program's impact on the development of individuals' career interests in the areas of science communication and teaching. The results showed that after participating in the volunteer program, individuals indicated increased interests in communicating science to the public, teaching in informal science settings, and teaching in K-12 settings. These findings suggest that museum volunteer programs with an explicit focus on communicating science to the public may be optimal places to cultivate the next generation of science educators and communicators.

KEYWORDS

career aspirations; science identity; informal science education

There is growing need for more individuals to support the science workforce. Almost 10 million new science, technology, engineering, and math (STEM) jobs are expected to be added to the U.S. workforce by 2022 (Vilorio, 2014). In addition to the growing need for scientists, there is a need for science communicators and educators who can support public understanding of complex science issues as citizens make everyday decisions related to their health and safety and sort through complex information to participate in societal decisions (Sinatra & Hofer, 2016). But building this workforce starts with an examination of K-12 education to ensure that all children have access to highly qualified science teachers. Without giving youth access to high-quality science programs taught by effective science teachers, we run the risk of students not getting a solid foundation in science education at the precollege level and missing opportunities to encourage interest in science, science education, and science communication careers. To address these immediate needs, new strategies must be developed to engage and interest youth in these fields of study. There is evidence that out-of-school programs at science museums can play a role in developing future scientists (Habig et al., 2020), but not much is known about whether or not museum programs can be effective in recruiting youth into communication, education, or teaching careers.

Literature review

Informal science experiences

In their 2012 report, the National Governors Association stressed the role of informal science in "generating interest in science, stimulating inquiry through organized activities outside the classroom, and exposing youth to the opportunities that STEM knowledge presents" (Thomasian, 2012, p. 3). Additionally, the report stated that informal science experiences may improve student interest and confidence related to science, which may subsequently improve the number of students choosing to major in science or pursue science careers (Dabney et al., 2012; Thiry et al., 2017; Thomasian, 2012). Out-of-school science experiences have also been shown to shape an individual's knowledge and skills in STEM (Corin et al., 2018) and are important for developing science identity (Jones et al., 2020). A study of out-of- school programs at a science museum found youth developed STEM career interests through experiences that allowed the participants to become practitioners of science, build social networks, develop shared science identities, and discover possible selves (Habig et al., 2020). This positions informal settings as important and unique contexts for science identity development which provides youth opportunities to do science in ways that differ from traditional school settings (Hazari et al., 2020).

While research has been done on the impacts of museum programs, little is known about how experiences working as a long-term volunteer at a museum helps youth to develop science identity to inform career decisions in STEM-adjacent fields like science communication or science education. In addition, there is a need to better understand how to promote science educator career interests and aspirations.

Science identity

This study was guided and informed by previous research on science identity (e.g., Carlone & Johnson, 2007), which has been reported to predict STEM career choice (Archer et al., 2010; Godwin et al., 2016; Jones et al., 2020). According to Carlone and Johnson (2007), science identity is shaped by perceptions of science competence (the ability to understand the world scientifically), science performance (the capability to show others one has the skills to properly use the tools attendant with science), and science recognition (recognizing oneself as being a science person, but also recognition by others). Hazari et al. (2010) utilized the Carlone and Johnson (2007) framework of identity to understand the development of physics identity but also emphasized science interest as an important dynamic in the development of a science identity. While competence and performance are integral to the development of a science identity, it is still necessary for individuals to feel recognized in order to be seen as a "science person" (Hazari et al., 2020). Recognition and interest have been shown to be such strong influences on future choices that recent identity work linked to career choice has pared down the identity-related factors to focus simply on interest and recognition (Dou et al., 2019).

The science identity framework was guided by Gee's (2000) theory of identity, which recognizes that people have multiple identities connected to their performances in society and these identities can change depending on context. The four ways Gee conceptualized identity included an individual's nature identity, institution identity, discourse identity, and affinity identity. Like other studies in science education (e.g., Dou et al., 2019), our research on science identity conceptualizes science identity as an affinity identity, as we describe "experiences shared in the practice of 'affinity groups'" (Gee, 2000, p. 100). Affinity groups are defined by distinctive experiences and practices that individuals participate in and share together. As Gee (2000) frames the affinity perspective, "we are what we are because of the experiences we have had within certain sorts of 'affinity groups.'" In the context of the science museum-based teen volunteer program, individuals share in the practice of being a "science person" with other "science people."

Teacher development in museum settings

In addition to serving as places to develop science interest and identity, informal science centers have emerged as effective partners for teacher education programs (Heredia & Yu, 2017; Kisiel, 2013; Seung et al., 2019). A study of teacher education offered in collaboration with a museum showed that preservice teachers learned to teach in student-centered ways when presenting educational material for museum visitors (Adams & Gupta, 2017). This study found that these future teachers learned to engage learners, utilize the unique affordances of the museum environment (e.g., museum collections), and learned from and with learners of all ages and backgrounds (Adams & Gupta, 2017). One of the benefits of engaging in teacher education within informal science centers is that these settings can provide teachers with nontraditional experiences in a low-stakes environment (Luehmann, 2007). The unique museum environment can support preservice teachers' developing identities as science teachers and communicators (e.g., Avraamidou, 2014a).

While museum education is different from classroom teaching, museum educators have been shown to adapt their lessons to different audiences similar to how a teacher may adjust lessons to their classroom (Tran, 2007). Much of a museum educator's job involves interpreting natural history artifacts, but often these educators also promote students' physical and emotional engagement with the exhibits (Shaby et al., 2019). In addition to engaging students with the exhibits, museums are increasingly offering youth opportunities to volunteer in various roles. This may include engaging in a variety of educational programming or research experiences (Habig et al., 2020). Volunteer programs such as the one described in the present study allow individuals to take on the role of educator, sharing science with multigenerational audiences through programs, talks, and one-on-one discussions. Such role-taking has been shown to build individuals' communication and helping skills in real-time which is a potent strategy for professional growth (Sprinthall, 1994).

Given the need to strengthen the science teacher, educator, and communicator pipeline, this study was designed to investigate the influence of a museum-based volunteer program for youth on the development of the participants' science identities. Of interest in this study was how adolescents developed burgeoning science identities in this program, as well as how these youth developed interest in science communication and education careers at the same time.

Research questions

This study was guided by the following research questions:

(1) How does a youth's volunteer experience at a science museum influence their science identity?

(2) How does a youth's volunteer experience at a science museum influence their science education or science communication career interests?

Methods

Research design

To understand how participating as a volunteer at a local science museum influences volunteers' identity and career interests, an exploratory qualitative study (Creswell & Poth, 2018) using a semi-structured interview protocol was employed. Participants were drawn from a sample of youth who had worked as volunteers at a large natural science museum in the southeastern region of the United States. To locate former museum volunteers, a local university was contacted, and the admissions office was asked to review student applications for any student who had noted doing museum volunteer work. The university provided a list of students who matched the criteria, and those students were contacted by e-mail and asked to participate in the study. Additional names of former youth museum volunteers were obtained from the museum's alumni list and from the museum's social media websites. These potential participants were also contacted by e-mail and were invited to participate in the study. The first 21 individuals who volunteered to participate, were currently inactive in the volunteer program, were high school graduates, and were over the age of eighteen were included as study participants.

Participants

Of the 21 participants included in the sample, 13 of respondents were women and 8 were men. Additionally, 15 self-identified as White/Non-Hispanic, 5 as Asian, and 1 as Black or African American. Just over half of the participants (57%, n = 12) were undergraduates at the time of the interviews. Participant pseudonyms, education profile, career status, and college major are outlined in Table 1. Eight of these individuals majored in STEM fields of study (Ginder et al., 2019), including agricultural science (n = 3), biological science (n = 3), computer science (n = 1), and engineering (n = 1). The other individuals majored in teaching (n = 1), fashion/textile management (n = 1), social science (n = 1), and one individual was undeclared. Two participants were Ph.D. students focusing on biological sciences. The rest of the participants (n = 7) were college graduates with degrees in biological science (n = 5) and agricultural science (n = 2). Most of these individuals held careers as science educators (n = 4), with jobs such as college science professor, postdoctoral researcher and teaching assistant in ecology, education outreach at an environmental consulting firm, and the head of a department at the local science museum. Of the remaining three individuals currently employed, one individual's career involved writing grants for a state governmental wildlife agency, one was an outreach coordinator for a local land conservancy group, and one worked in patent law. To summarize, 17 of the 21 participants (nine graduates and eight undergraduates) participants were engaged in a STEM career or major and five of the 21 participants (four graduates and one undergraduate) were in education fields.

Table 1. Participant education profiles and backgrounds.

Pseudonym	Education profile	Career Status	College Major
Charlie	None	Undergraduate	Agricultural science
Janine	Communicator	STEM Career	Agricultural science
Kim	Communicator	Other Career	Biological sciences
Nelson	Communicator	Undergraduate	Biological sciences
Tina	Communicator	Undergraduate	Textile management
Diane	Educator	Science Communication Career	Agricultural science
Daniel	Educator	Science Education Career	Biological sciences
Betty	Educator	Science Education Career	Biological sciences
Anna	Educator	Undergraduate	Biological sciences
Sam	Educator	Undergraduate	Engineering
Alex	Teacher	Science Education Career	Biological sciences
Hank	Teacher	Science Education Career	Biological sciences
Jessica	Teacher	PhD Candidate	Biological sciences
Gloria	Teacher	PhD Candidate	Biological sciences
Kelly	Teacher	Undergraduate	Agricultural science
Caroline	Teacher	Undergraduate	Agricultural science
Sarah	Teacher	Undergraduate	Biological sciences
Valerie	Teacher	Undergraduate	Computer science
Evan	Teacher	Undergraduate	Social science
Mary	Teacher	Undergraduate	Teaching
David	Teacher	Undergraduate	Undeclared

Program description

The youth volunteers had all participated in a program offered by the local science museum. This program was application-based and took place throughout the school year, with a cost of 50 USD per year to participate. The museum selected applicants based on the individual's expressed science interest, career goals, and previous science experiences. Due to the in-person nature of the volunteering events, all participants were local to the museum area. The time commitment throughout the school year included one 1.5-hour weekday shift per week and one 1.5-hour meeting per month, including additional field trips. Summer volunteers committed to weekly 3-hour shifts for 10 weeks.

The program had different discipline-based tracks that varied in focus, but all were consistent in the approach and engagement with the museum. The youth volunteers participated in an array of museum activities including assisting with educational programs, animal husbandry, museum floor demonstrations, and cart programs during museum special event days. Some volunteers coordinated hosting scientists for monthly "Science Café" presentations about cutting-edge science research and careers, while others were involved in developing multimedia journalism to communicate about museum collections to the public. Some of the participants were also involved in field-science research focused on conservation.

Each program track gave students opportunities for (1) science career exploration, bringing in museum scientists to talk about career and academic pathways, (2) collaboration with museum scientists and educators, (3) public outreach events giving the volunteers a role in public science communication, and (4) a chance to contribute to the scholarly and public engagement operations of the museum.

Data collection & analysis

A semi-structured interview protocol was developed to explore factors related to career aspirations, including questions related to background experiences (e.g., *What were your prior experiences with museums and volunteering before the program?*), career aspirations (e.g., *Can you tell us how the volunteer experience opened the possibility of either science communication or teaching as a career?*), experiences as a volunteer (e.g., *How do you think you benefited from being a volunteer at the museum? Did you gain any skills? Knowledge?*), as well as science and communication skill development (e.g., *Do you feel like you have more knowledge, skills, and competence in learning and communicating science to others after volunteering at the museum?*). The interview questions were reviewed for content validity and clarity by a panel of educators that included the museum's volunteer program coordinator, a former museum volunteer educator, and two informal education researchers who had previously worked as secondary science teachers.

The interview was piloted with museum volunteers and revised for clarity.

Interview transcripts were open-coded (Strauss & Corbin, 1998) to identify common themes. The themes identified during open coding included: teaching, communication, science self-concept, science interest, and career/college interests. Analysis through axial coding revealed a relationship between the themes related to the expression of science identity (competence, performance, and recognition) (Carlone & Johnson, 2007) and education- or communication-related interest. Selective coding was then applied to the transcripts based on these identity-related themes. A second coder was trained with the codes and the two coders independently coded 20% of the interviews with an interrater reliability of 0.83 (Krippendorf's Cu-Alpha coefficient). The remaining transcripts were independently coded by the two researchers. Responses were examined across questions to explore and examine these themes in the data.

The selective coding for evidence of the individuals' science-related identity included statements related to participants' self-identified science recognition, science competence, and science performance. Within these identity components, emergent categories were coded and are described below. Science recognition was coded according to the individuals credited with recognizing the volunteers as science people: teachers, themselves, the broader scientific community, the public, peers, and their parents. The frequencies of these recognition code reports for all participants are displayed in Table 3, where they are also broken down by different educator profile for further analysis. Codes for science competence revealed the various ways the participants indicated they gained skills and expertise. These included communication (competence speaking in front of groups and in scientific settings), learning science (understanding new concepts related to the natural science they explored at the museum), metacognition (learning about the best ways to learn science), museum skills (such as curation and animal handling skills), and other scientific practices such as observation and identification. The relative frequencies of these competence codes are displayed in Table 4. Science performance codes (Table 5) showed the ways students were able to express and demonstrate their science identities, and included teaching skills (how individuals learned about the best ways to present and differentiate lessons for the public), scientific practices (such as field science techniques or species identification), experiential learning (learning in an active and immersive way at the museum), communication skills (best practices for communicating complicated science topics), and animal handling (e.g., holding snakes).

Participants' responses to possible career interests centered on three different profiles of communication- or education-related interests, selectively coded as: *communicators, educators*, and *teachers*. The career interest questions are detailed in Table 2. A desire to communicate science was shared between all the profiles, however, those participants included in the *teacher* and *educator* profiles also expressed career interests related to formal and informal science teaching. Fifty-five percent of the participants were coded as having a *teacher profile* and included individuals who indicated interest in all areas of science communication or teaching, including teaching in a K-12 classroom. Twenty-five percent of the participants were coded as having an *educator profile* and expressed a desire to communicate and teach, but this teaching was limited to informal and out-of-school settings. The third group, those with a *communicator profile*, made up 20% of the participants and included those who were not interested in educating in either formal or informal settings and instead indicated preferences for careers that focused on communicating science rather than teaching it (e.g., journalism).

Table 2. Science communication interests of youth volunteers.

	Interests				
Education profile	Teaching science in a K-12 school	Teaching science out-of-school	Communicating science to the public	Freq.	%
Communicator	No	No	Yes	4	(20%)
Educator	No	Yes	Yes	5	(25%)
Teacher	Yes	Yes	Yes	11	(55%)
Percent of Total	(55%)	(80%)	(100%)		

n = 20. One individual did not indicate interest in any category and was excluded from further analyses.

Table 3. Sources of science recognition.

	Communicators (20%)		Educators (25%)		Teachers (55%)		All (100%)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Parents	0	(0%)	1	(8%)	3	(12%)	4	(9%)
Peers	4	(50%)	4	(31%)	7	(28%)	15	(33%)
Public	0	(0%)	1	(8%)	2	(8%)	3	(7%)
Scientific community	0	(0%)	0	(0%)	1	(4%)	1	(2%)
Self	4	(50%)	5	(38%)	9	(36%)	18	(39%)
Teachers	0	(0%)	2	(15%)	3	(12%)	5	(11%)
Total	8	(100%)	13	(100%)	25	(100%)	46	(100%)

The "All" category refers to the frequency and percentile of all the reported instances of recognition by source.

Table 4. Components of reported science competence.

	Communicators (20%)		Educators (25%)		Teachers (55%)		All (100%)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Communicating	0	(0%)	2	(22%)	7	(24%)	9	(20%)
Learning Science	3	(38%)	4	(44%)	7	(24%)	14	(30%)
Metacognition Skills	1	(13%)	0	(0%)	3	(10%)	4	(9%)
Museum Skills	2	(25%)	2	(22%)	6	(21%)	10	(22%)
Other Scientific Practices	2	(25%)	1	(11%)	6	(21%)	9	(20%)
Total	8	(100%)	9	(100%)	29	(100%)	46	(100%)

The "All" category refers to the frequency and percentile of all the reported instances of competence.

Table 5. Components of reported science performance.

	Communicators (20%)		Educators (25%)		Teachers (55%)		All (100%)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Animal Handling	2	(25%)	2	(22%)	4	(18%)	8	(21%)
Communication Skills	3	(38%)	3	(33%)	6	(27%)	12	(31%)
Experiential Learning	0	(0%)	1	(11%)	2	(9%)	3	(8%)
Scientific Practices	1	(13%)	1	(11%)	6	(27%)	8	(21%)
Teaching Skills	2	(25%)	2	(22%)	4	(18%)	8	(21%)
Total	8	(100%)	9	(100%)	22	(100%)	39	(100%)

The "All" category refers to the frequency and percentile of all the reported instances of performance.

Results

The analyses of the interview data revealed that throughout their time in the program, the youth participants reported having experiences that developed their identities as scientists (described below). This growing science identity development included reports of being recognized as a science person (including self-awareness as well as recognition by others), increased competence in science (including the ability to understand the world scientifically), and enhanced science performance (the capability to demonstrate to others the skills to properly do science and speak, act, and interact in scientific settings) (Carlone & Johnson, 2007).

The participants' enhanced science identities contributed to the development of their career goals. At the time of the interview, 86% of the participants were either currently employed in a STEM career or were interested in a future career in a STEM-related area. However, when asked if, because of participating in the museum program, they would be interested in communicating science to the public, teaching science in out-of-school settings, or teaching science in school-based settings, nearly all individuals reported that their museum experience led to an increased interest in at least one of these possible careers (see Table 2).

When the individuals' science identity components were analyzed by the emergent education profiles (*communicators, educators*, and *teachers)*, distinct differences emerged. The sections that follow describe the reported science identities of the volunteers and the identity characteristics broken down by education profiles. All the names used in the following descriptions are pseudonyms.

Science recognition

Science recognition refers to being recognized by oneself and others as being a science person. When asked about others who might view them as "science people", six recognition categories emerged. Table 3 shows how participants with different education profiles reported this recognition. Codes are reported as percentages to compare within a profile, as well as for the whole group so as to compare across groups.

For some museum volunteers, it was evident that taking on the role of being a museum interpreter and representing the museum to the public shaped the participants' views of themselves. For example, Diane found value in the hypothetical "badge" of being an "official museum person":

I think it shaped who I am today, because I don't think I've ever taken that badge off, since, I put it on and was like, 'wait, this feels good and I know what I'm doing!' Ever since then I've just always had this leadership inside of me.

Further, the role of presenting science information to the public allowed individuals to experience recognition from others as having science knowledge. As a result, they reported experiencing an increase in confidence. Alex described the recognition he gained by working with museum visitors,

Most adults don't have a very high level of science literacy when it comes to you know, "What kind of frog is that?" and the like, but we all knew that stuff and I think that was very empowering as a teenager to have some knowledge that adults didn't have, and to teach them something and for them to really be like, "Huh, you really know what you're talking about, kid." That was really cool.

Self-recognition was evident from many individuals, most of whom recognized themselves as being science people before entering the museum program. Daniel noted that he "was a bit of a misfit, and [. . .] really little bit of a science nerd, biology geek." Many of these self-identified science enthusiasts were also recognized by their parents and teachers who suggested the program for them in the first place.

Once in the program, it was evident that the youth participants solidified their interest and deepened their connection to the science world through their relationships with others. Daniel found recognition in the community with the other teens in his program, noting, “I’m a lot more comfortable knowing that there are other people out there that have the same interests in the creepy crawly critters.” Similarly, working on a team of likeminded individuals helped volunteers like Betty feel recognized by their peers, saying “one of the really important things that I gained was that it’s okay to be a science dork.”

When asked if their friends viewed them as a science person, it was a resounding “yes” from all participants. For example, Jessica actively engaged her friends with the museum:

My friends who aren’t in science always see me as a science person. I mean I dragged them to a lot of museum things. So, for the 24-hour opening of the new [museum] wing, I dragged a bunch of friends from college and volunteered them. I wanted to show them what a cool place the museum was. So, I would say yes, definitely my friends see me as a science person.

Recognition by others: communicators, educators, and teachers

Individuals of all profiles talked about self-recognition and recognition by peers. The *communicators*, however, did not report feeling as if adults in their lives (museum educators, scientists, and family members) recognized them as science people. On the other hand, the *educators* and *teachers* felt recognized by adults and the broader scientific community as science people, such as Alex (*teacher profile*) who worked with citizen science programs. The participants with *educator* and *teacher profiles* reported feeling drawn to serve as science educators in formal and informal settings. They also talked in more detail and depth about how their experiences communicating helped them feel comfortable in these public roles. Hank (*teacher profile*) remembered when starting off in the program that he “was very timid about approaching people and offering this [teaching] ability.” He reported being more comfortable being behind a museum exhibit table teaching about a small activity than he was with giving presentations but noted he developed confidence over time.

Science competence

While at the museum, the youth volunteers increased their competence, or ability to understand the world scientifically, in many ways. The different areas where participants reported feeling competent in science are shown in Table 4. The primary focus for the museum program was for these individuals to help present museum programming. Mary remembered,

> it was really cool to be able to do live animal handling, and I got to see a lot of parts of the museum you just don't get to see as a visitor. Working with their live collections was really cool.

The animal handling aspect was new for many volunteers, but they quickly felt competent in their handling of animals like snakes when giving presentations. Diane had "never touched a snake or an alligator and that also helped me in my confidence." Some individuals were also able to participate in collection curation. Alex learned that when "volunteering with dead animals, there's a lot more data and a lot more meaningful science that you can do."

In addition to these museum tasks and skills, the volunteers were involved in scientific practices like observing and collecting data, asking questions, and carrying out investigations. The program's focus on species identification stuck with the volunteers and gave them an advantage when entering their college science courses. "We already knew how to tell the difference between an American and a Fowler's toad, so [we were] just killing it out the gate," remembered Janine. Hank, who is currently working as a college science professor, recognized the many areas that the museum volunteer program contributed to his science practices.

> So, there's the development of a lot of skills from things like scientific observation, keeping a field notebook, identification of local flora and fauna, skills like pit tagging [a special fish tag], making a driftnet and mist netting, using binoculars and a microscope, and animal husbandry. All of these are lists of skills that I developed and could talk about going forward.

The museum volunteer experience involved the presentation of a lot of science content and, as a result, most of the individuals referenced the museum helping them learn science. The program expanded and deepened their science competence and helped them feel more comfortable learning about and exploring science. Nelson reflected: "the more I learned about exotic animals the easier it became to learn what they do, how they interact with the world, stuff like that." Further, Anna said,

> A high schooler's perception of what science is really limited to either the stuff you see in the

> news or pop culture. Like 'scientists have discovered this' or like superhero movies or what you just learned in school. So, I was definitely driven there because I wanted to learn more about science, but it was a very abstract type of idea and once I got started getting more and more involved in the program it definitely shifted and changed and strengthened my interest in science.

Not only did the participants gain a "tremendous amount of knowledge" (Daniel), but the volunteers reported developing their metacognitive skills as they learned how to learn science. Valerie reflected on how experiences learning and teaching at the museum "brought a different way of approaching a problem, a different way of learning science, a different way of getting engaged in science, rather than just reading a textbook or stuff like that." The museum also brought in scientists for talks throughout the program, and the participants reported this helped them to think metacognitively as well as learn how to ask good questions. For example, Janine saw other people asking good questions at these talks and thought, "I also want to be the person who asks really good questions."

Perceptions of science competency: communicators, educators, and teachers

We found differences in how the different groups discussed their competence in communicating science. The youth with the *communicator* profiles did not spontaneously talk about their science competence regarding communication in their interviews. The *educators* (22%) and *teachers* (24%), however, mentioned feeling a lot more competent in communicating science because of the program. For example, Sam (*educator profile*) remembered,

> While at the museum I definitely felt like I broke out of my shell a little more. I was kind of required to talk to a lot of different people of different backgrounds and different age groups. A lot of different people. So, I felt like I was able to adapt to different social situations and use my understanding of a certain scientific concept to steer the social situation as well.

Science performance

Related to their increased competence in science is how these volunteers performed science. Science performance refers to an individual's capability to show others they have the skills to properly do science and speak, act, and interact in scientific settings (Carlone & Johnson, 2007). Table 5 shows the ways participants talked about performing science during their time at the museum. The volunteer program provided opportunities for the volunteers to practice their new skills, like species identification. "I'm actually out doing the science, not just reading about it. Because we did a lot of actual practical work," said Diane. Additionally, for some volunteers this practical work included developing skills in animal handling. Jessica noted,

> I was pretty afraid of snakes when I started, and basically they were just like- 'Here, hold this snake.' I was like 'ok!' And [now] I have no fear of snakes, or really it helped me conquer all of my fear.

The participants also reported that they translated their learning of science content and metacognitive skills into their high school science classes. For example, Sam was able to draw on his volunteer experience to help with a school assignment for a science class. He reflected on the way that they learned new skills and content in the museum program and how valuable it was for him when applying this to a large-scale class assignment. Similarly, Diane noted that the program allowed her to be "actually out doing the science, not just reading about it. Because we did a lot of actual practical work."

One of the major ways these students reported developing science performance as part of their science identity was through learning and using communication skills. Anna recalled the museum's Science Cafe presentations impacted how she communicated to her peers.

> We had to think about how we could phrase something in order to make it interesting for a group of high schoolers . . . interesting enough for them to actually leave their house and come down to the Science Museum on a Friday night.

Participants talked about how the ways the program involved the volunteers in communicating to the public allowed them to develop effective communication skills. During special events held at the museum, the volunteers were given tasks to communicate about one specific topic. Jessica remembered, "I would have animals and I would be telling them about the animal and what they eat [. . .], so interacting with the public and speaking with the public was a skill that I developed there." The volunteers had to communicate with individuals of all ages, and this gave them the confidence to express their science knowledge more broadly. "It certainly influenced how I saw myself, like yeah, maybe I know things, maybe I can teach other people things that I already know," said Evan.

Deeper than just learning public speaking skills was the way the participants reflected on how the museum program helped them to think more deeply about how well they shared information. For example, Nelson described how he learned to be a more effective communicator. “[P]eople will ask you difficult questions and you have to be able to answer those difficult questions. So, you have to educate yourself and be clear with what you’re saying.” The participants gained an appreciation for the skill of differentiation, as Sam pointed out:

> Trying to communicate some scientific idea might be a little different based on who you’re talking to, so I feel like I gained a little more experience with how to convey such ideas to different people based on different personal factors like their age or maybe like what back- grounds they have.

Perceptions of performance: communicators, educators, and teachers

Youth of all profiles noted that the museum gave them a context to communicate with others and helped them think about how to communicate science ideas. Kim (*communicator profile*) recalled “learning about how [museum staff] explain things to young children in a way that is appealing to them, not necessarily in a way that is easy.” The *educators* (11%) and *teachers* (9%) also described how the experiential learning at the museum connected to their participation in science outside of the museum. For example, Valerie (*teacher profile*) said that participating in the museum program gave her “a different mindset” and taught her “how to look at material not just as knowledge, but information.” The *teachers* group tended to focus more on how their science performance was expressed through scientific practices; twenty-seven percent of their performance reports referred to science practices compared to 13% for *communicators* and 11% for *educators*. For example, Alex (*teacher profile*) learned to keep a binder of animal fact sheets and Gloria (*teacher profile*) learned field techniques like gillnetting and different population sampling techniques. The youth in the *teachers* group reported feeling confident in their ability to communicate science to all types of audiences.

Views of education

As outlined above, the three distinct profile types of individuals had similar experiences in the museum volunteer program that impacted their science identity in different ways. Throughout this science-focused program, the participants also developed additional interests and skills related to science communication and education. All the participants noted that they felt more comfortable with the idea of science communication, whether as a communicator, educator, or teacher, as a result of the program.

The *communicators* appeared to be able to see how others may be able to use science education to help others, but they felt less directly connected to that process themselves. The *educators* reported learning about the types of informal education jobs that exist and recognized the way the program gave them practice in communicating and educating. However, the *educators* did not think the program would have been attractive during the application process if it was explicitly called a "teaching" program. According to Diane, "[If labeled a teacher education program] I wouldn't have done it . . . I think that scares people away."

As we would expect from their interest in the teaching profession, the *teachers* had the most to say about the benefits of the program to how they learned to teach. Kelly (*teacher profile*) reflected on how the museum gave her an opportunity to feel the benefits of being a teacher.

> I remember one day, we were outside and waiting for everyone to get together, and some girl asked me something about genetics, and I started explaining Punnett squares and helixes to them and they were understanding it. And then I realized after a few minutes, it would have been just a small group of girls, eventually it was the entire group of girls just sitting there listening to me so intently talking about genetics and I was like, I just love this feeling.

Mary (*teacher profile*) realized "a lot of the stuff that I liked about the museum was the science but was also working with people and helping people understand science and learn. And then I got into education." Hank (*teacher profile*) talked about the way the program helped him improve teaching skills without him even knowing it.

> [Just dumping information] is not how learning works and by being a museum volunteer, you get intense one-on-one hands-on learning constantly with supportive peers . . . I think not only does it show the volunteers how they can teach others, but it also shows them how they teach others in an effective way.

Discussion

Influence on science identity

The results of this study are consistent with previous research that informal spaces such as museums can help individuals form or deepen their science identity (Jones et al., 2020). This program supported the development of budding scientists, giving individuals opportunities to become more competent in their ability to understand the world scientifically, to perform these new skills and be able to speak, act, and interact in science settings, and led participants to recognize themselves and be recognized by others as science people. The participants were able to form multiple, changing, and fluid “affinity-identities” (Gee, 2000) as science people.

The informal space allowed for students to leverage their science competence in new and exciting ways. This program had a goal of developing scientists, and the opportunities given to the students to engage in scientific practices helped them develop competence in the areas of museum programming and science skills, as well as learning both science content and learning how to learn. The participants were able to return to their places of formal learning with an enhanced skillset that helped them identify even more deeply as a science person. Students were able to engage in authentic data collection, such as gillnetting, that they may not have typically had the chance to do in a formal school setting.

An important facet of science competence and performance that was particularly developed in these participants was that of science communication and teaching. These youth volunteers were drawn to the program by their interest in science and the exciting experience of working closely with scientists but were also given a chance to develop communication skills. Individuals spent much of their interviews talking about performing communication (31%) and teaching skills (21%) and feeling competence in communicating (20%) which may indicate the importance of the communication aspect to their individual experiences.

It is evident from the interviews that individuals felt strongly about the influence of acting as a representative of the museum on their science recognition. Performing this role of “scientist” gave students the chance to be recognized by many types of people—parents, teachers, the public, the broader scientific community, and their peers. Recognition is integral to the development of a science identity (Hazari et al., 2020), and the results of this study show that the museum program provided a valuable arena for individuals to gain recognition as scientists and science communicators.

Education career interests

The museum program’s public-facing science communication component allowed the youth to interact with the public to develop skills as science educators alongside their science identity development. Analyses indicated that there was a continuum of interest in the field of education and that the participants expressed interest and comfort at points along this spectrum. Though most of the participants entered the program because of their interest in science or animals, remarkably over half (55%) left the program with an increased desire to teach in a K-12 setting (see Table 2). It was evident from the interviews that the museum volunteer experience had a formative influence on the participants about the importance of education. This authentic experience educating and communicating science with the public contributed to an interest in a future science education-related career.

Role-taking has been shown to be an important way for youth to feel comfortable with developing teaching and tutoring skills (Sprinthall, 1994). In this program, individuals were able to take on the role of museum educator that allowed them to practice science communication in a low-risk environment. For example, working on the floor at a museum cart, the volunteers had the chance to teach a topic to a few people who stopped by. If something went wrong, they would have the chance to immediately change their strategy and try out a new way of communicating the information. This type of authentic, low stakes teaching opportunity is hard to find in a traditional classroom. Even when given the chance to teach their peers, the power dynamics keep them in the role of "student," whereas they were given the chance to truly be the "teacher" in this museum volunteer program. Teachers benefit from this low-stakes environment provided by museums (Luehmann, 2007), and our results indicate that youth volunteers also experienced this benefit.

Not only does this museum volunteer role give students the chance to develop competence in science communication, but it acts as a very strong avenue for recognition as a science communicator. The development of a science identity included developing competence, performance, and recognition as a *communicator* of science, which may explain why the individuals expressed career interests in science communication and teaching. Some participants in this study, the *educators* and *communicators*, were given the chance to step into the role of teacher and discover that they possessed the skills and disposition to be successful. This recognition appears to have led to the development of an interest in a science teaching career of some kind. The museum environment has been shown to help develop burgeoning science teaching and communicating identities in teachers (Avraamidou, 2014a), and our results show this can also extend to youth volunteers.

Research indicates that experiences gained at museums play a role in developing future scientists, but these studies do not explore the effects of those programs on teaching career outcomes (Habig et al., 2020). This study contributes to our understanding of the broader impact of these types of programs. Programs like the one in this study aim to help individuals develop science career interests, but do not often capitalize on the subset of science careers that are focused on science education.

Museums have been shown to be places where teachers can strengthen their practice (e.g., Heredia & Yu, 2017; Kisiel, 2013; Seung et al., 2019), and our results show that this also extends to individuals who have not yet chosen to enter a career as a formal teacher. We know that museum programs help teachers learn to teach in student-centered ways (Adams & Gupta, 2017). Our results show that these skills can be learned by youth in similar ways, helping them gain skills as a teacher before committing to a college major or career. Given the serious shortage of science teachers (Cross, 2017), museum volunteer programs may serve as a source of an untapped pool of new science teachers.

Limitations

One of the limitations of the study is that the data are from self-reported retrospective accounts of the experiences that took place from 2 to 15 years earlier. The degree to which the reported perceptions and influences of events and experiences reflect the actual experiences and events is not known. The sample is composed of volunteers and it is not known how representative these perspectives are for all the former youth volunteers. The participant sample is also limited by the initial selection into the program due to the cost to participate. Many of the participants were recruited from one university and the degree to which these participants are representative of youth volunteers more broadly is not known. The study is bounded by the perspectives of the researchers and the lenses used in the analyses and care should be used when generalizing to other populations.

Implications and future research

The program had a differential effect on the youth volunteers regarding their interest in a possible teaching career, however it is not clear what led to this differential impact. Did the youth come to the program with different predispositions toward education, teaching, or communication? Future research in this area would benefit from explicitly measuring educational interests and education career motivations before participating in such a program.

Science and science teaching identity research has shown "the importance of recognition by others, and the importance of the places or contexts in which [. . .] identities are developed" (Avraamidou, 2014b, p. 156). Research on science teacher identity has traditionally focused on preservice or inservice teachers who develop their teaching identities after having made the decision to become a teacher. Future research is needed to see how individuals may develop an early identification with teaching before choosing it as a career. Informal spaces and volunteer programs like the one described here could be an interesting and fruitful avenue to recruit teachers if these programs intentionally incorporate the opportunity for individuals to be recognized in the role of "teacher."

One of the unexpected outcomes of this study was the finding that a program initially developed as a future scientist program also served a valuable role in developing future teachers, educators, and science communicators. Incorporating direct teaching components into these programs may increase individuals' experience and competence in science communication and can help them to envision themselves in a role as a science teacher. There is a desperate need for more highly qualified science teachers to educate the youth of the future. Understanding how informal science settings can develop education identities and career interests beyond their stated goals of increasing interest and identification with science can help create a new pipeline for developing science teachers.

This program was designed for individuals with a high initial expressed interest in science. As some programs are focused on developing science interest, future research is needed to investigate how education career interests may be cultivated in individuals without a high science interest. Further research is needed to identify the specific components of programs such as this that are most effective at encouraging individuals to go on to develop an interest in a teaching career. This program did not explicitly focus on developing future educators and teachers. However, studies are needed to understand the impact of a specific museum program focus on teaching and its impact on the likelihood of indivduals to become formal teachers in a K-12 setting.

This study documented the important roles that youth volunteer programs have on science career interests as well as provided insight into the positive influence of this experience on communication and education skills and aspirations. Programs like these may prove to be a valuable venue for discovering the next generation of teachers and communicators of science.

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