How Participation in STEM Focused Programming Resonates with Youth

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Abstract

Engaging youth in Science, Technology, Engineering,and Mathematics (STEM) fields earlier rather than later is important for developing a stronger foundation in these disciplines. The STEMinist project aims to engage young girls (fourth through sixth grade) in science and engineering through interactions with female scientists at the University of California, Santa Barbara. This study aims to identify what the girls take away from their interactions with the scientists and their visits to the labto inform after school STEM programming development. This paper presents themes that emerged from the analysis of participant interviews after completing the program.

Introduction

Engaging youth in Science, Technology, Engineering,and Mathematics (STEM) fields earlier rather than later is important for developinga stronger foundation in these disciplines. Research has shown that this early exposure to STEM better prepares children for school and their future chosen careers(Maltese & Tai, 2011). However, it is even more important to encourage youth to participatein STEM at young agesbefore they becomediscouraged from it by socially constructed gender stereotypes. According to research done by the Office of the Chief Economist (OCE), which ended up being published in a report by the U.S. Department of Commerce, “women filled 47 percent of all U.S. jobs in 2015 but held only 24 percent of STEM jobs” (Noonan, 2017). This massive gender imbalance seen in the national workplace, especially in STEM fields, reflects a greater issue with society and the influencesthat gender stereotypes have on career choices. A study (Selimbegovic et al., 2007) in France investigatedthe influence of perceived gender stereotypes on self-evaluation in math and science for children between the ages of thirteen and nineteen.While results showed no significant differencesin science and math grades between males and females, females who believed in gender stereotypes within STEM fields had significantly lower self-evaluation scores than females who held no belief in these stereotypes(Selimbegovic et al., 2007). When asked if they were considering pursuing higher education in math and science-related subjects, similar findings emerged: the number of females that believed in the gender stereotype and wished to pursue further education in STEM fields was significantly lower than the number of females who did not have a belief in gender stereotypes(Selimbegovic et al., 2007). These findings reveal that gender stereotypes are significant contributors to the lack of women representation in STEMfields. Therefore, it is important to encourage girls to pursue STEM at an earlyage. By exposing girls at young ages to STEM and creating environments where they are empowered and supported, we can create an environment where this bias is minimized, if not eradicated. This is possible with hands-on, project-based, collaborative learning that allows young students to get involved and work through the material. These experiences help to further instill confidence in STEM and potentially an admiration for itas well. Providing young girls with strong female rolemodels and mentors in STEM is also important and effective. Seeing high-achieving women flourishing in STEM helps girls feel like they belong in these fields. It is based on these ideas,and the commitment to encourage girls towards STEM that the STEMinist Project (pseudonym) was instituted.

Research Context

The STEMinist Project is a program that brings approximately 30girls in fourth through sixth grade (ages eight to eleven) to the University ofCalifornia, Santa Barbara campus,to introduce and engage them in STEM-related experiments and activities. In 2019, in the third year of thisprogram, there were 21youth participants. These participants spent around 20weeks developing interview questions, interviewing female scientists and engineers on campus, touring labs, and partaking in hands-on STEM activities that related to the scientists' research interests. For the first ten weeks of the program, the youth participants spent one hour each week on the university campus,with a new female researcher learning about their journeys in STEM as well as theirresearch interests. Additionally, participants had the opportunity to ask these researchers interview questionsthey developed. The next ten weeks of the program involved writing and art sessions reflecting on their visits and interviews with the female scientists. These efforts culminated in a book written and illustrated by the girls for fellow youth (Arya& McBeath, 2018). During these few weeks, in between working on their books, the girls also partake in a few additional STEM field trips and end the program with a presentation of their work for family and community members.

Existing Research

Impact of After-School STEM Programs

Education reform has been increasingly more important in the last few years, especially concerning STEM education. An understanding of STEM is necessary for overcoming the certain circumstances and complex issues we face as a society, such asclimate change, genetically modified foods, and water pollution, for example (National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2006).Consequently, there has been an increase in before-school, after-school, and summer STEM programs to supplement classroom STEM learning.One study (Krishnamurthi et al., 2014) found seven main themes that best demonstrated the impacts of out-of-school STEM programs, which were to successfully engage students in STEM investigation,retain a diverse population of students, strengthen student interest in STEM in and out of school, teach STEM-relevant life and career skills (like collaboration and public speaking), demonstrate the value of STEM and its impact on all people, increase awareness for the variety STEM-related career options, and have a positive impact on academic performance. These programs have many proven benefits and are undoubtedly valuable whether students ultimately strive for careers in STEM or not. An evaluation report of the long-term effects of Project Exploration, anafter-school and summer STEM programin Chicago,demonstrated that high-school graduation rates were higher for those whoparticipatedin this programthan those who did not (Chi et al., 2010). The reportalso found that alumni of these programs attended college and pursued degrees in STEM-related concentrations at higher rates. However, a research study done in the United Kingdom hasfound that student interest in science is at its peak around age ten, regardless of gender (Murphy & Beggs, 2005). However, this age also marks the point where interest will start to decline (Murphy & Beggs, 2005). Therefore, Lindahl(2007) concluded thatpositive experiences in science aremost important throughout the elementary school years. Specifically, students form ideas of what their future career might be around the fifth grade, which ends up influencing the field they choose to focus on in high school and college(Lindahl, 2007).

Empowering Women in STEM

Women,some minority groups, and working-class individuals are still largely consideredunder-represented in STEM careers (National Science Foundation, 2019). Due to the substantialneed for increased STEM-relatedskills in today's world, the education system hasturned to focus on these under-represented groups and on how to best empower and educate them to be competitive in this field, with a unique emphasis on female representation. Even though girls rate science as their favorite subject at a much higher rate than boys do, girls are less likely to aspire to careers in science (ASPIRES Project, 2014). The ASPIRES study from King's College London found that individualsfrom families who do not have an interest in or connection to scienceare uninformed of STEM jobs aside frombeing a scientist, teacher,or doctor. Furthermore, those who are not white, male, and middle-class seem to aspire to pursue STEM-related careers significantly less. Since many families lack an understanding of the potential jobs that are available to those whopursue science and/or also have a lack of interest or knowledge of science themselves, many children are raised to be unaware, and therefore, disinterested themselves. However, when girls are made aware of female scientists and how women are joining STEM fields in increasing numbers, there are positive implications. Shaffer et al. (2013) explored how male and female undergraduate students (ages between 18 and22) performedon a math test when stereotype threat was manipulated. They found that when students read articles that spoke about how men are favored in math fields, female undergraduatesperformed considerably worse than those who readarticles that highlighted women in STEM and how women and men are almost equally pursuing these careers. The femalesthat read the equality in STEM articles performed just as well as

the males, who performed equally as well regardless of the articles they had read. Therefore, this study suggests that the perception of representation is important for women. In fact, research has shown that when women's perceptions of STEM fields are altered to believe that theyaremore gender-balanced, women find the fieldsless threatening (Murphy et al., 2007). With the conception that the field is slowly moving towards balanced representation,women could find comfort and reassurance that they are capable of performing justas well as men do.

Data Collection and Analysis

The work presented here is a part of a larger project that follows a Design-Based Implementation Research (DBIR) approach (Penuel et al., 2011). Design-based research follows an iterative development process that is informed by multiple stakeholders to further understand the theory around youth learning and development. For more information about this program's development, see Nation et al. (2019). Participants of this program were interviewed by undergraduate facilitators whom they worked with over the course of the program using a semi-structured protocol (Drever, 1995) at the start and conclusion of the 20 weeks.This study focusedon the post-interviews,which included questions regarding youth experiences and what they remembered from the program. Of the 21participantsin the program that year, 14agreed to participate in research. Their post-interviews were examined and analyzed for use in this paper using emergent coding informed by grounded theory (Charmaz, 1996). The first round of analysis consisted of establishingcommon themes that reappeared throughout the interviews. The second round of analysis involved confirming these themes and extracting key quotes that embodied said themes. The last round of analysis was done to ensurethat these quotes could be understoodwith or without contextand that the quotes correctly illustrated the themes.

Results

Table 1. Emergent codes from qualitative analysis of participant post-interviews from 2019.

Code	Definition
Personal Connection	The girls exhibited an interest in the personal connections made with the scientists and/or the facilitators.
Scientific Experience Connection	The participants demonstrated enthusiasm for the experiences they had in the program.
Scientific Content Connection	The girls demonstrated an interest in the content or specific topics of scientific lessons.

In exploring and evaluating participant reflections about the program, three main themes emerged: connection with the scientific content, the scientific experience, and connection to the personal side of science. These themesare defined in Table 1.

Personal Connection

Five of the 14 girls interviewed mentioned that learning about the scientists was their favorite experience or was something that they wanted more of in the following years of the program. When reflecting on the interview experience with a female scientist, Faith (pseudonym) stated, "I got surprised when the scientist says their favorite hobby. I thought it was just talking science, but they have all different types of hobbies." Learning about who scientists are, as women, personalizes a seemingly impersonal and, perhaps, strict career. Science can seem like a cold and difficult subject, yet, finding out that scientists have similar hobbies to themselves and have lives not completely dominated by a love for science can be inspiring to young girls who are still curious about the world and interested in multiple things. In addition, these personal connections appear to remain with students throughout the program, with one youth participant commenting, "I remember most that she likes the Harry Potter series. And she studies coral. And she likes pie." Instead of speaking about the research, the personal details of the scientist's life surprisingly resonated with this participant the most, considering students only met each scientist for one hour weeks before these post-program reflections were collected. She was able to see this scientist as a person who was not just defined by her career. This is significant because it is personifying the profession to a relatable degree and not making it seem as objective.

In addition to recalling and connecting with the personal side of female scientists, one girl desired more opportunities to form these connections claiming, "I just wish we can visit other scientists and learn more about them." Note that she asks to learn more about them and not their research, which indicates the possibility that these youth value the personal connection to female scientists more than the introductions to their research. These interactions allow youth participants to see that being a scientist does not mean you have to abandon all hobbies outside of science and allows them to imagine themselves as future scientists. One example of this comes from a youth who, at the start of the program, claimed she did not want to become a scientist or like science, much like many of the youth participants in this program. However, in the end, she claimed, "I want to be two things now. An actor and a marine biologist." This program presented this participant with something she had never previously considered before and

formed a personal connection for her, allowing her to envision a combination of the two worlds of her choosing.

Representation is important because it dictates what people perceive as achievable. If women and men became doctors, scientists, engineers, and software developers, for instance, in equal numbers, the misconception that men are more capable in STEM-related fields would not exist. This is why it is necessary for young girls to see successful women in high-achieving STEM jobs. This emergent theme illustrates a need youth have for opportunities to develop personal connections to females in STEM, thus allowing STEM professionals to become less distant and a seemingly more attainable career pathway.

Scientific Experience Connection

The primary goal of the STEMinist Program is to expose and engage youth participants in STEM for them to gain familiarity with the subjects. Nine of the 14 girls explicitly used the word "fun" when describing the subject of science, the activities in the program as a whole, or the idea of becoming a scientist. For example, Lily (pseudonym) said, "I like more science because before, science was boring… I didn't think science was this fun." She came into the project with the notion that science was boring, and the experiences she shared with the program changed her mind. She did not note a particular activity as more enjoyable than the others, but instead, asserted that the entire subject was fun. It is likely the amalgamation of experiences throughout the entirety of the program that led her to change her mind, rather than one individual lesson or scientist.

Similarly, another participant said, "I started liking science more. And what made me like more science is going here to figure out how different science works… I always thought science was just putting potions together, but science can mean different things now that I'm here." What specifically made this participant claim to like science more was exploring different branches of science. Again, she did not mention one particular concept as fun but instead found the variety of ways that sciences exists engaging and impactful.

Having youth partake in scientific processes, engage within science, and see it all first-hand gives them a unique perspective into these disciplines. Whether it was the novelty of touching a lobster's butt, like it was for Delilah (pseudonym), seeing microscopic water bears, which was Grace's (pseudonym) favorite or using an iPad to see what colors animals see, like Arianna (pseudonym) enjoyed, many girls described experiences when asked about their favorite parts of the program. In fact, three girls mentioned that going to visit the lobsters and getting to touch other marine animals was their favorite experience in the program. This was the only field trip the girls took that did not involve interviewing and learning from a scientist and was purely a trip for the experience. They got to learn about marine science and animals first-hand by exploring and touching the animals personally. For these girls, it might not have been the interaction with people that increased their interest in STEM, but rather how they were engaged with and in activities.

Also, when the girls were asked what they had learned from some of these experiences, many found difficulty in remembering and elaborating on the specifics of the science lessons but reiterated an appreciation for the experiences. Ultimately, these experiences led some girls to gain a greater understanding of science and to see it in a different light. When a participant, Faith (pseudonym), was asked about her scientist, she remembered, "We put soap and other things together, and it made this cool thing," highlighting the fact that she remembered the experience of science. While she could not articulate the science concepts well and could not recall the end result, she remembered that it was "cool." Interacting with the science and getting to experiment herself was what was most memorable about her scientist visit. It was not necessarily the science that was impressive, but rather, her participation with it and how it came together. Personal connections to experiences within the field of science are shown to be of great importance to female youth participants and should be valued by program developers as well by increasing opportunities for youth to form these connections.

Scientific Content Connection

The Organisation for Economic Co-operation and Development 2006 forum (OECD, 2006) found that students need to feel the personal relevance of a subject to themselves, society, and the world in order to deem a subject interesting. When one participant, Janie (pseudonym), was asked about what she remembered about the scientist she interviewed, Janie responded, "She studied coral and how it bleached. And how it's bleached." This shows that Janie resonated the most with the scientist's research content during the scientist visit. This connection to the focus of the research being studied was further exhibited when she claimed that she wanted to be a marine biologist because of her participation in the program, as discussed earlier, illustrating this development of personal relevance, which lead to a subject being of interest.

When another participant, Jasmine (pseudonym), was asked what she remembered about the scientist she interviewed, she

also noted remembering the content of the scientist's research. In a similar fashion, she said, "[The scientist] was trying to help by reducing pollution, and she's making place cleaner, and she is doing something that is making an impact on cleaning the surface. It's making things a lot cleaner than now. Stores and everything now stop using plastic and I heard that CBS is stopping using plastic packages, which is good." This participant mentioned that she particularly remembered this scientist's contribution to helping the environment and then drew her own connection to something she had seen on CBS, a news station. In making these relevant connections between things she had individually heard and her scientist's research, it shows that this resonated with her throughout the duration of the program. Both youth participants resonated with the content of the research because it connected to contemporary science and had personal relevance.

In addition to the youth connecting to the scientific content that was explored when visiting these female scientists, they also expressed an interest in pursuing more scientific content in future years of the program. At the end of the interviews, girls were asked what they would like to see next year or what new things they would like to learn. Two girls mentioned they wanted to use different technologies and learn about technology more as a whole. One girl was curious about how robots move, while another asked if the facilitator could explain the chemistry of toothpaste. When the facilitator said she did not know, the participant said she wanted to learn about the periodic table and how elements work. Two girls asked about the environment and how to help it, with one specifically asking about pollution and why corals bleach. Three additional girls wanted new concentrations of science to be highlighted, with one requesting to learn about astronomy and what NASA is doing on Mars and another asking for "animal-based things, gravity, and dumbed-down physics."

These girls still thirst for more content, but they are all interested in different things. This shows that a variety of scientific content is crucial within a youth-based STEM program as nine girls resonated with various topics, albeit different topics from each other. Everyone will not be interested in the same things, but what is important is that they have an interest and can develop a connection to STEM fields through that interest.

Conclusion

In a society that is largely increasing the number of after-school STEM programs, it is imperative to know what resonates the most with youth participants in these programs to maximize the positive influences. Whether it be the personal connections formed with mentors/role models, the curiosity that comes with learning new scientific content, or the appreciation for the experience of engaging in science in a more direct and hands-on way, program developers can utilize what youth retain from participation in STEM-based programming to better inform future programming and to best support youth cultivation of STEM interests.

In conclusion, all three connections are important in their own ways to the participants. Some girls only had a connection to one of the themes, while others displayed all three, thus emphasizing the importance of creating opportunities for all three different types of connections to be formed. Personal connections inspire young girls and show them that women can succeed in STEM. It is important for these moments and mentor/role model relationships to exist because they prove that it is realistic and possibly more exciting than previously imagined for women to pursue STEM careers. It is also this dialogue that occurs between the scientists and participants during interviews that is critical, as opposed to just reading about successful women, because the girls can ask what is important to them and what they want to know. The opportunity for hands-on experience is also essential for many participants because it is an intimate interaction with science that allows girls to learn valuable skills. Working through experiments introduces them to different concentrations in science and allows them to gain confidence in the material, in a fun and supportive environment. Lastly, both the scientific connection and fostered curiosity for STEM concepts are also important. Some girls are introduced to subjects they would have never considered before, but in this explorative environment, they are encouraged to engage.

Even if these girls do not want to pursue STEM, what is wrong with having aspiring lawyers, artists, fashion designers, and cartoonists who know a bit more about science? Science is about problem-solving, collaboration, critical thinking, and communication. These are skills that will carry over into any profession and life itself. Ultimately, the goal of the program is to engage young girls in STEM with the hope that they would consider pursuing a career in STEM, without being burdened by gender stereotypes that would otherwise discourage them. If, in the end, they still do not consider STEM in the future, it is hopeful they took away something meaningful.

Limitations of the Study

While this study has the potential to have a powerful impact on the development of female youth-based STEM programming, there is still plenty of work that needs to be done to better understand how to support youth within these programs. This study was limited to one cohort of participants, meaning that the results are not repre-

sentative of all youth. The study would benefit from exploring other years in addition to the sister teen program that runs concurrently with the youth STEMinist program. In addition, to best support the diversification of STEM, future research should include further investigation into youth values in STEM programming across disciplines, age groups, and ethnicities of students.

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