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Women in STEM Interview Analysis: Encouraging Young Female Learners in STEM Pathways

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Abstract

This study used a qualitative approach to examine potential obstacles to and challenges in working in a STEM field for females from underrepresented groups. Unstructured interviews with 11 adult females representing diverse groups and various STEM careers yielded important historical perspectives, along with recommendations for building STEM careers for young females today. The findings indicated the critical role of having a strong mentor, role model, or support system in place along the STEM pathway; the need to work with and engage females in STEM activities and subjects when they are as young as possible, preferably while in primary/elementary school; and the importance of developing a sense of STEM self-efficacy in young females. Recommendations are given to inform studies in science communication and informal education.

Keywords

women in STEM, role models, biases, self-efficacy, qualitative interviews, career trajectories, underrepresented learners, elementary STEM education

1. Introduction

The history of women's contributions to the fields of Science, Technology, Engineering, and Math (STEM) is long and varied, but it often has been overlooked, and women remain statistically underrepresented. Today, although women work in every type of job within all STEM disciplines and represent the broadest range of backgrounds and experiences, there is not yet parity in representation numbers, pay, or rank. In the United States of America (U.S.) alone, women make up about 47% of the overall workforce. However, that nearly gender-equal percentage does not necessarily translate into STEM fields (Bureau of Labor Statistics, 2018). It is critical to keep in mind that true gender parity cannot be measured by percentages alone (Noll, 2020), as it also involves belonging and inclusion. Women are most significantly underrepresented in physical science fields, including astronomy. Computer science is the only STEM career path that consistently showed a decrease in the number of U.S. women obtaining undergraduate degrees since 2002 (Larson, 2014; National Academies of Sciences, Engineering, and Medicine, 2020). The American Astronomical Society Committee on the Status of Women in Astronomy reported that as of 2013, there were only 95 female full professors in astronomy in the U.S. versus 548 male full professors of astronomy (Schmelz et al., 2014). In 2013, women made up about 14% of physics professors in the U.S. (Pollack, 2013). For minority women, however, the statistics tended to be much lower. In 2015, only 83 Black American women held Ph.D.s in physics or a physics-related area of study (Pitney, 2017). Overall, only 1 in 10 women of color filled the position of scientist or engineer (National Girls Collaborative Project, 2016).

2. Overview

2.1 Why More Women are needed in STEM

The benefits of increasing representation of women from diverse backgrounds in STEM research and career paths range from higher job security (Langdon et al., 2011) and pay rates for women (Funk & Parker, 2018) to other pragmatic and perhaps life-saving gains. Women, for example, can experience more side effects from many medications than men do and with more variation (U.S. Government Accountability Office, 2001), and initial research studies for medicines have often been biased towards male subjects (Beery & Zucker, 2011). In addition, automobile airbags have been more dangerous for women of smaller stature because engineers initially designed and tested them around the male body (Bloch, 1998).

To design studies that avoid these omissions, women must contribute equitably to planning the relevant research frameworks. Studies have shown that when heterogeneous parties are included in problem-solving tasks, more comprehensive results can arise than if the parties were homogenous (Phillips et al., 2008; Shinchi, 2014). Therefore, it could be beneficial to include a higher diversity of researchers in fields such as biomedical engineering, where the female-to-male ratio is approximately 1:6 for workers in the U.S. as of 2016 (Bureau of Labor Statistics, 2018).

Beyond representation issues, and even beyond STEM jobs and outputs, lie more broad-reaching reasons for improving girls' interest in and potential prospects in STEM fields. Topics in the STEM domain are central to choices at the core of society, from political issues and government policies to business strategies. From boosting critical thinking abilities (Duran & Sendag, 2012) to shaping well-informed voters (Marincola, 2006), these issues affect people on election ballots, in finance, and the media - in other words, within the world. People from all sectors of society need to engage in framing and tackling problems through scientific and technological initiatives to find solutions incorporating diverse voices from the communities impacted.

2.2 Intersectionality

Kimberlé Crenshaw (1991), an expert and authority in civil rights, Black feminist legal theory, and race, racism, and the law, created the term "intersectionality" to define the intersection where race and gender bias occur. She noted that women of color could not choose to be female one day and a minority the next. In STEM fields specifically, biases being encoded into applications and products created with Artificial Intelligence (AI) or machine learning algorithms can negatively affect people with darker skin. For example, one Massachusetts Institute of Technology study found that facial recognition software has unusually high error rates among darker-skinned females (Buolamwini & Gebru, 2018). An improved skin tone dataset and better gender-distributed dataset for AI training purposes were recommended, one that more closely represents the population as a solution to a highly problematic paradigm that has far-reaching implications in search applications and police databases (Lohr, 2018).

Similar issues have been found in physical products, from automatic soap dispensers that use infrared technology that does not "see" or recognize darker skin to more impactful products such as personal wearable health trackers and heart monitors (Fussell, 2017). Such technological errors and issues could have been avoided or, at the minimum, decreased by paying greater attention to diversity and therefore having a wider range of people in technology and engineering fields that do not prioritize the perspective of a White male body. Looking at product design from the embodiment perspective is also helpful for comprehending the need to make these STEM products accessible to populations with different physical abilities, who may need to use a previously unexplored set of senses or modalities to perceive and analyze scientific data.

2.3 STEM and Disabled Learners: Blind and Visually Impaired

There are many different groups of learners. One category represented by an interview participant is audiences that are Blind or Visually Impaired (BVI). Finding ways to increase participation for all learners in science and engineering can be a universally heightened challenge for students with disabilities, as they are underrepresented in these disciplines (Villanueva & Di Stefano, 2017). Approximately one in nine employed scientists or engineers under the age of 75 reports a disability (National Center for Science and Engineering Statistics, 2017). When considering the needs of BVI audiences, especially students, it is crucial to note that each individual's development drastically correlates with the specific support or interventions that person has received in critical skills (Raisamo et al., 2006). Many STEM subjects rely heavily on visual resources that can be inaccessible to blind or low-vision students unless the material is presented in an alternative format (Cryer, 2013). Finding ways to help facilitate both the presentation and analysis of information in accessible ways and through multiple senses can enhance the quality of knowledge obtained from interpreting results for the scientific community, BVI, and sighted members alike (Díaz-Merced, 2014). Enabling equitable access to scientific information (Arcand et al., 2019) will also help a broader portion of the population realize that STEM subjects and careers could be a good match for their interests while teaching them the skills necessary to solve problems in these fields.

2.4 Biases, Role Models, and Identities: Additional Sociocultural Issues in STEM

Multiple studies have shown that STEM skills are learned (Hill et al., 2010), and gender bias still negatively impacts girls' noted interest in STEM fields from a very early age. For example, work from Spencer et al. (1999) demonstrated the strength of stereotype threat for girls in mathematics testing among top math performers, where even the mention of gender bias in a test led to reduced performance for female participants. Group stereotypes (whether based on gender or race) "can threaten how students evaluate themselves, which then alters academic identity and intellectual performance" and can affect "members of any group about whom negative stereotypes exist" (American Psychological Association, 2006, p. 1). Not only does gender bias support the perception that science and mathematics are "for boys," but, more importantly, it illustrates that stereotypical threats can lead to girls' performance anxiety and low expectations on academic tests (Doyle, 2016). Furthermore, personal judgments on the suitability of STEM fields can be based on known stereotypes of people considered like themselves (Deiglymayr et al., 2019; Richardson & GenderSciLab, 2020), which can solidify underrepresented groups' perception that the culture of STEM disciplines is not a right fit.

A growing body of research illustrates significant sociocultural roadblocks for women in computer science and engineering fields. Such barriers can significantly hinder the determination of STEM discipline selection and study (Cheryan et al., 2015; Ceci et al., 2009). A meta-analysis conducted by Cheryan et al. (2017) of 1,200 papers on gender gaps in computer science, engineering, and physics, pointed to three primary issues. These included a masculine culture with stereotypes and a lack of role models, leading to women feeling less welcome, less early exposure or work within those fields, and reduced self-efficacy. This research noted that STEM programs could benefit by addressing problematic cultural issues and building awareness in girls and boys that both are equally capable of succeeding in STEM careers. For example, intentionally designing equitable learning sites such as makerspaces can ensure that women feel comfortable and engaged moving around (Melo, 2020) and therefore increases their sense of ownership within these educational spaces.

2.4.1 STEM Identity

A personal STEM identity is a belief that one can do well and succeed in STEM subjects (Ayoub, 2017). The social aspect of this STEM identity explains how participants can visualize themselves as "accepted as a member of a STEM discipline or field" (Kim et al., 2018, p. 3). Several factors related to

STEM identities may make it challenging, particularly for underserved groups like young women of color, to adopt such an identity for themselves (Steinke, 2017). Self-efficacy is often lower in females than males generally (Gnilka & Novakovic, 2017), and issues of belonging and confidence related to self-efficacy (Settles, 2014) can be challenging to navigate in formulating the STEM identity. Importantly, however, recent research has demonstrated that through interventions, STEM identity challenges can be positively influenced (Kim et al., 2018).

Self-efficacy relates to the importance of mentorship regarding influence from others and identity. Self-efficacy can influence an individual's choices and efforts to reach given goals and if the individual will persist through difficulties and challenges to obtain those goals (Bandura, 1997; Rittmayer & Beier, 2008). Bandura's work further states that individuals with higher states of expectation towards self-efficacy, or the belief that they will be able to achieve their goal or goals, tend to be more successful compared to individuals with lower expectations towards their self-efficacy (Sobieraj & Krämer, 2019). This is a pertinent topic, as success in STEM subjects requires a strong sense of one's ability to succeed in such topics, and females can have lower senses of self-efficacy toward STEM than males (Williams & George-Jackson, 2014). Individual perceptions of self-efficacy during the process of learning scientific subjects can be impacted by the presence of harmful biases in the environments of students, employees, and other people exposed to STEM subject matter.

2.4.2 Explicit and Implicit Gender Bias

A University of Wisconsin-Milwaukee and National Science Foundation report in 2011 based on over 5,500 female participants stated that the primary reasons for women leaving the field of engineering were sexist behaviors in their workplaces and feeling undermined by their managers or peers, as compared to those who remained (Fouad & Singh, 2011). Women who left the field were also not as likely to report educational or advancement opportunities on the job, nor general support for a work-life balance, compared to those who stayed (Fouad & Singh, 2011). Therefore, women tended to leave not because they lacked skills or knowledge but because of work environments that were less civil or supportive of women (Doyle, 2016). This may point to an explicit bias—a bias that is more consciously held and therefore shapes how behavior toward certain groups of people is evaluated (Handelsman & Sakraney, 2015)—that could affect perceived notions about STEM careers for those deciding on which fields of study to pursue (Girl Scout Research Institute, 2012; Girlguiding, 2016).

According to an American Association of University Women (AAUW) report, "women and men are exposed to the same stereotypes about women in math and science in U.S. culture and, on average, acquire the same implicit or unconscious 'science/math=male' biases by age 7 or 8" (Hill et al., 2010, p. 56). This is an implicit bias—or an unconscious assumption—that influences our judgment and perceptions of others (Handelsman & Sakarney, 2015) versus the aforementioned explicit bias. Such unconscious biases can affect how adults talk to children, how family members select toys for them, and even how educators address them in environments for learning (Hill et al., 2010). Implicit biases, if they are not identified and consciously examined, can even negatively impact the hiring of elite female academic STEM researchers (Régner et al., 2019). One potential method of countering these biases is exposing elementary school-aged students from underserved groups to people like them demographically who currently work in STEM disciplines.

2.4.3 Role Models

The lack of visible role models in STEM fields in which women are currently underrepresented can be problematic. This dearth of female role models has been shown to exist mainly in the media, with even less representation than in reality (Smith et al., 2012). Lockwood (2006) stated that women specifically require female role models for success to feel attainable. Furthermore, exposure to role models is likely closely connected to formulating a stronger sense of STEM identity (Rosenthal et al., 2013; Young et al., 2013). Recent reports have shown that role models positively affected the development of interest in careers for 1,600 girls and young women aged 7 to 21. In contrast, the lack of such role models negatively affected the development of interest (Girlguiding, 2016). Exploring the educational and career pathways of diverse women involved in STEM disciplines and discussing them in detail helps present various role models who can be compared to contemporary STEM students.

3. Method

3.1 Women in Science, Technology, Engineering, & Math - Investigating Obstacles, Biases, & Perceptions

This study was undertaken to gain insights into the types of obstacles and challenges that underrepresented groups of females potentially face specific to STEM learning. The first author collected data in a series of individual interviews with women who represented a variety of underrepresented groups and who were currently working in a STEM-related career.

3.2 Participants

Participants in the study were 11 women currently active in STEM fields, aged 30-70, identified through the principal investigator's professional networks. The 11 participants (representing one Asian American, one Black, one Indian American, one Latina/Black, and seven White participants) included astronomers, a cosmologist, a planetary geologist, an astronaut, a biologist, an engineer, a technologist, and a mathematician. In addition, nine were prominent in their fields, and five identified publicly within LGBTQIA+. We refer to the participants in this study by their occupations.

The researchers had no supervisory role over any of the participants or other coercive professional or personal relationships with them that might have made them feel obligated to agree to take part in this research.

3.3 Materials

Questions were developed to guide the sessions based on the reviewed literature, along with the knowledge and experience of the first author as a woman in STEM. The interviews followed a semi-structured format, but all included the following questions:

1) Please tell me about your educational background and work experience.
2) What was your career path?
3) What were the attitudes towards women in STEM fields when you started your career?
4) What made you decide on a STEM career? What sorts of things led you to believe that you wanted to be a scientist?
5) Next, I'd like to know whether you hesitated to pursue your STEM field. If so, why? Did anyone encourage you? Discourage you? If so, how? (Note the gender of the encourager)
6) How many other women were pursuing or had active careers in your field when you started?
7) What might have prevented you from being successful in your chosen field? What hurdles did you need to overcome?
8) How has the climate toward women changed in your field since you started?
9) What suggestions do you have for engaging young women in STEM fields?
10) What suggestions do you have for retaining young women in STEM fields?

3.4 Procedure

An email invitation to participate in the study was sent to 12 women in STEM careers, along with an information sheet and consent form. Out of all those asked to participate, one did not respond. In the email invitation, the principal investigator offered to call the potential interviewees to discuss the project and respond to any questions before the interviewee gave consent. Ten participants noted satisfaction with email discussions and did not find it necessary for the principal investigator to call; one participant requested a short call to clarify the purpose of the interviews and how they would be analyzed.

Once the 11 women who responded to the original email agreed to participate, arrangements were made for a mutually agreeable time for the interviews. Each interview was conducted over the phone and lasted from 60 to 90 minutes. Due to the varied geographic locations of the participants, the interviews were conducted over an iPhone with a recording application installed. At the start of each interview, each participant was provided with a refresher on the study's purpose and an opportunity to ask questions. Each participant then orally confirmed her permission to have the interview recorded.

All interviews were transcribed by a secure digital service and reviewed by the researchers to correct for inaccuracies in the transcription process (e.g., names misspelled or garbled sounds). Participants were provided the transcriptions to edit or delete any sensitive or undesirable information and make other corrections as needed. Two participants provided edits to the transcripts; one removed a small amount of sensitive information (specific names and dates that had been discussed), and another added a few minor notes for clarity (such as a URL).

The interviews took place from March 2018 through September 2019, with the majority of the interviews occurring from March 2018 to mid-2018. Review, coding, and analysis of the transcripts occurred throughout the remainder of 2018 and through September 2019. No compensation was offered or requested. Ethics forms were completed, submitted, and approved.

4. Analysis

Transcripts were analyzed following Straus and Corbin's (1998) grounded theory with an iterative approach. Data were reviewed through five iterations, with repeated readings of the data lensed through sifting, sorting, coding, abstracting, and checking (Ryan & Bernard, 2003). As this was new research for the field, the authors used inductive themes derived from the data (O'Reilly, 2009) instead of deductive themes that otherwise might have come from existing research. Representative quotes were selected and categorized by the interviewee's occupation (e.g., "mathematician"). An excerpt from the coding for one participant is shown in Table 1 as an example.

Table 1. Interviews—Sample of Quote Selection for One Participant ("Astronomer")

Category	Quote
Influencers	"...how do I deal with a professor who doesn't support me, who doesn't want to write me recommendation [sic] like there's no class that teaches you how to do that...if you don't have good mentors around you to help buffer those negative things you're just going to wash out."
Hurdles	"And I think sometimes when people hear that you're coming from an HBCU [Historically Black College and University], they kind of immediately assume that you have gaps in your education or maybe you're not as smart, like it's not anything in what they're saying, but it's kind of an attitude – like you're here, but you're only here because you're part of this special program because you needed it and that's, it – it's all these little microaggressions that begin to add up."
Attitude Changes	"I think there are some good changes that have happening [sic] I know statistics, statistics-wise, the number of women in STEM field has increased since my time. But one thing that hasn't changed much since kind of going into the STEM field is the number of minorities who are getting their master's, or they're getting their Ph.D. And that hasn't changed. So it's a little discouraging."
Recommendations	"But I want to be able to explain this to other people, that real-world like I think there's just so many studies that I'm sure you've read, and I've read that's one of the connections

to get our young women into STEM, is the 'why,' why is this important?"

It can be seen in Table 2 that in addition to being female and working in a STEM field, all but three of the participants fit within a minority group of either ethnicity, physical ability, or sexual orientation.

Of the eleven women interviewed, each attended their undergraduate programs as a young person, with two having obtained a maximum of a Bachelor of Science degree (one of whom is currently enrolled in a post-baccalaureate program towards the goal of enrolling in medical school), four holding master's degrees, and five having studied at the Ph.D. level. One of the five reported being a Ph.D. candidate/ABD (all but dissertation), and four held Ph.D.s. Each participant proceeded into a career path after completing their current level of schooling. At least nine participants are considered prominent in their fields either through direct research outputs or by reputation or recognition in their fields. If the participant's status as a mother or as a non-native speaker of English was raised or previously mentioned publicly, that data was also included in Table 2.

5. Results

Five themes emerged from the data and were defined to facilitate accuracy in identification: influencers, educational experiences, hurdles, attitude changes, and recommendations. Table 3 shows the total number of responses by theme, as determined through the iterative process previously described. All participants commented at least once on each of the five themes. The first theme, containing the most responses (101 responses), addressed the participants' influencers that had positive or negative impacts, from role models and mentors to detractors. The second theme that emerged was an educational experience, which concerned the participants' educational background or range of educational experiences. Hurdles were the third theme that emerged from the data, pertaining to issues that needed to be overcome by the participants pursuing their careers. The fourth theme reflected attitudes perceived over the years toward women in STEM. Lastly, the fifth theme related to participants' recommendations for engaging and retaining females in STEM fields.

Table 2. Description of Interview Participants

ID	Occupation	Education	Ethnicity	Sexual Orientation[a]	NSE[b]	Stated Disability	Career	Mother
1	Astronaut	Ph.D.	White	Cishet	Yes	No	Late, Prominent	Yes
2	Engineer	B.S.	White	Cishet	Yes	No	Mid/Late	Yes

3	Software Developer	M.S.	White	LGBTQIA+	Yes	No	Late, Prominent	Yes
4	Technologist/ Pre-Med	B.S./ Post-Bacc[c]	Indian American	LGBTQIA+	No	No	Early	Unknown
5	Mathematician	Ph.D.	Asian American	Cishet	Unknown	No	Mid, Prominent	Yes
6	Radio Astronomer	Ph.D. Candidate	White	Unknown	Yes	No	Mid, Prominent	Unknown
7	Science Writer	M.A.	White	LGBTQIA+	Yes	No	Mid, Prominent	Yes
8	Astronomer	M.S.	Black	Unknown	Yes	No	Mid, Prominent	Yes
9	Cosmologist	Ph.D.	White	LGBTQIA+	Yes	No	Mid, Prominent	Unknown
10	Geologist	M.S.	White	LGBTQIA+	Yes	No	Mid, Prominent	Yes
11	Computer Scientist	Ph.D.	Hispanic/ Black	Unknown	No	Yes	Mid, Prominent	Unknown

[a] LGBTQIA+ is an abbreviation for lesbian, gay, bisexual, transgender, intersex, queer/questioning, asexual as well as other non-binary identifiers; Cishet is the combination of cisgender (identifying with gender as assigned at birth) and heterosexual (attracted to people of the opposite sex).

[b] NSE is the abbreviation of "Native Speaker of English," used to identify participants in our sample who speak English as their first language.

[c] Post-Bacc is a post-baccalaureate program offered in the U.S. to prepare for additional programs such as medical school.

5.1 Influencers/Role Models (Positive and Negative): 101 Responses

In their interviews, all participants discussed influencers, which could take the form of mentors, role models, or detractors. Although the mentors were, as expected, from more senior positions than the participants, some peer-to-peer or community support and influence were also discussed.

Five participants related information about male mentors and five concerning female mentors, while two did not mention the genders of their mentors. Two participants noted that the availability of female mentors was low or non-existent. Finally, seven participants referred to specific role models, all of whom were female, e.g.:

And . . ., you tend to look for role models. You tend to look for people who somehow are similar to you. That you, so you can put yourself in their shoes and imagine what you might be like or how you might succeed in the future. (Mathematician)

In my own judgment, I'm not performing at the top of my capacity. But other, other blind folks, they tell me - we want to do science at the level you do the science. And then I think, oh, this is not good, this is not good at all! (Computer Scientist)

Peer-to-peer mentorships were also mentioned as part of community building (8), e.g.,

Table 3. Number of Responses for Each of the Five Themes from the Qualitative Data

Theme	Total Collated Responses*
Influencers/Role models	101
Educational experiences	65
Hurdles	56
Attitude changes	44
Recommendations	41

Note. All participants responded at least once to each theme.

I think, the group of friends that I had at the time, a lot of us were like-minded. We were all interested in, you know, biology or some sort of an engineering field...I think that helped keep me on-path as well because I had good friends that, we could all study together and work together and encouraged each other throughout the process. (Engineer)

But an incredible thing that [female researcher] did, is she intentionally hired women. Like that was part of her agenda was to have a club-like lab that was very female positive and certainly like men that worked in the lab also…. (Technologist/Pre-medical Student)

About half of the participants (6) mentioned detractors or negativity in general, with two participants reflecting on specific persons or instances and the remaining four participants reflecting more broadly, e.g.,

Have you heard of the phrase 'racism without racists?' It's not like there were people who were being violent or verbally abusive or offensive or anything, more just like a general sense that there were opportunities and ways of being that other people had access to that I maybe had to work a little harder for. (Technologist/Pre-Medical Student)

. . . the disabled woman is by herself. I find that is true. I find myself very self-reliant, and I like life. But that has, that has a huge effect...on your performance in daily life. Because if I would be, if I would be an abled woman, I would have a way right to do my work…and to be [seen as capable]. (Computer Scientist)

> I feel like around the observatory, the people that work I work mostly...tend [to view me] at a lower status level [with a master's degree] than the Ph.D.s. There's not much question about that, except among the younger people, and mostly they've used my software *Laughter*. (Software Developer)

Community is critically essential to underserved audiences, whether it comprises mentor-mentee relationships or peer-to-peer networks. Positive instances of community, and particularly mentors or role models, were prioritized by most interviewees as having a substantial effect on their determination, success, or contentment with career or work circumstances. Conversely, negative influences in the community, or detractors, were either accumulated into larger conglomerations of negativity experienced over time or were singled out in specific detailed stories that seemed to have a lasting impact on the interviewees. Additionally, such negative influences did not always come from outside the underrepresented community. However, they were occasionally insiders who would have presumably also experienced the biases and stereotypes of the participants during their careers or education.

5.2 Educational Experiences: 65 Responses

All participants mentioned having been interested in science since they were very young. They expressed how their interests in STEM stretched back to early childhood days (e.g., "I always loved animals and trying to figure out how things worked" (Engineer); "[I was] always looking at the sky" (Radio Astronomer); "[I enjoyed] watching *Nova*" (Mathematician); "I did a lot of reading on my own about science and physics" (Cosmologist); "I played with Lego's and I took apart my Transformers" (Geologist); and "I had always had this interest in geology, and it went on and on" (Software Developer)).

The participants mentioned a range of educational experiences, both formal and informal, as well as diverse educational backgrounds. Formal education backgrounds included private schools and universities, public schools (including two public schools that specialized in STEM), and universities, specifically Historically Black Colleges and Universities (HBCUs). They also took advantage of informal learning such as museums, books, television series, special programs, and science fairs, all of which were part of their pathways into STEM.

Encouragement seemed an essential aspect within this theme and connects with the prior theme concerning role models. Most participants recalled encouragement from someone in their very young years, mostly from teachers (4) or parents (3). For example, three participants mentioned looking up at the night sky with their families. Three other participants mentioned wanting to be something specific when they were little (an astronaut, doctor, or teacher), and three mentioned having parents that encouraged science and math activities at home or after school from an early age:

> I do feel again lucky to have had parents who, from day one, just never questioned my ability to do anything. I mean, they were certainly very explicitly encouraging of my ability to be good in math and science. But it was, but they were just very supportive and encouraging in general. (Technologist/Pre-Medical Student).

Three participants also mentioned having family members who were scientists, Ph.D. researchers, or engineers that helped give them an insider's perspective and additional educational opportunities or insights. One participant recalled that she felt as if she belonged in STEM even though she did not mention specific educational experiences or encouragement from someone at a young age ("No one seemed to ever question me being there when I was growing up," and [science and math] "that was my spot" (Science Writer)). Many of these responses reflected on the role of positive influences in education at home or school, e.g.,

> So, from an early age, I had a predisposition to STEM activities. I mean, there was an emphasis on it at home. Of course: math is important, science is important. (Mathematician)

> I had a really great teacher in high school for biology, which helped to cement my college major choice as biology. (Engineer)

Eight participants discussed the demographics or changing representation within their classes in either high school or college, with the majority of responses focused on the lack of equal representation in the student body, as well as a lack of equal representation in their educators, and how that had affected the culture of their classes. However, some mentions also stood out for positive or negative feelings, e.g.:

> I noticed the [high school] classmates around me started to dwindle down, and I'll never forget...I looked around the room, and I was the only Black woman. (Astronomer)

> The library is where I used to do my problem sets. And the math library, not the general library, because I used to want, you know, look up stuff in books that were only in the math library, and I would be there pretty late and it wasn't, it didn't take me so long to realize that the women's bathroom closed at 5 o'clock because the only women in the building were the secretaries and they locked up the bathroom before they left . . .And the first time I realized this, I had to walk in the snow to go to the bathroom and then come back to the library. (Mathematician)

Only one of the 11 participants, the geologist, had a markedly positive experience in this area of representation across her educational program:

> And you know, just there were a lot of other cool women [in my grad school program], so it was a good mix of students pretty much 50/50, and so it was, I don't know if I've been, if I have particularly good judgment which is, or if I had good luck, I'm sure it's a mixture of a little bit of both. But I, I always have managed to land in environments that are not toxic. (Geologist)

These quotes highlighted the importance of formal and informal educational experiences and how they affected the participants' career development. They also reinforced the significance of encouragement for young women towards education in STEM from trusted sources in their lives that have a say in education, such as parents, teachers, or caregivers, given the positive influence they can exert starting from an early age. This impact can help to counter any hurdles encountered.

5.3 Hurdles: 56 Responses

In their interviews, all participants discussed hurdles they faced in their careers. These focused mainly on personal issues of motherhood (3), policy issues (4), or biases against gender, disability, sexuality, race, or educational level (10).

All of the women provided examples of discrimination in some form in either education (5) or career-related situations (4). Most examples seemingly fell between microaggressions (3) and unconscious biases (5). Four of the participants mentioned they did not recognize biases until later:

> My advisor challenged me a lot to reflect on my own experiences and to come to terms with it frankly because...when I was in elementary school [and] high school, I think I was just oblivious to the way I was being treated. (Mathematician)

One of the participants mentioned that they did not yet, at the time, have the vocabulary to process their experiences in reference to broader frameworks they would later understand:

> I'm sure there were microaggressions that I experienced all the time as a kid, and I definitely have some memories of these. But what really made it difficult for me to understand is that it wasn't really until college that I had the, like, the liberal arts vocabulary to talk about maybe what was happening. (Technologist/Pre-medical Student).

Participants' reflections indicated a range of hurdles experienced, e.g.,

> For a lot of women, myself included, after getting married and starting a job, it's hard to go back and get a graduate degree. I think that's probably the main hurdle, and then if you start a family, that could be an additional hurdle, just your time that you are available to invest. (Engineer)...like what about pay scale? It's one thing to have like 50 percent of their staff being women, but if they all make like 75 percent of the pay that a man at that same level would make, that's certainly not equity. (Technologist/Pre-Medical Student)
>
> I'm Hispanic, Afro, Afro Puerto Rican proudly...I have a physical disability, and I'm a woman...and I think...if I would be a sighted woman in a room, how will it be? I would have lots more chances because when people talk to me, they don't see the scientist. Once I lost my sight...the biggest shock was to notice that I didn't have access to the same amount and quality of information that I had when I was sighted. I couldn't understand the professors...they were just pointing at things on the blackboard. (Computer Scientist)

Additionally, there were four specific incidences concerning a participant experiencing the burden of having to explain or over-compensate for differences in ethnicity, sexuality, ability, or educational level. The following quotes exemplify this additional pressure mentioned:

> I think the burden comes from having to compensate. Yeah, that sometimes you get...cognitively tired. Right. Right. For having to compensate so much. You know, most of the time I do not...most of the time, I think—why do I have to interrupt this person to explain? Sometimes I just stay at the back of the room. (Computer Scientist)
>
> It's just, it's this constant feeling of you're constantly having to prove yourself, that you deserve to sit at the table. (Astronomer)

This theme of hurdles helps demonstrate the types of issues underrepresented groups in STEM face, particularly as related to intersectionality, and how those issues can be compounded when women identify with multiple groups. In addition, it is possible that attitudinal shifts among STEM practitioners over time can help to remove hurdles, biases, and other obstacles to success in their fields that these women might otherwise face.

5.4 Attitude Changes: 44 Responses

All participants discussed attitude changes, and nine expressly agreed that attitudes toward women in STEM had improved in most fields. However, five participants spoke on how not enough change has occurred to support women (as well as people who are non-binary, which is not a focus of this paper) in STEM, e.g.:

> Growing up in the 80s and 90s, there was a general understanding that getting more women into sciences is a good thing. There needed to be opportunities made and sexism was real...Then somewhere in the early 2000s, I started to perceive that people thought women were getting an unfair advantage. So, there was starting to be this kind of backlash where people would say, "Oh you know you'll definitely get a job. Everybody's trying to hire women" (Cosmologist).
>
> You know you ask the question - have we seen progress over the time at least in my professional lifetime. We have, but there is still the underlying culture that I don't think will change until that generation moves on. (Mathematician)

Expanding upon that concept, another grouping of five women mentioned that although representation had improved somewhat for women, there was not nearly enough change in specific subsets of underrepresented people, e.g.,

> I think there are some good changes that have [sic] happening. I know statistics, statistics-wise was the number of women in STEM field has increased since my time. But one thing that hasn't changed much since kind of going into the STEM field is the number of minorities who are getting their masters, or they're getting their Ph.D. And that hasn't changed. So, it's a little discouraging. (Astronomer)
>
> Even though, even though [all] the people that I know, all of the people that I know in the field that have jobs, that have permanent jobs, and have severe disabilities...the most I'm just talking about two, no not even three right. (Computer Scientist)

Though participants remarked upon positive attitude changes, the lack of enough substantial change was made clear. Underrepresentation in STEM for women remains a serious issue, compounded by additional marginalized identities. The emphasis on the impacts of negative stereotypes and potential backlash by perceived unfair advantages is also essential to consider in developing interventions with such groups, for which interviewees had a range of ideas.

5.5 Recommendations: 41 Responses

In giving recommendations for engaging or retaining young women in STEM fields, the participants commented on the need for positivity. They stressed the importance of not focusing solely on discouraging stories and challenging aspects, with the understanding that such negativity might dissuade even greater numbers of talented individuals from entering STEM fields. "I want them not to be scared - as we are not scared, right?" (Computer Scientist)

Ten participants commented on the importance of changing policies or cultures to help retain more underrepresented groups in STEM, e.g.:

> I think that in all of these areas of bias and privilege and stuff, it is really, it's the responsibility of the people who are in a position of greater privilege or power to work on making that change. You know, so I think that men need to speak up more against sexism. You know, White people need to speak up more against racism. People who are able-bodied need to speak up more against ableism...(Cosmologist)

> All of the advice is being given to women to tell them how to change, but it's equally important to get existing culture to change to be more welcoming to women and other underrepresented groups. (Geologist)

Other recommendations included mentorship and community (3) (relating to the first theme of influencers), as well as the potential for creating new communities in younger STEM fields (1):

> So, finding mentors and then finding community. So, and hopefully - if you're lucky, you can find community in your own department. But if you can't, there are other places to find community. There's social media, there are - you know, make sure that you are not isolated. (Geologist)

> Planetary science: my theory about women in science is that when there's a new field, that's when there's not as much of an 'old boy network' maybe, or that's the way it's been, and women can get into it. (Software Developer)

Being cognizant of representation was also a strong message throughout many of the interviews, and in particular for women of color and people who are disabled:

> When I'm doing outreach events sometimes, a young African American is like, "Oh, your hair is so beautiful!" Others comment on what I'm wearing. I asked a colleague, "I don't know why they do that...it always catches me off guard. I want to talk about this cool infrared

> demonstration I'm doing. Thank you for complimenting me, but let's focus on this." But she said, "It's because they see themselves in you."(Astronomer)
>
> Now...people with disabilities, we are different among each other, as abled people are different among themselves. We are completely different. (Computer Scientist)

From focusing on life-long learning to helping to enact positive change for others, to ensuring that negative stories and situations are not the sole focus of any single issue of working on under-representations in STEM, setting a positive stage for further work, and further change, in STEM fields was strongly encouraged.

6. Discussion and Potential Impacts of the Findings

From the five overall themes mentioned in the previous sections, multiple takeaways could be applied to further studies, such as the importance of access to role models and mentors. One additional point was an expression of concern that girls must be engaged with and encouraged in STEM fields before entering middle school. All participants but two recalled their movement towards STEM pathways starting at very young ages (as early as kindergarten). Furthermore, a few participants (3) specifically mentioned they had seen, experienced, or heard of girls "opting out" of STEM topics or feeling discouraged from STEM topics while still in elementary school. Additionally, it was clear from these interviewees that the broader STEM community needs to understand the importance of equity in information accessibility to help ensure that STEM materials and outputs are usable for disabled learners.

Just over half of the interviewees (6) commented on the importance of discussing personal stories of failure, resilience, and creativity when communicating about STEM careers to help dispel the "genius" stigma often associated with such fields. An emphasis on "brilliance" as a primary criterion for success in STEM can create uncertainty for women, especially in more math-heavy fields. (Deiglmayr et al., 2019). For example, the astronomer noted, "It was a huge misconception that I had, [STEM] was just these geniuses. They were really smart, things just came to them quickly, and that wasn't the case with me." Closely related to that was the need to help dispel the idea of perfection in STEM, a particular concern for interviewees and, importantly, for those who identified with other underrepresented subgroups. For instance:

> The [positive] fact that you see other people potentially talking about both successes and failures, because that's the other half of that, seeing that, is that you know things that they're not good at or not doing perfect, they're not on the *one true path*...Which is going to affect women and minorities. (Radio Astronomer)

The literature found to date did not contain qualitative research that investigated personal recollections of diverse women in STEM regarding how those recollections could be applied to understanding the needs of underrepresented young female learners. This study helps to address that void. Although the demographics of the women interviewed represented various age groups and career stages, most participants were in a mid-career stage, with most participants in their 30s or 40s. The memories seemed still relatively fresh for the participants. Therefore, it is reasonable to posit that the time elapsed for many interviewees since the experiences they discussed either helped or harmed them in their STEM career paths was short enough to make the information helpful for analyzing current situations.

Three primary findings from the study may directly impact work with young people focused on STEM. The first addressed the critical role of having a good mentor, role model, or support system along the girls' pathways (whether in school, at home, or during activities). The second stressed the need to work with and engage females in STEM activities and subjects when they are as young as possible, preferably while in primary or elementary school. Finally, the third emphasized the importance of young girls believing in themselves. Overall, the interviewees' responses could be interpreted as a call for developing a sense of STEM self-efficacy in young females.

6.1 The Critical Role of Mentors, Role Models, and Support Systems

The first main finding of the study is the importance of positive influencers in the capacity of mentors, role models, and similar peer or community systems of support for women in STEM. As the most discussed topic by the interviewees overall, it stood out in significance, with every participant mentioning it multiple times (just over 100 coded responses in total). This issue is a critical component that relates to the research question regarding how to moderate the obstacles and challenges that female-identifying underrepresented groups face. The underlying meanings of American astronaut Sally Ride's often-quoted statement, "You can't be what you can't see" (Harvard Business Review, 2012, para. 2), can be applied directly to opinions expressed by the participants of the study.

Multiple participants remarked that being the only woman in the room, or among dwindling numbers of women and other underrepresented minorities in STEM, could have feelings of belonging, awareness of biases, and a lack of the network or community support in STEM. The interviewees emphasized the need for role models and mentors, as well as peer support, in their career paths and stressed the importance of having these from as early an age as possible. This point from the study supported the extant literature that has demonstrated the positive impact of mentorship and role models, specifically for women in STEM (Dennehy & Dasgupta, 2017; Marx & Roman, 2002; National Academies of Sciences, Engineering, and Medicine, 2020; Stout et al., 2011).

This finding also clarifies the need to continue the numerous STEM initiatives that involve aspects of mentorship or role modeling for students, particularly for underrepresented students such as females and people of color, in initiatives based at various universities. Programs in the U.S. that include mentorship are currently being run by organizations such as Million Women Mentors, US2020, and AmeriCorps (Kupersmidt et al., 2018). However, the finding suggests that by the time most current programs impact their audiences, it could be too late to accomplish all that might be done for younger female learners. Therefore, this point extends the literature as it currently exists to underscore the importance of the early timing for these mentorship programs.

6.2 Engagement in STEM at a Young Age

The need for engagement in STEM at ages younger than middle school is the second main finding of this study. This point supports the literature to date (see, e.g., Bystydzienski et al., 2015; Hirsch et al., 2011; Milgram, 2011; Sadler et al., 2012; Shapiro & Williams, 2012), clarifying that girls need to be encouraged toward STEM areas, which includes assistance in working against any perceived discouragement they might face, through actions of unconscious bias or more explicit stereotyping, well before they enter postsecondary education. In a large study by Microsoft (2017), 11,500 girls across 12 European countries reported that young female learners lose interest in STEM by age 15. A recent meta-analysis (Miller et al., 2018) examined studies of children in the U.S. who were asked to draw scientists. This analysis indicated that kindergarten girls often drew women scientists (70%). However, after that age, more highly stereotyped White and male "lone genius" images appeared progressively with each year, with drawings in the high school years showing women scientists only 25% of the time (Miller et al., 2018).

Additional literature has also demonstrated that intrinsic motivation in academics—or the desire to participate in an activity for the sake of the journey or challenge versus for an external reward or credit (Dhami, 2019)—decreases between grades three and eight (Lepper et al., 2005). Therefore, earlier ages, before middle grades and high school, might indeed be critical times to reach young female learners. This timing allows programs to positively impact girls before motivation levels change before biases are heavily entrenched, and before the further reinforcement of negative stereotypes, affecting these girls' interest levels, self-efficacy, and engagement related to formulating STEM identities. In addition, there is the potential to engage young girls during early childhood in informal science centers (McGuire et al., 2020) and through activities in engineering and coding (Sullivan & Bers, 2019). This study expands on what parents, educators, museum communities, and other professionals might consider when developing interest, confidence, or self-efficacy in STEM topics for young female learners, particularly those who might be part of other historically disadvantaged groups.

6.3 The Importance of Young Girls Believing in Themselves

The study's third primary finding was the importance of self-efficacy or believing in oneself and one's abilities, for young female learners in STEM. Numerous discussions with the interviewees related to self-efficacy ranged from confidence building and coping mechanisms to dispelling the myths of genius and perfection as necessary steps for building a STEM identity. These issues are grouped under one all-encompassing giant umbrella of self-efficacy. Undergraduate women who highly identified with a virtual reality simulation portraying a successful future in STEM demonstrated a significant improvement in factors such as motivation and perceived stereotype threat (Starr et al., 2019), indicating that technology can be a potential source of interventions, particularly in areas with a lack of in-person female mentors.

Believing in oneself is also a key component that relates to the research question regarding the obstacles and challenges that female-identifying underrepresented groups can face, specifically concerning combatting sociocultural biases towards women in STEM. For example, Dare (2015) reported that unequal gender balances in STEM fields such as physics are not due to differences in intrinsic aptitudes but instead seem to draw partially from girls' increasingly negative self-assessments, among other issues such as cultural conditioning and stereotypes. Correspondingly, although there is literature showing the judgments associated with the perception of STEM fields as not always a good fit with many middle school girls' identities, there is also research suggesting that such judgments can potentially be overcome (Kager, 2015). It is, therefore, vital to study the factors that can positively affect these perceptions, particularly at developmentally critical periods, to create more impactful interventions.

6.4 Additional Findings

A key finding from the study related to the ideas of inherent STEM genius is the importance of emphasizing to young female learners that "scientists are made, not born" (Burke & Mattis, 2007, p. 4). This issue, as stressed by the interviewees, supports findings from the literature. For example, The Scientista Foundation, a large collective of U.S. women pursuing STEM degrees at various higher education institutions, links the concepts outlined by Gladwell (2008) that cleverly synthesized this distinction in a popular piece comparing experts and non-experts in sports, music, and other fields, with the expert being differentiated not by innate ability but by thousands of hours of practice (Mathews, 2013). Further literature by Ericsson et al. (2007) goes into greater detail, studying and elucidating the concept of genius being made, not born, providing evidence through case studies. Interestingly, one example involved upsetting the notion that females had subpar spatial thinking through a case study demonstrating that three sisters became top-ranking female chess players through a regimented education program. Similar training programs can help women to gain and strengthen skills in STEM.

Numerous STEM-based interventions for middle school girls, spanning a variety of models and disciplines, have demonstrated some effects on issues of self-efficacy in STEM, seeing oneself in STEM, or at least understanding the potential career options in STEM. Efforts connecting concrete skills and strategies to topics related to participants' everyday lives have been shown to improve self-efficacy in STEM by helping to overcome the negative perceptions of STEM fields that may emerge during early adolescence (Ogle et al., 2017). Hands-on activities across STEM fields have demonstrated the practical applications of science and how they relate to ordinary pursuits while also increasing girls' interest in school subjects and careers in STEM (Levine et al., 2015).

Engineering-based camps have been shown to boost engagement with STEM topics while also increasing interest in attending college by including interactive lab activities to build confidence along with female role models such as teachers, local STEM professionals, and high school girls serving as peer mentors who had previously participated in the camp (Frye et al., 2018). Therefore, the study supports this literature by stressing the importance of teaching self-efficacy and providing a realistic portrayal of life and work as a scientist (Starr et al., 2019) while extending this body of research by shifting the age range downward to include younger females.

Finally, the importance of talking about imperfection was raised by several interviewees in the study, often intertwined with the problem of the genius stereotype mentioned previously. Integrating "growth" messaging into the language and culture of STEM can encourage students, especially women, to seek help (Covarrubias et al., 2019). Dispelling the genius myth was seen as a possible way to combat the culturally prevalent idea that one must be a mental giant to flourish in STEM fields, something they noted could be holding back young female learners, particularly those who also belong to other underrepresented groups. Perfectionism was referenced in the interviews, along with the issue of having to show up and constantly be "the best" to best represent your group. The struggle of constantly acting as the ideal representation of a specific group was a strong concern for those who identified with other underserved populations and aligned with higher stress levels they experienced, as previously noted in Rice et al. (2015).

Learners with disabilities were another underrepresented group that faced barriers mentioned by the interview participants. Interviewees strongly recommended that STEM materials and outputs or formats be created with accessibility to work with all learners and not simply create special materials for a particular event with disabled learners. This suggestion and approach align with the research on Universal Design (UD)—a set of principles for designing materials that everyone can use, regardless of abilities (Luna, n.d.).

Furthermore, another secondary finding from the study concerned the intersectional experiences of women who identified with additional underserved communities besides gender, implying a hierarchy of burden. This was expressed such that race, ethnicity, or disability, for example, could outweigh gender in terms of the number of biases and stereotypes that must be fought in their STEM fields. This study does not claim to show that there is a hierarchy of oppression, but rather that the participants of this study specifically noted how certain identities could cost more for them in terms of needing to overcome cultural biases and stereotypes while handling additional pressures related to their workloads. This is an important cultural challenge to consider for female-identifying groups in STEM overall, and awareness of such an obstacle could perhaps have implications as to how interventions are designed and conducted with such underrepresented female learners in the future.

Related to this finding is the cognitive load some participants mentioned as a result of being considered as "other" (in other terms, an "outsider within" (Rios & Stewart, 2014, p. 295) in their fields, workplaces, or careers. They were often expected to help inform, educate, or sway others who are not marginalized, so they felt pressure to be the absolute best models of their underrepresented groups and, therefore, could not fail (relating to the perfectionism discussed in the previous section). In addition, they were often placed in positions of having to do more or work harder to represent their underserved communities because of expectations being placed upon them, such as being asked to serve on more committees, provide diversity talks, or serve more often as mentors. These types of "performance pressures" (Settles, 2014, para. 3) and burdens have been noted for women in STEM more broadly, so it is understood that this pressure and burden could significantly increase if the person identifies with another marginalized group. It is helpful to consider such issues when working with underrepresented communities in STEM to increase potential career retention.

7. Summary and Significance

This study was primarily developed to help fill a void around a lack of research on how personal recollections of diverse women in STEM could be applied to developing interventions with underrepresented young female learners to encourage engagement with STEM disciplines. The fact that these diverse women in STEM with successful careers across a range of life stages considered it important to reach beyond high school and middle school-aged girls to elementary school-age girls sends an important message that extends the literature found to date. It perhaps also holds the key to helping change the current culture for these young learners to ensure that opportunities in STEM fields remain in their sights. The main findings from this study are significant for several reasons. First, as the interviewees noted, there is work to be done to help negate cultural and other biases and encourage young female learners to continue to move towards and within STEM-related pathways while helping them thrive in and throughout those pathways.

Providing role models and mentorship is of critical importance. Reaching out to girls when they are young, in middle school but also younger, could be an important way to broaden many current interventions, help set young females on a STEM pathway, and give them tools for potential success. Working to combat stereotypes and biases for such underserved groups in STEM, which could include discussing the genius and the perfectionist fallacies, recognizing the burdens and pressures on additionally underrepresented groups, and providing materials that are universally accessible, also helps to build confidence, self-efficacy, and STEM identity in young girls.

Finally, it is critical to note that this study is not about "fixing" young females but instead should be viewed as helping to identify how the STEM community can assist underserved populations in overcoming negative implicit or explicit biases and discouragements, building confidence and self-envisioning in STEM, and further developing or acquiring the skills needed for STEM topics that might be overlooked or delayed due to cultural conditioning and stereotyping.

7.1 Limitations

As with any research, there were limitations to this study. These limitations were the small sample size (n = 11) and the fact that the distribution of participants came from a convenience sample who agreed to volunteer to participate from within the researcher's more extensive professional network in the United States. Consequently, the sample comprises space-related scientists and researchers in their 30s and 40s, with many in a mid-career stage. Any researcher biases resulting from being in a similar demographic might have been overlooked in the analysis of the interviewees' responses. Also, the method of individual interviews might have been a limitation in terms of what might have been discussed or emphasized had the interviews been conducted in a focus group.

7.2 Practical Considerations and Recommendations

To improve the potential results in future studies, the researchers recommend repeating the interviews with different, larger sample sizes, spread geographically in locations beyond the United States, and spread further across the career trajectory with a better balance of early career and advanced career women. In addition, adding more participants would benefit from gaining more information, viewpoints, and perspectives that could be analyzed and further applied to STEM interventions.

Future researchers might also consider conducting in-person focus groups in which the participants could compare and contrast their thoughts in a dynamic and responsive environment. Such settings, where participants can listen to others and expand their responses based on feedback and inputs, might uncover additional experiences, perspectives, and potential approaches for future studies. Additionally, expanding such studies to obtain the viewpoints of participants who are non-binary, as well as males in STEM, either in single-sex groups and/or in mixed groups, would be ideal for improving this research. This study focused on women in STEM, but it is important to consider and include perspectives and concerns from other marginalized groups—particularly people who are non-binary, for whom there is not much research in this area to date, but who can report higher levels of discomfort as well as harassing behavior aimed at them in their STEM jobs (Gibney, 2019).

Adding a cohort of male professionals in STEM to future studies who might be working through unconscious biases or stereotypes and who might also be potential allies to help support issues facing young women in STEM could help further inform future work. Male STEM researchers who are in a majority racial or ethnic group may contribute insight from what can be thought of as a position of privilege (Etchells et al., 2017) and, as such, could help leverage strategically potential advantages as allies (O'Donnell, 2019) for issues outside of their own experiences. It is also important to capture future data on males of color in STEM who are in marginalized groups themselves. For example, Black or Hispanic males in STEM in the United States are underrepresented and report facing discrimination in the workforce (Funk & Parker, 2018). Recent reports have shown that the representation of African

Americans in topics like physics and astronomy can be improved through culturally and financially supportive environments (American Institute of Physics, 2020). Further developments of this research could consider other similarly underrepresented populations.

In summary, although this was a small-scale and exploratory qualitative study, the results were academically important and could potentially be built upon, including for applications to other underrepresented groups, through future research and expanded qualitative studies.

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References

American Institute of Physics (AIP) National Task Force to Elevate African American Representation in Undergraduate Physics & Astronomy (TEAM-UP). (2020). *The time is now: Systemic changes to increase African Americans with bachelor's degrees in physics and astronomy*. American Institute of Physics. Retrieved from https://www.aip.org/sites/default/files/aipcorp/files/teamup-full-report.pdf

American Psychological Association. (2006). *Stereotype threat widens achievement gap*. Retrieved from http://www.apa.org/research/action/stereotype.aspx

Anderson, E., & Kim, D. (2006). *Increasing the success of minority students in science and technology*. American Council on Education. Retrieved from https://www.acenet.edu/Documents/Increasing-the-Success-of-Minority-Students-in-Science-and-Technology-2006.pdf

Ayoub, C. (2017, May 1). *After-school STEM programs need our help*. Amy Poehler's Smart Girls. Retrieved from https://amysmartgirls.com/afterschool-stem-programs-need-our-help-86a7d7d8b35b

Bandura, A. (1997). *Self-efficacy: The exercise of control* (10th ed.). W. H. Freeman and Company.

Beery, A. K., & Zucker, I. (2011). Sex bias in neuroscience and biomedical research. *Neuroscience & Biobehavioral Reviews*, *35*(3), 565-572. https://doi.org/10.1016/j.neubiorev.2010.07.002

Bloch, B. (1998). *The tragedy of airbag fatalities to children and short drivers, and how to reduce the hazards*. Auto Safety Expert. Retrieved from http://www.autosafetyexpert.com/Assets/Docs/article-airbagdefects.pdf

Block, C. J., Koch, S. M., Liberman, B. E., Merriweather, T. J., & Roberson, L. (2011). Contending with stereotype threat at work: A model of long-term responses. *The Counseling Psychologist*, *39*(4), 570-600. https://doi.org/10.1177/0011000010382459

Breda, T., Grenet, J., Monnet, M., & Van Effenterre, C. (2018). *Can female role models reduce the gender gap in science? Evidence from classroom interventions in French high schools*. (PSE Working Papers n 2018-06). Paris-Jourdan Sciences Economiques. Retrieved from https://halshs.archives-ouvertes.fr/halshs-01713068/document

Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. *Proceedings of Machine Learning Research*, *81*, 1-15. Retrieved from http://proceedings.mlr.press/v81/buolamwini18a/buolamwini18a.pdf

Bureau of Labor Statistics. (2018). *Occupational outlook handbook, biomedical engineers*. U.S. Department of Labor. Retrieved from https://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm

Bystydzienski, J. M., Eisenhart, M., & Bruning, M. (2015). High school is not too late: Developing girls' interest and engagement in engineering careers. *The Career Development Quarterly*, *63*(1), 88-95. https://doi.org/10.1002/j.2161-0045.2015.00097.x

Ceci, S. J., Williams, W. M., & Barnett, S. M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin*, *135*(2), 218-261. https://doi.org/10.1037/a0014412

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, *6*(49), 1-8. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4323745/

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, *143*(1), 1-35. https://doi.org/10.1037/bul0000052

Covarrubias, R., Laiduc, G., & Valle, I. (2019). Growth messages increase help-seeking and performance for women in STEM. *Group Processes & Intergroup Relations*, *22*(3), 434-451. https://doi.org/10.1177/1368430218802958

Crenshaw, K. (2016). *Kimberlé Crenshaw: The urgency of intersectionality*. TED. Retrieved from https://www.ted.com/talks/kimberle_crenshaw_the_urgency_of_intersectionality?language=en

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*(6), 1241-1299. https://doi.org/10.2307/1229039

Cryer, H. (2013). *Teaching STEM subjects to blind and partially sighted learners*. Royal National Institute of Blind People (RNIB) Centre for Accessible Information (CAI). Retrieved from https://www.rnib.org.uk/knowledge-and-research-hub/research-reports/education-research/stem

Dare, E. (2015). *Understanding middle school students' perceptions of physics using girl-friendly and integrated STEM strategies: A gender study* (Publication No. 3727776) [Doctoral dissertation, University of Minnesota]. ProQuest Dissertations and Theses Global.

Deiglmayr, A., Stern, E., & Schubert, R. (2019). Beliefs in "brilliance" and belonging uncertainty in male and female STEM students. *Frontiers in Psychology*, *10*, Article 1114. https://doi.org/10.3389/fpsyg.2019.01114

Dennehy, T. C., & Dasgupta, N. (2017). Female peer mentors early in college increase women's positive academic experiences and retention in engineering. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(23), 5964-5969. https://doi.org/10.1073/pnas.1613117114

Dhami, H. (2019, June 27). *Intrinsic motivation in the classroom: The ultimate guide*. Top Hat. Retrieved from https://tophat.com/blog/intrinsic-motivation/

Díaz-Merced, W. (2014, September 22). *Making astronomy accessible for the visually impaired Voices*. Retrieved from https://blogs.scientificamerican.com/voices/making-astronomy-accessible-for-the-visually-impaired/

Doyle, M. (2016, March 10). *The truth about why boys and girls need STEM Toys*. The Good Men Project. Retrieved from https://goodmenproject.com/gender-sexuality/the-truth-about-why-boys-and-girls-need-stem-toys-dg/

Duran, M., & Sendag, S. (2012). A preliminary investigation into critical thinking skills of urban high school students: Role of an IT/STEM program. *Creative Education*, *3*(2), 241-250. https://doi.org/10.4236/ce.2012.32038

Ericsson, K. A., Prietula, M. J., & Cokely, E. T. (2007, July-August). *The making of an expert*. Harvard Business Review. Retrieved from https://hbr.org/2007/07/the-making-of-an-expert

Etchells, M. J., Deuermeyer, E., Liles, V., Meister, S., Suarez, M. I., & Chalklen, W. L. (2017). White male privilege: An intersectional deconstruction. *Journal of Ethnic and Cultural Studies*, *4*(2), 13-27. Retrieved from http://www.ejecs.org/index.php/JECS/article/view/78/pdf

Fouad, N. A., & Singh, R. (2011). *Stemming the tide: Why women leave engineering*. University of Wisconsin, Milwaukee, National Science Foundation. Retrieved from https://www.energy.gov/sites/prod/files/NSF_Stemming%20the%20Tide%20Why%20Women%20Leave%20Engineering.pdf

Funk, C., & Parker, K. (2018, January 9). 4. *Blacks in STEM jobs are especially concerned about diversity and discrimination in the workplace*. Pew Research Center. https://www.pewsocialtrends.org/2018/01/09/blacks-in-stem-jobs-are-especially-concerned-about-diversity-and-discrimination-in-the-workplace/

Fussell, S. (2017). *Why can't this soap dispenser identify dark skin?* Gizmodo. Retrieved from https://gizmodo.com/why-cant-this-soap-dispenser-identify-dark-skin-1797931773

Gibney, E. (2019, June 27). Discrimination drives many LGBTQ+ scientists to think about quitting. *Nature*, *571*, 16-17. https://doi.org/10.1038/d41586-019-02013-9

Girlguiding. (2016). *Girls' attitudes survey*. Retrieved from https://www.girlguiding.org.uk/globalassets/docs-and-resources/research-and-campaigns/girls-attitudes-survey-2016.pdf

Girl Scout Research Institute. (2012). *Generation STEM: What girls say about science, technology, engineering, and math*. Retrieved from https://www.girlscouts.org/join/educators/generation_stem_full_report.pdf

Gladwell, M. (2008). *Outliers: The story of success*. Little, Brown and Company.

Gnilka, P. B., & Novakovic, A. (2017). Gender differences in STEM students' perfectionism, career search self-efficacy, and perception of career barriers. *Journal of Counseling & Development*, *95*(1), 56-66. https://doi.org/10.1002/jcad.12117

Handelsman, J., & Sakraney, N. (2015). *Implicit bias*. White House Office of Science and Technology Policy. Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/bias_9-14-15_final.pdf

Harvard Business Review. (2012, September). *Sally Ride*. Retrieved from https://hbr.org/2012/09/sally-ride

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics (ED509653)*. American Association of University Women. ERIC. Retrieved from https://files.eric.ed.gov/fulltext/ED509653.pdf

Kager, E., (2015). *Effects of participation in a STEM camp on STEM attitudes and anticipated career choices of middle school girls: A mixed methods study* (Publication No. 10145051) [Doctoral dissertation, Ohio University]. ProQuest Dissertations and Theses Global.

Kim, A., Sinatra, G., & Seyranian, V. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research*, *88*(4), 589-625. https://doi.org/10.3102/0034654318779957

Klinger, E. (1977). *Meaning and void: Inner experiences and the incentives in people's lives*. University of Minnesota Press.

Kupersmidt, J., Stelter, R., Garringer, M., & Bourgoin, J. (2018). *STEM Mentoring—Supplement to the "Elements of Effective Practice for Mentoring": Research-informed recommendations for youth mentoring programs with a science, technology, engineering, or mathematics focus*. MENTOR: The National Mentoring Partnership. Retrieved from https://www.mentoring.org/new-site/wp-content/uploads/2018/10/STEM-Supplement-to-EEP.pdf

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). *STEM: Good jobs now and for the future* (ESA Issue Brief #03-11). U.S. Department of Commerce, Economics and Statistics

Administration. Retrieved from https://www.purdue.edu/hhs/hdfs/fii/wp-content/uploads/2015/07/s_iafis04c01.pdf

Larson, S. (2014, September 2). *Why so few women are studying computer science*. ReadWrite. Retrieved from http://readwrite.com/2014/09/02/women-in-computer-science-why-so-few/

Lepper, M. R., Corpus, J. H., & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology*, *97*(2), 184-196. https://doi.org/10.1037/0022-0663.97.2.184

Levine, M., Serio, N., Radaram, B., Chauduri, S., & Talbert, W. (2015). Addressing the STEM gender gap by designing and implementing an educational outreach chemistry camp for middle school girls. *Journal of Chemical Education*, *92*(10), 1639-1644. https://doi.org/10.1021/ed500945g

Levine, S. (2014, June 24). *New bill aims to end bias against women in clinical trials*. HuffPost. Retrieved from https://www.huffingtonpost.com/2014/06/24/research-for-all-act_n_5525757.html

Lockwood, P. (2006). "Someone like me can be successful": Do college students need same-gender role models? *Psychology of Women Quarterly*, *30*(1), 36-46. https://doi.org/10.1111/j.1471-6402.2006.00260.x

Lohr, S. (2018, February 9). *Facial recognition is accurate, if you're a white guy*. The New York Times. Retrieved from https://www.nytimes.com/2018/02/09/technology/facial-recognition-race-artificial-intelligence.html

Luna, C. (n.d.). *Universal Design techniques*. Clark College. Retrieved from http://www.clark.edu/tlc/technology/universaldesign.php

Mathews, C. (2013, October 10). *Physicists are made, not born*. The Scientista Foundation. Retrieved from http://www.scientistafoundation.com/women-in-science-news/physicists-are-made-not-born

Marincola, E. (2006). Why is public science education important? *Journal of Translational Medicine*, *4*, Article 7. Retrieved from https://doi.org/10.1186/1479-5876-4-7

Marx, D. M., & Roman, J. S. (2002). Female role models: Protecting women's math test performance. *Personality and Social Psychology Bulletin*, *28*(9), 1183-1193. https://doi.org/10.1177/01461672022812004

Melo, M. (2020). How do makerspaces communicate who belongs? Examining gender inclusion through the analysis of user journey maps in a makerspace. *Journal of Learning Spaces*, *9*(1), 59-68. Retrieved from http://libjournal.uncg.edu/jls/article/view/1942

Microsoft (2017). *Why Europe's girls aren't studying STEM*. Microsoft Corporation. Retrieved from https://news.microsoft.com/uploads/2017/03/ms_stem_whitepaper.pdf

McGuire, L., Mulvey, K. L., Goff, E., Irvin, M. J., Winterbottom, M., Fields, G. E., Hartstone-Rose, A., & Rutland, A. (2020). STEM gender stereotypes from early childhood through adolescence at informal science centers. *Journal of Applied Developmental Psychology*, *67*, Article 101109. https://doi.org/10.1016/j.appdev.2020.101109

Milgram, D. (2011). How to recruit women and girls to the science, technology, engineering, and math (STEM) classroom. *Technology and Engineering Teacher*, *71*(3), 4-11. Retrieved from https://www.iteea.org/File.aspx?id=137394&v=340d4cae

Miller, D. I., Nolla, K. M., Eagly, A. H. & Uttal, D. H. (2018). The development of children's gender-science stereotypes: A meta-analysis of 5 decades of U.S. draw-a-scientist studies. *Child Development*, *89*(6), 1943-1955. https://doi.org/10.1111/cdev.13039

Ministry for Women. (2018, July 20). *Women in innovation*. Retrieved from https://women.govt.nz/council/information/women-innovation

National Center for Science and Engineering Statistics. (2017). *Women, Minorities, and Persons with Disabilities in Science and Engineering—NCSES—US National Science Foundation (NSF)*. National Science Foundation. Retrieved from https://www.nsf.gov/statistics/2017/nsf17310/downloads.cfm

Noll, N. E. (2020, February 17). *Gender equality ≠ gender neutrality: When a paradox is not so paradoxical, after all*. GenderSci Blog. Retrieved from https://www.genderscilab.org/blog/gender-equality-does-not-equal-gender-neutrality

O'Donnell, G. (2019, August 19). *STEM fields need male allies to advocate for greater gender equity*. Insight into Diversity. Retrieved from https://www.insightintodiversity.com/stem-fields-need-male-allies-to-advocate-for-greater-gender-equity/

Ogle, J. P., Hyllegard, K. H., Rambo-Hernandez, K. E., & Park, J. (2017). Building middle school girls' self-efficacy, knowledge, and interest in math and science through the integration of fashion and STEM. *Journal of Family & Consumer Sciences*, *109*(4), 33-40. https://doi.org/10.14307/JFCS109.4.33

O'Reilly, K. (2009). *Key concepts in ethnography*. SAGE Publications. https://doi.org/10.4135/9781446268308

Phillips, K. W., Liljenquist, K. A., & Neale, M. A. (2008). Is the pain worth the gain? The advantages and liabilities of agreeing with socially distinct newcomers. *Personality and Social Psychology Bulletin*, *35*(3), 336-350. https://doi.org/10.1177/0146167208328062

Pitney, N. (2017, December 6). *Meet the 63rd Black woman in American history with a physics Ph.D.* The Huffington Post. Retrieved from http://www.huffingtonpost.com/2015/06/24/chanda-prescod-weinstein_n_7574020.html

Pollack, E. (2013, October 3). *Why are there still so few women in science?* The New York Times Magazine. Retrieved from https://www.nytimes.com/2013/10/06/magazine/why-are-there-still-so-few-women-in-science.html

Raisamo, R., Hippula, A., Patomaki, S., Tuominen, E., Pasto, V., & Hasu, M. (2006). Testing usability of multimodal applications with visually impaired children. *IEEE MultiMedia*, *13*(3), 70-76. https://doi.org/10.1109/MMUL.2006.68

Régner, I., Thinus-Blanc, C., Netter, A., Schmader, T., & Huguet, P. (2019). Committees with implicit biases promote fewer women when they do not believe gender bias exists. *Nature Human Behaviour*, *3*, 1171-1179, https://doi.org/10.1038/s41562-019-0686-3

Rice, K. G., Ray, M. E., Davis, D. E., DeBlaere, C., & Ashby, J. S. (2015). Perfectionism and longitudinal patterns of stress for STEM majors: Implications for academic performance. *Journal of Counseling Psychology*, *62*(4), 718-731. https://doi.org/10.1037/cou000009

Richardson, Sarah and the GenderSci Lab. (2020, February 14). *Gender stereotypes, gendered self-expression, and gender Segregation in fields of study: A Q&A with Professor Maria Charles*. GenderSci Blog. Retrieved from https://genderscilab.org/blog/gender-stereotypes-gendered-self-expression-and-gender-segregation-in-fields-of-study-a-qampa-with-professor-maria-charles

Rios, D., & Stewart, A. J. (2014). Insider and outsider-within standpoints: The experiences of diverse faculty in science and engineering fields. *Journal of Women and Minorities in Science and Engineering*, *21*(4), 295-322. https://doi.org/10.1615/JWomenMinorScienEng.2015010375

Rittmayer, A. D., & Beier, M. E. (2008). Overview: Self-efficacy in STEM. *SWE-AWE CASEE Overviews*, *1*(12). Retrieved from http://aweonline.org/arp_selfefficacy_overview_122208_001.pdf

Rosenthal, L., Levy, S., London, B., Lobel, M., & Bazile, C. (2013). *In pursuit of the MD: The impact of role models, identity compatibility, and belonging among undergraduate women. Sex Roles*, *68*(7-8), 464-473. https://doi.org/10.1007/s11199-012-0257-9

Ryan, G.W., & Bernard, H.R. (2003). Techniques to identify themes in qualitative data. *Field Methods*, *15*(1), 85-109. https://doi.org/10.1177/1525822X02239569

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Sci. Educ.*, *96*(3), 411-427. https://doi.org/10.1002/sce.21007

Schmelz, J., Montgomery, M., Trouille, L., Morrison, N., Bertschinger, E., & Charbonneau, D., Gehrels, N., Hughes, M., Kirkpatrick, J., Murphy, N., Zellner, N., Johnson, J., & Simpson, C. (2014). *Annual report on the Committee on the Status of Women in Astronomy for 2013-2014*. Retrieved from https://aas.org/sites/default/files/2019-09/CSWA_Ann_Rep_2014.pdf

Settles, I. H. (2014). *Women in STEM: Challenges and determinants of success and well-being*. Retrieved from http://www.apa.org/science/about/psa/2014/10/women-stem.aspx

Shapiro, J. R., & Williams, A. M. (2012). The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields. *Sex Roles*, *66*, 175-183. Retrieved from https://link.springer.com/article/10.1007/s11199-011-0051-0

Shinchi, T. (2014). Group problem solving performance by members of homogeneous and heterogeneous groups. *Jpn. J Exp. Soc. Psychol.*, *54*(1), 55-67. https://doi.org/10.2130/jjesp.1217

Smith, S., Choueiti, M., Prescott, A., & Pieper, K. (2012). *Gender roles & occupations: Look at character attributes and job-related aspirations in film and television*. Geena Davis Institute on Gender in Media. Retrieved from https://seejane.org/wp-content/uploads/key-findings-gender-roles-2013.pdf

Smith, W. S., & Erb, T. O. (1986). Effect of women science career role models on early adolescents' attitudes toward scientists and women in science. *Journal of Research in Science Teaching*, *23*(8), 667-676. https://doi.org/10.1002/tea.3660230802

Sobieraj, S., Krämer, N. C. (2019). The impacts of gender and subject on experience of competence and autonomy in STEM. *Front. Psychol.*, *10*, Article 1432. https://doi.org/10.3389/fpsyg.2019.01432

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, *35*(1), 4-28. https://doi.org/10.1006/jesp.1998.1373

Starr, C. R., Anderson, B. R., & Green, K. A. (2019). "I'm a computer scientist!" Virtual reality experience influences stereotype threat and STEM motivation among undergraduate women. *Journal of Science Education and Technology*, *28*, 493-507. https://doi.org/10.1007/s10956-019-09781-z

Steinke, J. (2017). Adolescent girls' STEM identity formation and media images of STEM professionals: Considering the influence of contextual cues. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.00716

Strauss, A. L., & Corbin, J. M. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. SAGE Publications.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology*, *100*(2), 255-270. https://doi.org/10.1037/a0021385

Sullivan, A., & Bers, M. U. (2019). Investigating the use of robotics to increase girls' interest in engineering during early elementary school. *International Journal of Technology and Design Education*, *29*, 1033-1051. https://doi.org/10.1007/s10798-018-9483-y

U.S. Government Accountability Office. (2001). *Most drugs withdrawn in recent years had greater health risks for women*. Retrieved from http://www.gao.gov/products/GAO-01-286R

Villanueva, I. & Di Stefano, M. (2017). Narrative inquiry on the teaching of STEM to blind high school students. *Education Sciences*, *7*(4), Article 89. https://doi.org/10.3390/educsci7040089

Williams, M. M., & George-Jackson, C. (2014). Using and doing science: Gender, self-efficacy, and science identity of undergraduate students in STEM. *Journal of Women and Minorities in Science and Engineering*, *20*(2), 99-126. https://doi.org/10.1615/JWomenMinorScienEng.2014004477

Young, D., Rudman, L., Buettner, H., & McLean, M. (2013). The influence of female role models on women's implicit science cognitions. *Psychology of Women Quarterly*, *37*(3), 283-292. https://doi.org/10.1177/0361684313482109