Teacher, Researcher, Designer

Science Museum Internships Expand What Counts as STEM

Carrie D. Allen

The well-documented underrepresentation of women and people of color in science fields (Ong et al., 2011) remains persistent in the United States (National Science Foundation, 2018). A growing body of research suggests that a contributing factor is the ways in which K–12 learning environments recapitulate constrained notions of what it means to participate in and be "good at" science, technology, engineering, and mathematics (STEM).

Young people's experiences with STEM disciplines in school often involve arriving at established answers in uniform ways (Calabrese Barton et al., 2012; Carlone et al., 2014). Therefore, students who can get the answer quickly and work independently are more likely to be seen as "scientific" by their peers and teachers (Carlone et al., 2011). Ability in mathematics is often treated as a stagnant trait (you have it or you don't); emphasis on learning through trying and doing is often absent (Dweck, 2013). Further, in schools, STEM disciplines are often treated separately, with little connection made across domains (Honey et al., 2014), which are not seen as integrated ideas and resources for sense-making.

Such classroom practices offer limited avenues for young people to express themselves or be recognized as STEM-oriented people (Allen & Eisenhart, 2017; Carlone et al., 2014; Eisenhart & Allen, 2016; Nasir & Vakil, 2017). They can isolate youth from the rich applications of STEM practices and culture. Additionally, they tend to further marginalize youth already underrepresented in STEM fields (Carlone et

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al., 2014; Nasir, 2012) by favoring dominant students (typically White and male) while repeating limited notions of STEM (Carlone et al., 2011).

By contrast, learning environments that enable young people to participate in and engage with diverse STEM practices hold promise for reimagining what counts as STEM and, ultimately, for broadening participation (Eisenhart & Allen, 2020). Out-of-school time (OST) STEM learning experiences have great potential for supporting robust notions of STEM practices and providing opportunities for youth to engage in STEM-linked identity work (Adams & Gupta, 2013; Adams et al., 2014; Bell et al., 2009). For example, OST STEM experiences can bolster young people's science-linked identities across OST and formal classroom learning environments (Adams & Gupta, 2013; Calabrese Barton et al., 2013). They can open up possibilities for young people to participate in STEM and be recognized as "a STEM person" by their peers and teachers.

Further, research suggests that OST STEM programs ignite participants' interests and support their learning and identification with STEM in ways they do not experience in school. In an analysis of girls' participation in an afterschool science camp, Riedinger and Taylor (2016) found that engagement in authentic science tasks supported participants' science-linked identities in ways not provided in school. One participant, for instance, shared that, although she was known as a "good worker" in science class at school because she took good notes, her interest in science often waned. Through her participation in the science camp, and particularly in field labs, she came to see herself as a scientist—because she was "actually do[ing]" science work (Riedinger & Taylor, 2016, p. 3). Similarly, in their analysis of the Explainer program at the New York Hall of Science, Adams and Gupta (2013) found that participants' newfound confidence in their science ideas traveled with them from the museum into the classroom. They shared that they learned more as Explainers than they did in school.

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In science museum programs specifically, young participants may come to see themselves as part of a broader community that works toward common interests and goals related to science and STEM (Adams et al., 2014). Such recognition by their peers can foster a collective identity (Riedinger & Taylor, 2016) that supports them in navigating difficult challenges as they pursue STEM-related college degrees (Adams et al., 2014). OST STEM learning experiences thus have potential to support participants' interest in and pursuit of STEM. Still, the field needs to identify which aspects of program design lead to these desired outcomes. This research can inform approaches to STEM learning in K–12 schools and support understanding of the kinds of learning opportunities that foster youth identity work in STEM across settings (Penuel et al., 2016).

This paper draws on participant interview data and science museum artifacts to understand the relationship between the design of science museum internship programs and the STEM identity work of the participants. The analysis focuses on what it means to be recognized as "a STEM person," participate in STEM-related activities, and pursue STEM interests in science museum internship programs.

Understanding STEM Identity in Science Museum Internship Programs

To examine the relationship between STEM identity work and the design of science museum internship programs, I drew on conceptual tools from social practice theory. The work of Holland and colleagues (Holland et al., 1998; Holland & Lave, 2009) views identity as being constructed in local practice. The theory focuses on three central components of identity construction:

- The **institutional forms**, practices, or opportunities that organize people for participation in local practices. In the museum program, what STEM activities are available to interns, and how do they gain access?
- The "**figured worlds**" or cultural visions that provide symbolic resources for interpreting or mediating participation. What ideas are circulating among the science museum interns about what it means to engage in STEM or be a STEM person?
- The process of **self-authoring** through which individuals develop identities-in-practice. What do participants emphasize when they talk about their

involvement in the museum or the ways in which they are doing STEM?

This analysis employed an embedded case approach (Yin, 2013) to explore the relationship between the design of science museum internship programs and participants' self-authoring in these programs. I examined this issue in two science museums that offered long-term internship programs for middle school to college-aged youth. These programs were selected because their interns were part of a larger longitudinal study examining interest development, persistence in learning, civic participation, and development of future selves for youth in Connected Learning programs (http://clrn.dmlhub.net/projects/longitudinal-study-of-connected-learning). Of the three science museums in the larger study, "City Science Academy" and "Coastal Science Museum" (both pseudonyms) were most similar in program design and had the most participants. Both were based in large cities. Their internship programs were for high school and college youth, who were required to apply for the position and were paid for their work. In both programs, interns were expected to work on the museum floor as educators to the public. Through regular participation and skill mastery, interns eventual took on greater responsibility and new roles.

The study focused on 13 participants who served as interns in one of the two science museums and who identified as members of one or more groups that are underrepresented in STEM: female, Black, or Latinx. Members of the Connected Learning project team—a mix of faculty and graduate students from the University of Colorado at Boulder, including me—surveyed and interviewed the study respondents over a three-year period. Interview topics included how participants became involved in the program, how their participation changed over time, what their interests were in the program, and how their involvement connected to future plans. All interviews were audio-recorded and transcribed to be coded later by all members of the research team.

Analysis focused on how respondents described the primary activities in which they engaged in the science museum internship program, how their involvement and interests changed (or not) over time, and what their plans were for future engagement in either the program or related STEM activities, such as pursuing a STEM college major or continuing to conduct research. I developed data displays organized by the individual respondents, by the identity components of Holland et al. (1998), and by program design. Program design constructs were identified as components of the design that seemed to be most salient to the participants, based on their interview responses. Through this initial process, the team generated working program area categories to examine more closely in our analysis of youth interviews. I then refined these initial categories in light of our coding and research team discussions. Further, the team used online literature, such as program websites, and other published materials, including journal articles, to ground our understanding of each program.

Doing STEM in the Science Museum Internship Programs

Study respondents named a number of roles and responsibilities in the internship programs that shaped their participation and identity work in STEM:

- Being teachers on the museum floor and becoming experts both in the content of their exhibits and in delivering that content
- Engaging in ongoing learning with support from peers and mentors
- Contributing to a science community and working toward common goals

Becoming Science Experts and Artful Educators

The most prominent activity respondents described in their interviews was teaching the public in demonstrations or exhibitions on the museum floor. Interns were assigned exhibits for which they were responsible to deliver content and engage museum patrons in. For example, Gina (a pseudonym, like all participant names), an intern at City Science, described the demonstrations she conducted: "The flight demonstration is about the science concept behind how things fly. Then air demonstration is about air pressure and how that affects us. The chemistry demonstration just teaches audiences about atoms and molecules." The demonstrations used a variety of activities to show everyday examples of the focal concept.

Almost all respondents described feeling "intimidated," "fearful," or "shy" when they first led demonstrations. However, they also described a process of becoming experts both in the science content and in the skill of delivering the content. For example, Raul, an intern at City Science, said:

[When I first started] I would just ask [the public] yes or no questions, and it wouldn't really require much thinking [on the part of the patrons]. Now I ask them, "Oh, so what do you see? What do you think is happening?" Questions that are more open-ended…. For the chemistry demonstration, I don't even know what the script says. I adapted it. I know what to talk about, and I know how to say it [so the audience] would understand it, so I just use my information that I know.

Similarly, Emily, an intern at Coastal Science, stated:

> [When I first started] I didn't know all the exhibit contents in depth, and I didn't know demonstrations in depth. It was a little daunting just going out there [on the museum floor] not knowing everything, because, if someone asked you a question, you have to try to learn it with them while explaining it to them. As you … learn and practice, it became clear what you needed to do. You became more comfortable with everything else around you. [Now] any of the fear that I may have had when I first started, like worrying about … if I know the material—that's really gone away, because I just feel comfortable. It's like I know what I'm talking about for sure now.

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The mastery of science content and development of teaching skills shaped how participants came to understand STEM and themselves. Raul's and Emily's comments show that they had gained confidence in their science knowledge and in their craft as science educators and communicators. Raul grasped the importance of asking open-ended questions that required patrons to engage with the science content and their own process of inquiry. He was also confident enough in his grasp of the material that he could craft his own lesson.

Artfully engaging museum patrons was a point of pride for many respondents. For example, Jade of City Science said:

> [My role as an intern is] making sure the visitors get an understanding of what's going on and also even that we have science concepts here. That's not necessarily what you can talk about, having a great interaction with the visitors and make them feel like they're awesome, that they're learning, that they're happy.

Being Learners and Asking for Help

Interns' movement from being shy or unsure about science knowledge and teaching practice to being artful experts was supported by intentional scaffolding and mentorship designed into both science museum programs. Respondents referred to the design as the process of "leveling up." They began in entry-level positions; over time, as they demonstrated mastery at each level, they gained more responsibility, autonomy, and access to rich STEM practices. For example, at City Science, participants began as trainees, learning to engage museum visitors in exhibits. After completing a certain number of hours on the museum floor, they moved into more permanent internship roles. In those roles, they had opportunities to demonstrate their mastery of the content and presentation of specific exhibits, earning certification over time in numerous exhibits. From here, they could move into leadership roles, managing the staffing and training of exhibits and supporting newer interns as they joined the program, eventually serving as mentors.

Similarly, at Coastal Science, program participants conducted demonstrations on the museum floor as public educators. Once they advanced to Level 2, they began doing work behind the scenes, collaborating with other interns and conducting research within ongoing projects led by museum staff and senior mentors. Such work contributed to publishable manuscripts and presentations at national and international conferences. At Level 3, participants became part of the program's leadership council, in which they supported newer interns and helped decide how to grow and improve the program.

"Leveling up" certainly happened when participants accomplished milestones in the internship program. However, those accomplishments were fostered by a *culture* of learning and the practice of intentional mentorship. Raul described the modeling and practice that went into developing his skills as an explainer:

> You can watch the demonstration first. You can watch another explainer do it, and you can practice it. [You] get pre-certified so that [program facilitators] know that you know the content. Then you go for certification, which is you just talk and you do it in front of a live audience, and then a trainer will watch you and evaluate you…. During the school year, we do get training every week…. They'll give us content training one week so that we understand the concepts behind the exhibit area…. If I have any questions ever, [the trainers are] always open for me to ask them how to explain the exhibit better, to explain the content a little more clearly if I didn't catch it the first time.

Because of the scaffolding Raul described, respondents often described themselves as "learners" and "students." Stories from their more-expert peers led them to understand that they would not master a demonstration on their first try. They expected to need to learn more, so they did not experience a need for improvement as a marker of their ability or belonging in STEM.

Li of Coastal Science described the process of learning and coming to see herself as a thinker that she experienced during her time in the museum:

> I … really didn't expect all the knowledge that I'd accumulate, not just from my peers and all the other scientists that work here, but even on the floor. I teach people, but it's not just teaching experience. I've learned a lot, actually, from the visitors that come here from all over the world. They know things that I don't, and it's really, really cool to have conversations from them outside of the script…. Like, you get more answers, but that means more questions, and then I keep on thinking. I think "thinker" would adequately describe [how I see myself].

This learner stance showed up in the ways respondents talked about STEM disciplines and their interests in STEM beyond the museum. Raul, for example, described engineering as a process of trial and error:

> [If] you build something and you don't like how it turned out, it doesn't do the things that you wanted it to do, you can analyze the situation. You can figure out what's wrong, and then you can try to build on that part. Nothing is really a failure when you're doing design.

Jamal expressed the common view that doing science involves this continual learning-teaching process:

> I do science in here. Not only behind the scenes, but also on the floor. Like I can say, on the floor I learn all the contents of a certain topic and then I share it to people, and then they're going to share it to everybody also.

Being Members of a Science Community

The interns' continual-learner stance was fostered by the deep sense of community and trust the museum programs cultivated. In this community, mistakes or shortcomings were treated not as setbacks, but as fodder for growth and learning. Li described an experience in which she felt supported after she fell short in fulfilling her role:

> Everyone in the leadership council was assigned specific duties that they're in charge of, and usually multiple people were assigned the same duty to make sure it's covered. When I was very [new to the role] ... I was in charge of this one demonstration station, but I wasn't really on top of it, and it didn't help that I wasn't communicating with the older interns who were also in charge of it. I overcame [this problem] by communicating and actually talking and asking questions, asking them about how I should do the station.

Li learned that she could and should ask more senior peers how to make her demonstration—an integral part of the work her science museum community was producing—run smoothly. Overwhelmingly, interview respondents named the older interns and mentors as those who helped them when they encountered a challenge; from these encounters, they learned to ask for help.

They expected to need to learn more, so they did not experience a need for improvement as a marker of their ability or belonging in STEM.

Furthermore, Coastal Science participants engaged in ongoing research projects and presented their research findings at national and international conferences. Lorena, for example, described a project in which she and three other young women worked with a mentor researcher at the museum to investigate a fungus that was affecting amphibians. The team collected samples, used software at a local university to run tests on their data, and then presented their work at conferences in China and the U.S. These experiences positioned the interns as contributing members of a broader science community. Both Coastal Science and City Science hosted STEM nights in which participants could listen to and meet with professionals in STEM careers. These connections expanded participants' ideas of STEM career options and broadened their community to include working professionals.

Taken together, the science museum experiences guided participants to a sense of belonging. Interviewees said they were contributing to meaningful work alongside others who were like them. Emily said:

> I feel like a lot of people here are kind of similar. Because, I mean, there's already a binding force between us that we all work here, but sometimes it goes deeper. Like you find a lot of people have similar interests [to you].

Being a STEM Person in the Science Museum Programs

Interviewees described unique constellations of activities in which they participated as science museum interns. Raul, for example, defined himself as a "teacher," "designer," and "not-yet engineer." Jamal described himself in this way: "In this program they kind of put us in every position. We are teachers, but we are also students. Then we are explainers, we are researchers, we are—what's the word I'm looking for?" He went on to describe having engaged in a research project and then presented that work to others.

Jamal's reflections illuminate a key finding from this analysis: Ways of participating in STEM in the science museum programs were multifaceted; the programs thus welcomed a variety of ways of demonstrating expertise and being recognized as a STEM person. Participants taught the public, learned content and pedagogy, participated in research, managed demonstrations and projects, mentored others and received mentoring, supported others' work, and engaged with working professionals who could answer career questions. Doing STEM and being a science person took on various forms. Being able to communicate science ideas in accessible ways was just as important to study respondents as learning the information itself. For many, knowing the information did not matter if they could not communicate their ideas effectively to museum patrons or conference attendees. Additionally, doing STEM work effectively required the help of others; it required practice and learning through trial and error. Interviewees' depictions run counter to how young people often engage with STEM in school, suggesting a profound change in how STEM work can be framed.

STEM Practices as "Tools to Think With"

Through their work as science museum interns, participants in this study took on sophisticated, nuanced perspectives of STEM and of themselves as STEM-linked people. They developed research skills, science knowledge, and professional connections that would provide invaluable currency toward pursuing STEM interests. They also took on dispositions that are not always recognized favorably in STEM learning environments; they assumed a stance of not knowing, needing help, and requiring practice to develop their skills. They saw STEM as a collective endeavor and STEM knowledge as something to be shared broadly with others who, like them, wanted to learn. Particularly powerful for interview respondents was the link between teaching and being scientific. Being a STEM person meant supporting the learning of others.

These findings represent the experiences of a small sample of youth from two science museum programs. However, they suggest promising directions for practice and for further research. They highlight the need to design STEM learning environments to support multiple avenues for participation. Participants need opportunities to take on varying roles toward the kinds of knowledge building and design goals characteristic of STEM disciplines. Learning environments should celebrate learning, encourage questions, and promote trial-and-error experimentation. They should be designed to position STEM activities as collective pursuits, supported by individual contributions.

The goal is not for all participants to pursue STEM careers. Rather, reframing STEM can help participants to see science or engineering as, to use Emily's words, "tools to think with." Well-designed STEM science museum programs can expand the ways in which participants imagine themselves taking up these tools and using them for their goals and futures.

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