Long-Term Participants

A Museum Program Enhances Girls' STEM Interest, Motivation, and Persistence

by Jennifer D. Adams, Preeti Gupta, and Alix Cotumaccio

"Had I not been a participant in Lang, I don't think I would have pursued biomedical engineering in college. I definitely would have been intimidated by it and perceived it as an unapproachable subject. My science background, developed though years at Lang, gave me confidence to succeed at Johns Hopkins through a very difficult freshman year."

As an alumna of the Lang Science Program at the American Museum of Natural History shared this sentiment, others in the focus group nodded in agreement. They chimed in with their own stories of having built perseverance and confidence in the multi-year Lang program. All of these Lang alumnae were either majoring in STEM (science, technology, engineering, and math) fields or beginning STEM careers.

Out-of-school time (OST) science programs play an important role in influencing the trajectory of science learning for many young people. OST programs are especially important for students from groups underrepresented in science, who, more often than not, attend schools with inadequate science education resources (Rahm, 2008). Programs like Lang Science have great potential for young women of color, who often have to grapple with both race- and gender-based barriers to STEM careers (Modi, Schoenberg, & Salmond, 2012).

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Over the last ten years, OST science programs have multiplied to increase young people's exposure to science (Bell, Lewenstein, Shouse, & Feder, 2009). However, there are still not enough opportunities for *long-term engagement*, which is essential to move youth from having interest in science to having the skills, knowledge, and self-efficacy to pursue careers in science (Hidi & Renninger, 2006). This article describes findings from exploratory research conducted to document the experiences of a small group of young women of color who participated in a museum-based OST program during their middle and high school years. We were particularly interested in learning how their long-term participation in the Lang Science Program mediated their developing interests and identities as people who like science, understand science, want to do science, and can persevere in STEM majors and careers.

Underrepresentation of Women in Science

Underrepresentation of African-American and Latina women in STEM fields is a long-standing issue. The seminal *Double Bind* report of 1976 identified the inequities in STEM fields for women of color (Ong, Wright, Espinosa, & Orfield, 2010). Since that initial report, the numbers of women of color pursuing STEM careers has increased. However, this progress has been "uneven and inconsistent," and "disturbing patterns of racial and gender stratification by STEM discipline" persist (Malcom & Malcom, 2011, p. 165). Although a growing body of empirical research examines the experience of women of color in STEM, research on the environments and experiences that allow women of color to pursue and persist in STEM majors and careers is still needed (Ong et al., 2010)—particularly at the transition points between high school and undergraduate studies (Modi et al., 2012) and beyond to graduate studies.

Museums and STEM Learning

Museums have long played a role in engaging underrepresented children and youth in STEM (Bell et al., 2009). The museum context allows youth to access science in personally meaningful ways, develop positive science-related identities, and, often, pursue science careers (Adams & Gupta, 2013; McCreedy & Dierking, 2013). Middle school is a critical time when youth begin to make decisions about curriculum choices for high school (Akos, Lambie, Milsom, & Gilbert, 2007; Tai, Liu, Maltese, & Fan, 2006). During high school, they solidify those decisions and make choices about postsecondary education based on their career interests. OST STEM programs can play a critical role in supporting that decision making. Alumni of OST programs often report increased understanding of different types of STEM careers and of how to apply their own interests and talents to possible careers (Sickler & Johnson, 2009).

Many museums offer a continuum of OST programs—including summer camps, afterschool programs, weekend programs, and internships—as youth move from elementary to high school. Often these are standalone programs: Kids apply for each new experience, essentially carving their own STEM pipeline. Intuitively, program staff know that youth who participate in a continuum of STEM experiences over time undergo transformations that are not possible with school science alone.

However, there are many challenges in documenting the effects of museum programs. For one, the pipeline youth carve out may be circuitous. They may pick from a menu of programs within one museum and then participate in programs with other organizations, only to return to their initial institution a few years later. Such pathways are not bad, but they make it hard to document impacts and attribute them to specific programmatic factors. In addition, the quality and scope of programs can vary, even within an institution. Although reviewing curricula and sharing best practices are goals for virtually all institutions, the barrier is finding time for staff to engage in these critical dialogues. Frequent staff turnover also subverts program continuity and long-term adult-youth relationships. Finally, unlike schools, museums do not have robust systems for keeping track of individual student data across programs.

Lang Science Program addresses some of these limitations. Lang is a multi-year program though which youth move in cohorts. It is intended to support youth who are traditionally underrepresented in STEM. True, impact can be rarely attributed to one program, and learning takes place across all the spheres of a young person's life. However, examining the experiences of young women of color who participated in this long-term program allows us to connect aspects of that program to the participants' STEM-related career choices, interests, and beliefs.

Our primary research question was "In what ways does long-term participation in OST science programs shape the interest, motivation, and ability of young women of color to pursue and persist in STEM majors?" We used a retrospective approach in which we asked participants to reflect on their experiences in the Lang Science Program. A narrative approach to data analysis enabled us to uncover themes about how these young women built strong interests in STEM and developed

related identities over the years, including how they navigated any challenges they encountered.

About the Lang Science Program

The American Museum of Natural History has a continuum of programs that are designed to attract children from age 2 all the way through postsecondary education. The Lang Science Program is designed so that youth begin in sixth grade and continue until high school graduation. Youth apply through a competitive process. Since the time commitment is long, the program attracts girls and boys who are motivated in science but may not have the resources to pursue their interests outside of school. The program meets for three consecutive weeks during the summer and every other Saturday during the school year, for approximately 165 contact hours per year. The teaching staff, who serve as mentors as well as instructors, are experienced STEM educators, hold doctoral degrees in a STEM field, or both.

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Curriculum and Pedagogy

The curriculum begins in middle school with a spiraled focus on three areas of science in the museum: astrophysics with Earth and planetary science, anthropology, and biodiversity and conservation science. In high school, elective courses continue the focus on the content themes, many of which relate to special exhibits at the museum. All learning experiences include hands-on activities, scientist talks, visits to the museum's behind-the-scenes research labs and collections, and field trips. Starting in eighth grade, the youth work in groups to carry out an authentic science research project each year. Program staff choose research topics that span the museum's areas of expertise and are broad enough to give youth flexibility in what they investigate. Another component of the program is a college and career readiness curriculum for students in grades 11 and 12. As of June 2013, the program had graduated eight cohorts of young people. Though graduation rates were lower in the early years, revisions in program design have brought the current retention rate to approximately 85 percent.

Lang's pedagogical approach gives middle school students structured experiences that expose them to many different topics. In the higher grades, the program invites youth to direct their own learning experiences; they choose their electives and their research groups. Older high school youth engage in activities that support them to decide where to go to college and what to study. This intentional scaffolded design is supported by recent studies (Deschenes, Little, Grossman, & Arbreton, 2010) showing that middle school youth need structure and exposure to many different sciences, while older youth need more focused, self-directed experiences that give them greater responsibility, deepen their content knowledge, and help them plan their future.

The program design is dynamic, evolving to strengthen youths' experiences. For example, the college and career readiness piece did not exist when the program started; it was added based on alumni feedback. Another way the program evolved was to develop a more explicit scaffolding structure in the middle school curriculum so that instructors could build on youths' growing knowledge and skills.

Developing Science Identities

When done well, STEM OST programs engage youth in rigorous, high-quality, and purposeful activities (Gupta, Adams, & Dierking, 2011). Youth become actively involved in producing scientific culture as they come to understand science as a meaningful part of their lives (Bell et al., 2009). In the Lang Science Program, interactions among peers, museum educators, and scientists allow for authentic learning. Youth learn and participate in the culture of science, but they also come to realize that they can contribute to science. They simultaneously learn science, do science, and develop a science *affinity-identity*—that is, they learn not only to like science but also to view themselves as active participants in the scientific endeavor (Gray, 2013). Having a science affinity-identity helps them to make career choices that are congruent with how they see themselves contributing to the science community. The place where this learning occurs is important, because interest development is context-dependent (Hidi & Renninger, 2006). The resources museums offer—exhibits, collections, educators, scientists—mediate the learning that takes place. Without them, the program design and learning experiences would be quite different (Bell et al., 2009; Adams & Gupta, 2013). This context, together with ongoing participation in a science-rich learning community, mediates the development of sci-

ence identities in young people as they learn science in multiple contexts over time.

Studying the Experience of Lang Alumnae

We invited eight female alumnae of the Lang Science Program, mostly from underrepresented groups, to participate in the study. Of the six who agreed to participate, three were African American, one was Latina, one was South Asian, and one was European American. For this exploratory study, we wanted to collect qualitative data from a small group in order to generate themes that we will later investigate in more formal longitudinal research with a larger sample. We held a focus group at the museum where we invited participants to reflect on their experiences in the Lang program and to share their post-graduation successes and challenges with science-related activities. We prompted discussion with questions but did not limit the direction of the conversation. To promote dialogue, we also contributed our own experiences as researchers, educators, and science learners and practitioners. We probed more deeply into themes that emerged from the focus group with follow-up individual interviews and e-mails. The focus group and interviews were digitally recorded. An additional data source was interviews with museum staff who witnessed the participation of the young women over time.

The primary theme in our data was that the young women felt a sense of belonging both to the program and to the museum. The words "cool" and "comfortable" came up often.

Through the process of re-storying, "reorganizing the narratives into some general type of framework" (Creswell, 2007, p. 56), we looked for patterns in the young women's STEM participation in context of the research questions. Grounded theory analysis (Strauss & Corbin, 1998) allowed us to generate themes. We began with open coding of the narrative to establish baseline descriptions of the emerging themes. Then we moved to a constructivist (Charmaz, 2005) framework, which recognizes the centrality of researchers' prior experiences with and perspectives on the phenomena and their relationships with participants (Creswell, 2007).

What Long-Term Participation Contributed to Science Identity

The primary theme in our data was that the young women felt a sense of belonging both to the program and to the museum. The words "cool" and "comfortable" came up often. The young women felt that they had access to unlimited science resources at the museum. We can sum up the relationship between long-term participation in the Lang Science Program and the young women's STEM affinity-identities and career trajectories in four key themes:

- Building a collective identity
- Belonging in a physical place
- Broad exposure to science topics and careers
- Moving from the museum to college

Building a Collective Identity

Building a collective identity, a sense of group membership with like-minded peers, emerged as an important theme in the study. Countering the narrative that being smart and getting good grades isolates teens from their peers in urban schools (Ogbu, 1992), Lang offered participants a space to nurture their science affinity-identities and develop relationships with others who held similar interests and goals. As one participant noted:

> I honestly felt like I was meeting people like me. In middle school I loved science and talked about animals and the Discovery Channel all the time, and everyone was just, like, "You're a weirdo." But when I came here I didn't feel like a weirdo anymore.

For the young women in our study, who were at times outsiders at school because of their science interests, the museum program provided a space where they could bond with peers who shared an excitement about science and where it was safe to, as one participant put it, "be a nerd." Being recognized by others as a certain "kind of person" is important in developing and confirming identities (Gee, 2001). Carlone and Johnson (2007) found that it was important for women of color to be recognized as scientists by others. The young women in our study belonged to a collective of emerging scientists and science-minded people.

When asked why they returned year after year, the young women consistently gave non-academic reasons, saying, for example, "[You] didn't want to miss a day because you thought you would miss something cool…." That cool thing might have been a behind-the-scenes visit to the dermestid beetles, but it could also have been

the appearance of a plate of gourmet sandwiches in the classroom or an instructor doing or saying something humorously memorable. The focus group participants shared many such stories, starting with the phrase, "Remember when…?" These cool things may not have been planned or have contributed to the program's science-related objectives, but they produced solidarity and a shared identity as a group of young women who have fun and love science. Months and years later, these stories were points of remembrance that continued to bind the group together. The excitement of creating such social experiences kept study participants attending regularly and fully engaged with the program.

Study participants told us that the collective identity they built in the Lang Science Program helped them continue their studies in college in spite of obstacles they encountered. Some noted that the shared identity and peer support continued in college even though they were attending different schools. They recounted going through difficult times in college, as we explore in more detail below. In these difficult times, they thought back to their Lang experiences and felt that, as one said, "I couldn't see myself doing anything else." The identity they built in the program helped them to persist through self-doubt.

Belonging in a Physical Place

The collective identity participants developed in Lang extended to a sense of belonging to the museum both as a physical facility and as a community of science-minded people. The large number of contact hours in the program enabled participants to take advantage of many diverse experiences at the museum, many of which took students behind the scenes, both at the museum and on field trips. One study participant said:

> I liked all the opportunities it gave you. We went to all kinds of behind-the-scenes [spaces]. I remember this one day, there was this huge bottle thing, and they opened up and there was a 20-foot lizard thing. And it was really fun and interesting. And it wasn't a classroom-type thing…. The trips they took us on were totally different from what we would do in school….

Lang participants met science professionals in various departments and roles in the museum. They also attended social functions where they engaged informally with, as one young woman put it, "people around the museum [who are] genuinely liking what they are doing in the science field." These interactions, both formal and informal, allowed participants to develop professional communication skills and build social networks with adults in the field. The program also gave them the confidence to approach these adults for assistance after the program ended. For example, one study participant recounted that she e-mailed the director of one of the museum's scientific centers to ask for a research internship. She said that she would never have had the courage to do so if she had not been familiar with the museum and its scientists or learned to speak with adults in professional settings. Another student who did a research project with a museum scientist while in Lang continues to stay in touch with her mentor, who is also a woman of color. This young woman said that she really values her relationship with the scientist and her connection back to the museum.

Lang students receive museum IDs that give them access to floors that are inaccessible to the general public. They gain an intimate knowledge of the physical facility, encountering "secret" staircases and old exhibits that ordinary visitors never see…. One young woman noted that this access made her feel both "special" and "powerful."

Lang students receive museum IDs that give them access to floors that are inaccessible to the general public. They gain an intimate knowledge of the physical facility, encountering "secret" staircases and old exhibits that ordinary visitors never see. Students who take on leadership roles get magnetic badges that allow them a higher level of access to elevators and offices. One young woman noted that this access made her feel both "special" and "powerful." The ID, with its special access to the physical space, was a symbol of belonging. It gave study participants a sense of ownership of museum resources and of agency in relation to the science content and processes behind the public exhibits. Coupled with their long-term participation, the ID card helped the young women develop identities as people who participate in the production of science while building social capital from their associations with museum personnel. The museum ID also allowed program participants, as one put it, to "get vouchers and bring our families and friends here" free of charge. These young women took pride in their association with the

museum and became its ambassadors, inviting their friends, families, and even teachers to visit.

Broad Exposure to Science Topics and Careers

An important part of building a science affinity-identity is learning what one does and does not like. All too often, young people are taught to view science as a lab-based endeavor. However, the young women in our study said that their exposure in the program to various ways of practicing science broadened how they defined science careers. They learned that science careers include not only research and teaching but also science writing and communication, outreach, and many others. One study participant described herself as not being "a lab work type of person," adding that she "enjoyed being in the office and analyzing stuff." She discovered this preference when she interned on a citizen science project in one of the museum's departments, where her work involved working on a computer and doing outreach. This experience, she said "changed what I wanted to do in life," sending her on a trajectory into environmental studies.

Participants also learned that science includes not only the major fields such as biology, physics, or Earth science, but also sub-disciplines and interrelated disciplines such as astro-biology or nanotechnology. Experiencing the many disciplines of science helped the participants develop science identities that were congruent with their individual personalities and interests and to think creatively about their career choices. One participant summed it up:

> The good thing about Lang [is that] we took so many classes on so many subjects…. I got to learn so much about everything in science… I learned what I like and what I don't like. [I] got exposed to everything.

At its core, the Lang curriculum is about teaching youth to develop the critical thinking and problem-solving skills necessary both for scientific investigation and for 21st century citizenship. Over many years of thinking and viewing the world in scientific ways, the young women in our study developed fluency in the culture of science. As one said, "[The program] got me used to being outside and doing things; it made me comfortable in the science field."

Another young woman described an experience that changed her career trajectory. After graduating from Lang, this young woman went to a liberal arts college and majored first in economics and then in philosophy because, as she said, she "did science for a while and wanted to try something different." During the summer, she came back to Lang to work as a teaching assistant. When a program participant had a seizure, she accompanied him to the emergency room. The way the emergency room doctor questioned the youth "reminded me of the Lang program…. [The doctor was] an investigator…. This was a turning point for me and made me realize that I loved science." She changed her major to biology and is now doing cancer research data management in a renowned local research hospital.

For other study participants, the specific experiences that influenced their decisions to consider STEM careers may not have been as clear cut. However, all of them agreed that, as they gained a true understanding of what it means to do science, science became a part of who they are. They described science as their "comfort subject" and the museum as their "second home."

Moving from the Museum to College

For several focus group participants, college presented many challenges. For one, they were not prepared for the culture of science as practiced in the "gateway" or "weeding-out" courses. One young woman started out in chemical engineering at an Ivy League college but found it very competitive and male dominated. She switched to biochemical engineering, where there were "more girls." Though she was more comfortable there, she still felt that "everyone was looking out for themselves" and that it was "competitive and cut-throat"—in contrast to the museum, where she had experienced a sense of community. Another Lang alum majored in forestry in a rural college, where there were "a lot of girls but not a lot of minorities." The few minority-group students "stayed together, and the other students did not talk to us…. We were left out of study groups." In contrast, the Lang program offered a collegial and nurturing environment where students engaged with supportive adults and worked in peer groups that included girls and boys of different ethnicities. All but two focus group participants described facing isolation, competitiveness, and an impersonal environment as STEM majors. Furthermore, they felt their professors were not accessible.

Studies have shown that, in light of such college experiences, underrepresented students often switch from STEM majors or drop out of school entirely (Bayer, 2011). When we asked these young women what helped them to persist, they cited several factors, including their participation in Lang. One focus group participant said that her "ego" kept her going: "I did not want to fail out of school. My mother also pushed me." She added

that reflecting on her Lang years helped her to remember that she was "smart and doing science since middle school." Another young woman said, "When I was in denial about science, I thought about how much I loved it at Lang, and it kept me going." These young women persisted in STEM not only because of family support but also because, having gone through a rigorous museum program, they knew they were capable. Furthermore, they were committed to doing science because of their years at Lang.

Offering a Continuum of Participation

In the recent report *Cascading Influences*, McCreedy and Dierking (2013) examine the long-term effects of STEM OST experiences on girls. Like us, they used a retrospective analysis of young women's memories and reflections to determine the long-term effects of OST STEM participation. They noted, "If our findings showed that program experiences were exceedingly memorable and long-lasting, this would be an indicator of the potential learning and evidence for the cascading influence of these experiences" (p. 9). They use the term "cascading influences" to describe how experiences that young women have in multiple areas—home, school, OST, college, and so on—"build on one another, as well as connect to and reinforce the countless other experiences in a woman's lifetime" (p. 3).

These young women persisted in STEM not only because of family support but also because, having gone through a rigorous museum program, they knew they were capable. Furthermore, they were committed to doing science because of their years at Lang.

This concept resonated with our interest in the effects of long-term OST STEM experiences—what we call a "continuum of participation" (Adams & Gupta, 2010)—on the college major and career choices of the young women in our study. Our study offers a window into how a continuum of participation can influence early choices that lead to successful STEM careers. Our results show that long-term participation in the museum's OST program helped these young women develop positive STEM identities, confidence in their ability to do science, and persistence in the face of challenges.

The design of the Lang Science Program is critical to the effectiveness of long-term participation. Lang offers diverse STEM-related experiences, allowing participants to engage in different ways of practicing science. Plotting out such experiences over several years, the program enables participants to delve deep into areas that interest them. In addition to traditional lab and research-based activities, Lang gives young women (and men) opportunities to interact with science writers, administrators, artists, lawyers, and others who are engaged in science beyond doing research. Meetings with scientists are woven into the curriculum in ways that feel integral to the science learning objectives. For example, in a course about extinct marine animals, participants take a field trip with a museum paleontologist to collect fossils that they then use, back at the museum, to help them build scientific models. Youth are exposed to scientists and their work by working alongside them. Smaller programs that don't have access to the resources of a large research-based institution may be able to provide similar opportunities by reaching out to the local scientific community.

McCreedy and Dierking (2013) found that the unique adventures and social connections of the STEM programs they studied were particularly memorable to the young women they surveyed. Our study found that similar experiences led to social bonding and the development of collective science affinity-identities. Because Lang participants move through the program in cohorts, the young women developed peer relationships that lasted many years. Such continuity can be unusual in urban areas, where young people may not stay in school with the same peer group for long. The long-term social bonding fostered at Lang allowed the young women to create memories and develop connections to peers and adult staff. These memories and connections provided a source of strength alumnae could draw on when faced with challenges in college.

One study participant who is currently employed in science said, "If I didn't do Lang, I don't think I would be doing science right now!" This and similar kernels of evidence suggest that long-term OST STEM programs can provide young women of color with key identity-building experiences to help them persevere in college and beyond.

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