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Challenging Media Stereotypes of STEM: Examining an Intervention to Change Adolescent Girls' Gender Stereotypes of STEM Professionals

Jocelyn Steinke[1] and Tamia Duncan[2]

[1]University of Connecticut, [2]Western Michigan University

ABSTRACT:
Media play a key role in the cultural reproduction of gender stereotypes of science, technology, engineering, and mathematics (STEM). This study examined the efficacy of a media-focused intervention to decrease adolescent girls' gender-STEM-stereotypes and increase their knowledge of STEM careers. An interactive presentation challenging gender-stereotyped images of women STEM professionals in popular media and participation in STEM learning activities featuring interactions with women STEM professionals were part of an out-of-school, informal STEM learning program designed to foster adolescent girls' interest in STEM. Findings from pre- and post-test Draw-a-Scientist Test (DAST) drawings used to assess perceptions of STEM professionals revealed a decrease in gender-STEM-stereotypes and greater knowledge of types of STEM careers. Findings suggest that creating awareness about gender-STEM-stereotypes in popular media, presenting counter-stereotyped media images of women as STEM professionals, and providing opportunities to engage in STEM activities were crucial for adolescent girls' development of more inclusive views of women and STEM, which may be essential for seeing themselves as future STEM professionals. Implications for theory and recommendations for informal STEM educators and media practitioners for designing interventions to address, challenge, and change gender-STEM-stereotypes are discussed.

KEYWORDS: gender-STEM-stereotypes, media, STEM intervention, Draw-a-Scientist Test (DAST)

Challenging Media Stereotypes of STEM: Examining an Intervention to Change Adolescent Girls' Gender Stereotypes of STEM Professionals

Informal science learning (ISL) programs for girls are important for broadening interest and engagement in STEM (science, technology, engineering, mathematics) as well as for promoting knowledge of STEM careers (Chapman, 2022; Hug & Eyerman, 2021). ISL programs are useful for addressing gender differences in STEM interest that first emerge during childhood (Conner & Danielson, 2016). Girls develop gender stereotypes about intellectual ability and aptitude related to specific academic areas after age five (Prieto, Cvencek, Llácera, Escobara, & Meltzoff, 2017). By age six, girls are more likely to view boys as more intelligent (Bian, Leslie, & Cimpian, 2017); and by age seven, girls report gender stereotypes related to aptitude and ability in math (Cvencek, Meltzoff, & Greenwald, 2011). Prior studies have shown that gender-STEM-stereotypes often persist from childhood in to adolescence (Rubach et al., 2022) and on in to the undergraduate years (Deiglmayr, Stern, & Schubert, 2019), deterring young women from STEM careers (Makarova, Aeschlimann, & Herzog, 2016). Thus, it is crucial to develop best practices for ISL programs for girls during adolescence to directly address gender stereotypes of STEM professionals and build girls' knowledge of STEM careers in ways that sustain their interest and engagement in STEM.

Despite greater representation of women in STEM occupations over the years in the United States, women are still underrepresented in several STEM disciplines such as computer science, physics, and engineering (National Science Foundation, 2023). To increase women's representation in STEM, it is essential to identify ways to address girls' gender-STEM-stereotypes when girls first begin to consider potential careers. Early adolescence is an especially impressionable time for forming ideas about future careers (Erikson, 1968; Marcia, 1980), but also a time when many girls perceive STEM professions as masculine domains (Miller, Nolla, Eagly, & Uttal, 2018) and experience low science identity (Aschbacher, Ing, & Tsai, 2014).

Media play a key role in the development of children's and adolescents' perceptions of STEM professionals (Song & Kim, 1999; Steinke et al., 2007; Todd & Zvoch, 2017). In fact, research indicates that children and adolescents often report media as the primary sources of information about STEM professionals (Steinke et al., 2007). Media images influence children's and adolescents' perceptions of who is a scientist, where scientists work, what scientists do, and who can be a scientist (Bond, 2016; Steinke et al., 2007) as well as their STEM career interest (Chen, Hardjo, Sonnert, Hui, & Sadler, 2023). However, for decades, media images of STEM professionals have reinforced cultural stereotypes about who belongs in STEM fields (Master & Meltzoff, 2020) and have promoted a masculine ideal of STEM (Parson, Steele, & Wilkins, 2021) through underrepresentation and stereotyped portrayals of women STEM professionals (Flicker, 2003; LaFollette, 1981; Long et al., 2010; Steinke, 2005; Steinke & Long, 1996; Steinke & Tavarez, 2017; Weitekamp, 2015).

Many ISL programs designed to promote adolescent girls' interest in STEM have focused on how to address these stereotypes by promoting interactions with women STEM role models. Indeed, women STEM role models have been found to foster girls' interest in STEM (for a review, see Gladstone & Cimpian, 2021) and have demonstrated positive outcomes (Jones, Howe, & Rua, 2000), including positive changes in gender stereotyped perceptions of STEM professionals (Master, Cheryan, & Meltzoff, 2014) and STEM identity (Merritt et al., 2021). However, few ISL programs have integrated *media* STEM role models as ways of directly challenging gender-STEM-stereotypes conveyed through popular media (Cakmakci et al., 2011; Steinke et al., 2007). Prior research has highlighted the potential for programs that feature counter-stereotypical media portrayals of women STEM professionals in changing girls' gender-stereotyped perceptions of STEM (Steinke, Applegate, Penny, & Merlino, 2021; Steinke et al., 2007). Given girls' frequent use of both traditional and new social media (Auxier & Anderson, 2021), ISL programs with this focus are needed.

Informal STEM learning ecosystems (partnerships that include schools, community organizations after-school and summer programs, science centers and museums, and informal experiences at home) (Traphagen & Traill, 2014) have been identified as important for effective ISL opportunities for adolescents (Chapman, 2022). The present study examined the efficacy of a unique STEM learning ecosystem for middle school girls: an ISL program featuring partnerships among a community math and science center, STEM professors from local colleges and a university, STEM professionals in the community, and a social science researcher and advocate for girls in STEM. A local math and science center developed and coordinated this girls-only ISL program. The program included two phases: 1) an interactive presentation designed to challenge traditional gender stereotypes of STEM professionals in popular media and 2) participation in five, inquiry-based STEM learning activities led primarily by women STEM professionals. Girls' engagement in STEM was further encouraged by providing them with access to STEM laboratories and an environment that featured posters that celebrated the contributions of prominent women in STEM of diverse racial and ethnic backgrounds. Changes in girls' gender stereotyped perceptions of scientists were assessed using a modified version of the Draw-a-Scientist Test (DAST) (Chambers, 1983; Finson, 2003), which asked girls to describe their drawings through self-reports. Study findings have implications for theory as well as practice and provide recommendations for the design of ISL programs for adolescent girls.

LITERATURE REVIEW

Theoretical Frameworks

This study is grounded in two theoretical perspectives that (1) explain the influence of gender-stereotyped media images of STEM professionals on adolescent girls' perceptions and (2) identify conditions by which gender-STEM-stereotype change is most likely to occur. *Social cognitive theory* advances understanding of how children's perceptions of the world are formed through both direct and observational experiences (Bandura, 2001) and how children learn from repeated observations of both direct models and symbolic models in the social environment (Bandura, 1969, 2009). Social cognitive theory also describes the factors that promote children's imitation of behavior from media models (Bandura, 1965, 1986; Bandura, Ross, & Ross, 1963). Specifically, observational learning is guided by four distinct processes: attention, retention in memory, translation of the symbolic representations of models' behavior into action, and motivation to imitate modeled behavior (Bandura, 2009). Furthermore, the degree of influence of media models of STEM professionals on adolescent girls will be affected by their *attention* to the models, *retention* of information about the models in memory, *translation* of the symbolic representations of models' behavior into personal action, and personal *motivation* to imitate the behavior of the models (Bandura, 2009). Thus, social cognitive theory explains *when* and *how* STEM media role models might influence girls' perceptions because it acknowledges how their social reality can be influenced by vicarious experiences or "by what they see, hear, and read— without direct experiential correctives" (Bandura, 2001, p. 271).

Social identity theory (Tajfel, 1982; Tajfel & Turner, 1979) explains how individuals negotiate and form an identity, or a sense of who they are, through associations and disassociations with various social groups (Korte, 2007; Miner-Rubino, Settles, & Stewart, 2009). Individuals strive to maintain a positive identity by affiliating with groups perceived to be ingroups rather than those perceived to be outgroups (Tajfel & Turner, 1979). Social identity theory explains *why* and *how* adolescent girls' perceptions of STEM professionals might influence their consideration of STEM careers as possible future careers. That is, as adolescent girls strive to achieve a positive social identity, they are "motivated to think and act in ways that achieve or maintain a positive distinctiveness between one's own group and relevant outgroups" (Hornsey, 2008 p. 207). Thus, when considering possible future careers, adolescent girls are most likely to identify with careers perceived as compatible with their existing social identities (e.g., gender, class, race) and viewed as "possible and desirable" (Archer et al., 2012, p. 970). However, gender stereotyped portrayals of STEM professionals in popular media often depict STEM fields as masculine (Parson et al., 2021) and STEM occupations as incompatible, undesirable, impossible, and unattainable outgroups for girls and women, potentially deterring girls from pursuing these careers.

Draw-a-Scientist Test (DAST) and Gender-STEM-Stereotypes

The Draw-A-Scientist Test (DAST) has proved to be a useful instrument for obtaining insights about children's and adolescents' views of scientists. The DAST was derived from early research in the 1950s (Mead & Metraux, 1957) that analyzed 35,000 high school students' written essays to assess their views of scientists. Later, DAST studies introduced illustration to assess students' perceptions of scientists (Chambers, 1983). Several modifications of the DAST have been developed to address concerns about the accuracy of interpretation of drawings or to glean more specific information from participants. These modifications include the DAST Checklist (DAST-C) (Finson, Beaver, & Cramond, 1995) to assess specific stereotypes, the mDAST (Farland-Smith, 2012) that prompts students to include speech bubbles, physical characteristics, and objects in their drawings (Farland-Smith, 2012; Ponners & Piller, 2019), the InDAST (Bernard & Dudek, 2017) that asks students to draw pictures of scientific research, the Enhanced Draw-A-Scientist Test (E-DAST) that prompts students to draw three scientists (Farland-Smith & McComas, 2009), and the Emo-DAST that assesses students' perceptions of scientists' emotions (Christidou, Bonoti, & Hatzinikita, 2021).

Decades of DAST research have revealed that children and adolescents typically hold gender-stereotyped views of scientists. One of the largest early DAST studies in the U.S. found that only 28 of 4,000 drawings by children from kindergarten to 5th grade depicted women scientists, and only girls drew women scientists (Chambers, 1983). Later studies conducted across all age groups and in various countries have reported similar findings with only few variations. For example, preschool-aged children in Turkey drew more men than women scientists (Pekdoğan & Bozgün, 2019). Kindergarteners in Turkey depicted an almost equal percentage of men and women scientists, but 5th grade students depicted mostly men scientists (Özel, 2012). Young school children in grades 3 to 5 in Romania drew more men scientists than women scientists (Thomson, Zakaria, & Radut-Taciu, 2019). A cross-cultural comparison of elementary-aged children's DAST drawings found American and Chinese boys drew more men scientists than women scientists, but American and Chinese girls drew more women as scientists (Farland-Smith, 2009). Secondary school-aged students in Turkey drew more men than women as scientists (Baybars, 2020). Secondary school students in Poland drew twice as many men working alone than women working alone – although students were more likely to draw pictures featuring both men and women together (Bernard & Dudek, 2017). Elementary, middle, high school students in Korea drew more men scientists across all age groups (Song & Kim, 1999). A study of 6th and 7th grade students in Turkey found that while boys drew all men scientists, girls drew slightly more women scientists than men scientists (Acisli & Kumandas, 2019). Similarly, gifted 7th and 8th grade students in Turkey drew more men than women scientists, with none of the boys drawing women scientists (Camcı-Erdoğan, 2013). Gifted high school students in Mexico mostly drew men scientists, with boys drawing only men scientists (Aguilar, Rosas, Gabriel, Zavaleta, & Romo-Vazquez, 2016). A systematic review of decades of DAST research found that while gender stereotypes of STEM professionals have decreased over time, adolescents are still more likely than young children to view scientists or STEM professionals as men (Miller et al., 2018). Collectively, these studies have demonstrated that girls are more likely to draw women as STEM professionals, thus suggesting that they are likely to be influenced by ISL programs that feature women STEM role models.

STEM Role Models and STEM Interventions

A STEM role model has been defined as a STEM individual "who can positively shape a student's motivation by acting as a successful exemplar" (Gladstone & Cimpian, 2021, p. 59). Studies have shown that girls' and young women's stereotypes of STEM professionals can be changed through interventions that feature women STEM professionals as role models (Barakat, 2022; Merritt et al., 2021; O'Brien et al., 2017; Todd & Zvoch, 2017). For example, a study of 6- to 8-year old girls found that stories about successful women in STEM were effective in countering negative stereotypes, and researchers attributed the intervention's success to the fact that gender-STEM-stereotypes and sources of gender-STEM-stereotypes were first addressed (Buckley, Farrell, & Tyndall, 2022). A study of an after-school, informal STEM education program for 4th-6th grade girls found that mentorship provided by women undergraduate and graduate students plus participation in hands-on science activities increased elementary-aged girls' interest, knowledge, and confidence in science, math, and engineering (Chen et al., 2011). A study of 6th grade students in Turkey found that an intervention that included discussions focused on the abilities of both men and women to be scientists along with visits from scientists were effective in changing students' gender stereotypes of STEM professionals (Cakmakci et al., 2011). A study of 2nd to 5th grade students found that participation in an 18-week formal STEM education program led students to draw more women scientists and also self-identify or draw themselves as scientists (Barakat, 2022). Similarly, early adolescent girls who attended a brief, one-day, workshop led by women STEM role models reported identification with the role models and greater science identity (Merritt et al., 2021).

Few STEM interventions, however, have examined the efficacy of women STEM *media* role models in promoting gender-STEM-stereotype change (Bond, 2016; Steinke et al., 2021; Yonas, Sleeth, & Cotner, 2013), and even fewer interventions have directly addressed and challenged gender stereotypes of STEM in popular media (Steinke et al., 2009; Steinke et al., 2007). Some prior interventions centered on changing stereotyped *media images* of STEM professionals have provided evidence of effectiveness. For example, one study found that after listening to nine "Scientist Spotlight" podcasts featuring scientists of diverse identities (gender, race, ethnicity, religion, sexual orientation, profession), undergraduate students' perceptions of the types of people who do science changed and students often mentioned their own identities when relating to scientists in the podcasts (Yonas et al., 2013). This study specifically noted that podcast stories about the scientists countered several stereotypes students held about science and scientists (Yonas et al., 2013), and students' counter-stereotypical perceptions even persisted six months after intervention (Schinske, Perkins, Snyder, & Wyer, 2016). Another study found that adults who viewed selfies of scientists on Instagram were less likely to hold the negative stereotypes of scientists as not being warm, and adults who viewed a series of female scientist selfies on Instagram led to a shift in stereotypes that associate STEM fields with being male (Jarreau et al., 2019). Collectively, these studies suggest the importance of examining the influence of STEM *media* role models on adolescent girls' gender stereotyped perceptions of STEM professionals.

Guided by the theories and research noted above, this study assessed the efficacy of a girls-only ISL program by examining these hypotheses and research question:

> H1: Adolescent girls' *gender stereotypes of STEM professionals* will decrease following participation in the informal STEM education program for adolescent girls.
> H2: Adolescent girls' *knowledge of STEM careers* will increase following participation in the informal STEM education program for adolescent girls.

RQ: What are adolescent girls' *sources of information about STEM professionals*?

METHOD

Participants

Study participants were 58, sixth (n=37) and seventh (n=21) grade girls recruited from middle schools in the Midwest in the U.S. to attend a one-day, out-of-school, informal STEM education program for girls. Participants were recruited by fliers sent to area schools by a local math and science center that sponsored the event. Participants included 66 students from 11 public middle schools, 4 private middle schools, and 1 homeschool. Program participant race/ethnicity was reported: White (n=51), Asian/Asian American/Indian (n=6), Black/African American (n=5), and Hispanic/Latina (n=4). University IRB approval was obtained and parental or guardian consent and student assent were obtained prior to study implementation. Participation in this program spanned several hours during the day from 9 a.m. until 3 p.m. Participants were randomly divided into small groups of 10-15 participants led by high school-aged girls who attended the math and science center. Of 66 total program participants, 58 provided parental or guardian consent, student assent, and completed both pre- and post-assessments, which was necessary to be included in this study.

Research Design

This study used a mixed methods pre-/post-test design utilizing a modified version of the Draw-A-Scientist Test (DAST) to assess changes in middle school girls' gender stereotyped perceptions of scientists and knowledge of STEM fields. This design generated both quantitative as well as qualitative data that provided additional insights on the variety of ways in which girls' perceptions were shaped by participation in this program (Creswell & Plano Clark, 2018). In addition, participant witnessing (Tracy, 2020) during the informal STEM education program setting was conducted by the first author. This approach allowed for greater consideration of how nuanced messages and context may have influenced girls during this STEM outreach event and a greater understanding of the tacit values inherent in the design of this program (Tracy, 2020).

Informal STEM Education and Outreach Program for Middle School Girls

The informal STEM education program was organized and led by staff and volunteers at a local math and science center in November 2019. The overall goal of the program was to promote adolescent girls' interest in STEM careers. Specific program objectives were to 1) promote adolescent girls' awareness of STEM gender stereotypes in popular media to challenge any existing gender-STEM-stereotypes and broaden their image of the type of people who work in STEM and 2) expand their knowledge of the type of work STEM professionals do. To achieve these objectives, the program featured two phases: 1) an interactive presentation designed to create awareness of and challenge traditional gender stereotypes of STEM professionals in popular media and 2) five, hands-on STEM activities (led by STEM professionals) designed to promote interest in and knowledge of various STEM disciplines (Figure 1).

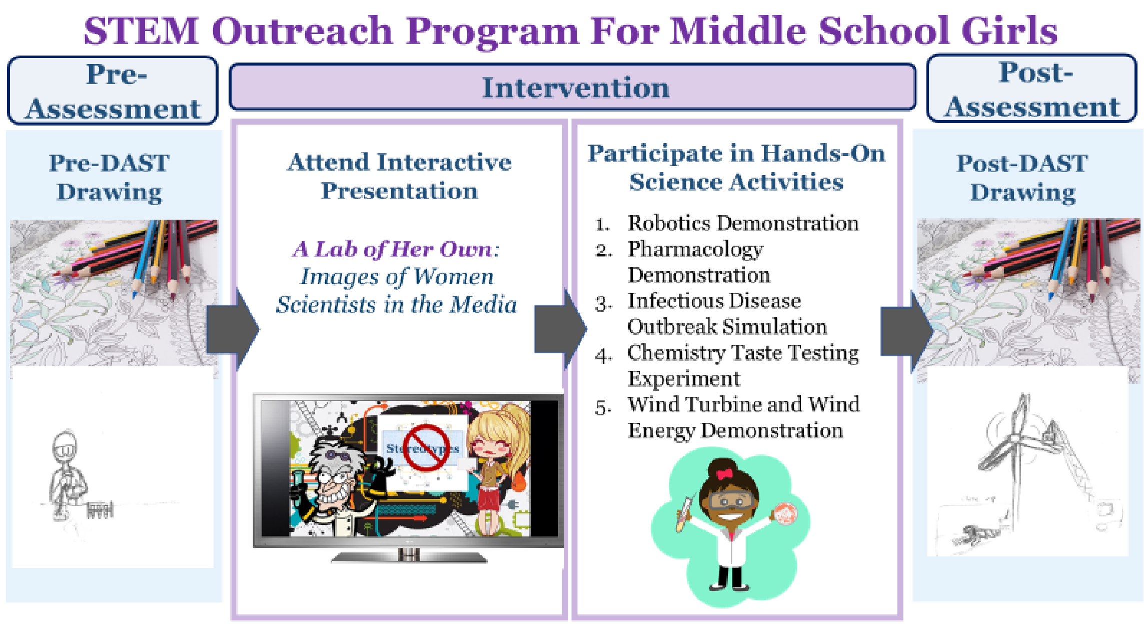


Figure 1: *Research Design and Informal STEM Education Program for Middle School Girls*

After parents and/or caregivers registered participants for the event, participants gathered in the auditorium in pre-assigned groups of 10-12 students that were led by a high school-aged young woman who attended the math and science center. Participants completed a pre-DAST drawing before both phases of the intervention began. Participants then attended the interactive presentation, "A Lab of Her Own: Images of Woman Scientists in the Media," given by the first author. Next, in their small groups, participants completed each of the five, inquiry-based STEM activities in random order. A short lunch break was provided in between these activities. Finally, all participants reconvened in the auditorium and completed the post-DAST assessment. Participants were thanked for their assistance and waited with their guides for their parents or guardians. Additional details about each phase of this program are described below.

Phase 1: Presentation on STEM Gender Stereotypes in Media. A unique feature of this program was the focus on media gender-STEM-stereotypes. During the interactive presentation, "A Lab of Her Own: Images of Women Scientists in Media," girls were asked to consider images of famous, prominent, and successful women STEM professionals projected on a large screen in the auditorium. The presentation focused on stereotypes of STEM professionals, including a discussion of gender stereotypes and their effects on people's perceptions, attitudes, and behaviors. The presenter (first author) explained how gender stereotypes of STEM professionals often shown in popular media influence people's perceptions of who STEM professionals are, how STEM professionals look, and the type of work they do. An interactive discussion followed, inviting participants to consider both stereotypes and counter-stereotypes of images shown of several prominent STEM professionals (i.e., Albert Einstein, Gregor Mendel, Jane Goodall, Mae Jemison) and STEM characters depicted in popular media (i.e., Bill Nye, *Bill Nye the Science Guy*;

Sheldon Cooper, *The Big Bang Theory*; Amy Fowler, *The Big Bang Theory*; Dr. Henry Wu, *Jurassic World*; and Erin Gilbert, *Ghostbusters*). The presentation then highlighted how fewer women STEM professionals are typically featured in popular media but also showed images from more recent television programs and films that prominently featured women STEM professionals (i.e., *SciGirls*, PBS; *Project MC2*, Netflix; *Science with Sophie*, YouTube; Gwen Stacy, *Amazing Spiderman*; Shuri, *Black Panther*; Katherine Johnson, *Hidden Figures*). Throughout the interactive presentation, participants were asked frequently about the STEM professionals featured on the large screen and asked to consider *"Who is a scientist?"* and *"Who can be a scientist?"* The presenter concluded by reminding participants that a scientist/STEM professional does not have to look like the stereotyped depictions they may have seen and encouraged participants to think of themselves as scientists as they explored the STEM activities planned for them during this event. The presenter concluded with this final reminder: "You also are changing the idea or pictures in people's heads about who can be a scientist, or technologist, or engineer, or mathematician. You are a scientist! You are a STEM professional! You belong in STEM!" The interactive presentation lasted approximately 50 minutes.

Phase 2: Inquiry-based STEM Learning Activities. Immediately following the interactive presentation, participants engaged in the second phase of the intervention. Participants randomly rotated in their assigned groups among five, inquiry-based science activities and demonstrations (approximately 47 min. each), which were held in STEM laboratories and classrooms and mostly led by women STEM professionals. These activities included the following:

- Pharmacology demonstration (1 woman)
- Infectious disease outbreak simulation (60/40 women to men)
- Taste testing demonstration (1 woman)
- Wind turbine and wind energy demonstration (1 woman, 2 men)
- Robotics demonstration (1 man)

Pre- and Post- DAST Assessments

To assess changes in gender stereotyped perceptions of STEM professionals, a modified version of the DAST (Chambers, 1983) was administered at the beginning of the event before the interactive presentation. Participants were given colored pencils, paper, and the following instructions: "We are going to start this morning with a drawing activity. On a blank side of this piece of paper, please draw a picture of a scientist, or computer scientist, or engineer, or mathematician. Take about 10 minutes to do this drawing." After completing their drawings, participants were asked a series of prompts requesting that they describe their drawings and write down additional information about their drawings. Specifically, participants were asked to indicate the STEM profession, gender, race and ethnicity, age of the STEM professional in their drawing, sources of ideas for their drawings, and sources of information about images of STEM professionals, in general. These modifications were used to address previous methodological concerns about limitations of the DAST related to the sensitivity of the instrument and accuracy of interpretation (Reinisch, Krell, Hergert, Gogolin, & Krüger, 2017; Thomas, Henley, & Snell, 2006), wording of questions (Bernard & Dudek, 2017), assessment of details in interpretation of drawings (Donna Farland-Smith, 2012), limitations in interpretations caused by culturally bound perceptions (Ferguson & Lezotte, 2020), and an inability to discern race and ethnicity in interpreting drawings (Reinisch et al., 2017). Prior research has found written prompts effective for assessing mental representations of perceptions of STEM professionals for this age group (Steinke et al., 2007).

For the post-test DAST assessment, participants were asked the same questions given during the pre-test as well as additional questions related to how the drawings were similar or different and why, whether anything they saw or learned during the day influenced or changed their drawings and why, whether their drawings represented how they think scientists, computer scientists, engineers, mathematicians should be shown on TV and in films and why or why not, and finally, how they think scientists, computer scientists, engineers, mathematicians should be shown on TV and in films. These questions were used to further assess how participation in this program may have influenced participants' perceptions. Pre- and post-test DAST drawings were collected from participants after written responses were completed.

Analysis of DAST Drawings and Participants' Written Responses

All identifying information was removed, and DAST drawings and written responses about the drawings were copied for analysis for all participants who provided completed consent and assent forms. Based on prior DAST studies reviewed above, the first author created a codebook to guide analysis (Appendix). The codebook included 7 codes: gender, race or ethnicity, age, STEM job/discipline, sources of ideas of DAST drawing, sources of images of STEM professionals. Because participants provided self-reports about their DAST drawings, inferences about the drawings were not necessary and eliminated the need to assess reliability of coding. This improved the accuracy of interpretation of the drawings and accounted for previous methodological concerns about the DAST as described above. The first author recorded information from participants' written responses by code for all drawings and calculated percentages for each code. If participants provided more than one code for demographic characteristics (gender, race/ethnicity, age), only the first listed code was recorded. In addition to assessing the frequency of appearance of each code, the first author also took notes related to changes in the pre- and post-DAST drawings, marking exemplars. Data triangulation was conducted through analysis of DAST drawings, written descriptions of DAST drawings, and field observations taken during the informal STEM education event.

RESULTS

In written responses describing their pre- and post-test DAST drawings, participants provided demographic characteristics (gender, race/ethnicity, age) for the STEM professionals they drew and listed sources of information for their DAST drawings and perceptions of STEM professionals (Table 1).

Table 1: *Pre- and Post-Test Descriptions of DAST Drawings*

Variable, Pre-Test (Sample *n*)	**Percentage**, *n*	**Variable, Post-Test (Sample *n*)**	**Percentage**, *n*
Gender (58)		**Gender (58)**	
Man	**20.6%**, 12	Man	**6.9%**, 4
Woman	**72.4%**, 42	Woman	**88.0%**, 51
Neither or none	**6.9%**, 4	Neither or none	**3.4%**, 2
Not given	**1.7%**, 1	Not given	**0.0%**, 0
Race/Ethnicity (58)		**Race/Ethnicity (58)**	
White	**74.1%**, 43	White	**55.2%**, 32
African American/Black	**3.4%**, 2	African American/Black	**10.3%**, 6
Hispanic/Latina	**3.4%**, 2	Hispanic/Latina	**5.2%**, 3
Native American	**0.0%**, 0	Native American	**1.7%**, 1
Asian or Asian American/Indian	**0.0%**, 0	Asian or Asian American/Indian	**5.2%**, 3
Any race or ethnicity	**1.7%**, 1	Any race or ethnicity	**1.7%**, 1
No specific race or ethnicity	**12.1%**, 7	No specific race or ethnicity	**13.8%**, 8
Not given	**5.2%**, 3	Not given	**6.9%**, 4
Age (58)		**Age (58)**	
Teenager (middle/high school)	**5.2%**, 3	Teenager (middle/high school)	**5.2%**, 3
Young adult/college aged	**27.6%**, 16	Young adult/college aged	**20.7%**, 12
Middle-aged adult	**51.7%**, 30	Middle-aged adult	**48.3%**, 28
Older adult	**8.6%**, 5	Older adult	**10.3%**, 6
Dead	**5.2%**, 3	Dead	**0.0%**, 0
Not given	**1.7%**, 1	Not given	**10.3%**, 6
STEM Job/Discipline (58)		**STEM Job/Discipline (58)**	
Astronomy and outer space	**1.7%**, 1	Astronomy and outer space	**1.7%**, 1
Biology	**5.2%**, 3	Biology	**13.8%**, 8
Chemistry	**12.1%**, 7	Chemistry	**15.5%**, 9
Engineering	**0%**, 0	Engineering	**12.1%**, 7
Medicine/Pharmacology	**1.7%**, 1	Medicine/Pharmacology	**13.8%**, 8
Computer science	**6.9%**, 4	Computer science	**5.2%**, 3
Physics	**0.0%**, 0	Physics	**1.7%**, 1
Mathematics	**27.6%**, 16	Mathematics	**20.7%**, 12
General STEM job/scientist	**36.2%**, 21	General STEM job/scientist	**6.9%**, 4
General STEM teacher	**6.9%**, 4	General STEM teacher	**1.7%**, 1
Technology/robots	**0.0%**, 0	Technology/robots	**3.4%**, 2
Not given	**1.7%**, 1	Not given	**3.4%**, 2
Poster/picture	**6.2%**, 4	Poster/picture	**0.0%**, 0
My brain/my ideas	**10.8%**, 7	My brain/my ideas	**4.8%**, 4
Not given	**9.2%**, 6	Not given	**6.0%**, 5
Source of Images of STEM Professionals (87)		**Source of Images of STEM Professionals (113)**	
Teacher/school/science class	**28.7%**, 25	Teacher/school/science class	**19.5%**, 22

Parent/relative	**5.7%**, 5	Parent/relative	**5.3%**, 6
TV	**5.7%**, 5	TV	**12.4%**, 14
Film/movie	**0.0%**, 0	Film/movie	**2.7%**, 3
Video/YouTube	**3.4%**, 3	Video/YouTube	**0.9%**, 1
Internet/Google/online	**24.1%**, 21	Internet/Google/online	**15.0%**, 17
Book/textbook	**18.4%**, 16	Book/textbook	**9.7%**, 11
Keynote address	**1.1%**, 1	Keynote address	**11.5%**, 13
This ISL event	**0.0%**, 0	This ISL event	**13.3%**, 15
List other	**6.9%**, 6	List other	**3.5%**, 4
Famous scientist	**1.1%**, 1	Famous scientist	**0.9%**, 1
Magazine	**1.1%**, 1	Magazine	**0.0%**, 0
Poster/picture	**1.1%**, 1	Poster/picture	**2.7%**, 3
My brain/my ideas	**0.0%**, 0	My brain/my ideas	**0.0%**, 0
Not given	**2.3%**, 2	Not given	**2.7%**, 3

Note. This table presents descriptions of DAST drawings given by participants in written responses describing their drawings. *More than one response could be provided.

H1a predicted a decrease in gender stereotyping in DAST drawings following the intervention. Findings supported H1. Participants drew more women than men STEM professionals in both the pretest (72.4% women, 20.6% men) and the post-test (88.1% women and 6.8% men), with an increase (15.7%) in the percentage of women represented in post-test drawings (Table 1). A McNemar test was conducted to analyze whether the gender[1] distribution of DAST images changed following the intervention. McNemar's test allows for analysis of two-category nominal variables in a repeated measure design[1]. Results of the McNemar test indicated that there was a statistically different distribution of gender pre- and post-intervention, $p<.05$.

DAST drawings by many participants reflected this decrease in gender stereotyping. As indicated the drawings presented in Figure 2, pre-test drawings of STEM professionals that depicted iconic images of scientists from history or popular culture (i.e. Albert Einstein and Bill Nye), while post-test DAST drawings reflected more images of women as STEM professionals. For example, one participant drew an image of Albert Einstein during the pre-test and an image of Jane Goodall during the post-test. Similarly, another participant drew an image of Bill Nye the Science Guy during the pre-test and an image of a girl in the post-test, indicating in the written description that this change was the result of the interactive presentation delivered during the first phase of the intervention. It is important to note that images of Albert Einstein, Bill Nye, and Jane Goodall were shown and discussed during the interactive presentation challenging media stereotypes of STEM professionals.

[1] Gender was dichotomized and effect coded as men, neither or none, both, and not given (-1) and women (1).

Pre-test DAST Drawings	Post-test DAST Drawings

Figure 2: *Pre-test and Post-test DAST Drawings Indicating Gender Stereotype Change*

H2 predicted adolescent girls' *knowledge of STEM careers* would increase following participation in this informal STEM education program. Increased knowledge was assessed by considering whether participants depicted a greater range of careers for STEM professionals in their drawings. Consistent with Hypothesis 2, participants' *knowledge of STEM careers* increased following participation in this informal STEM education program. As noted in Figure 3, a greater array of STEM careers was noted by participants following the informal STEM education program. Prior to the intervention, the most frequently reported STEM job was that of a scientist or STEM professional, in general (36.2%), which was much less likely a response after the intervention (6.9%) with more participants listing several other distinct STEM disciplines (Table 1). A McNemar test also showed that participants were significantly less likely to draw general STEM scientists[2], and more likely to draw specific types of scientists after the intervention, *p*<.001. Finally, a McNemar test showed that the distribution of STEM disciplines focused on the various activities (biology, medicine/pharmacology, engineering, and technology/robots[3]) was significantly higher after the intervention, *p*<.001.

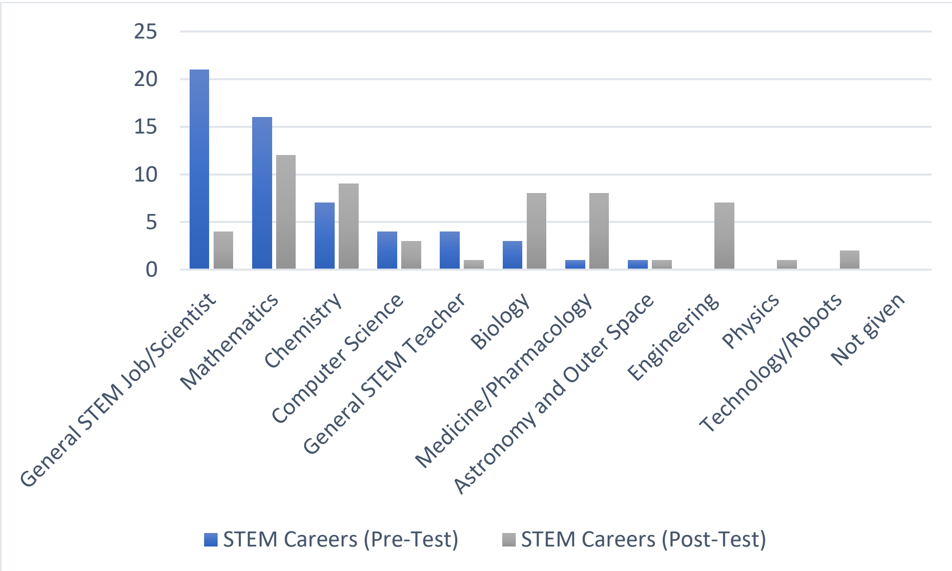
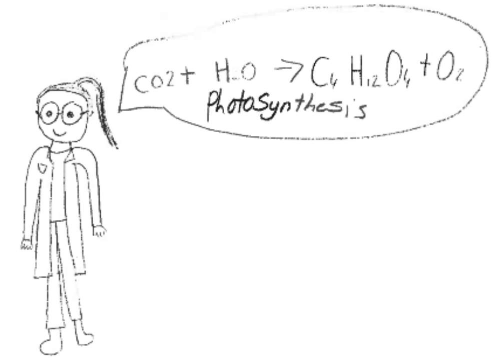
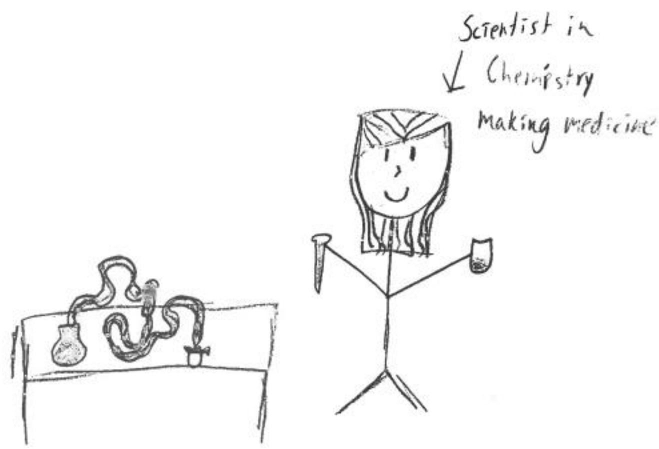
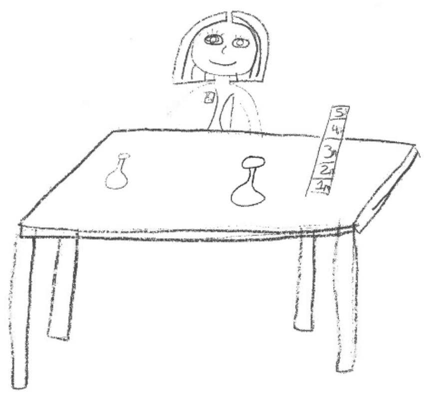


Figure 3: *STEM Careers Depicted in Pre- and Post-test DAST Drawings*

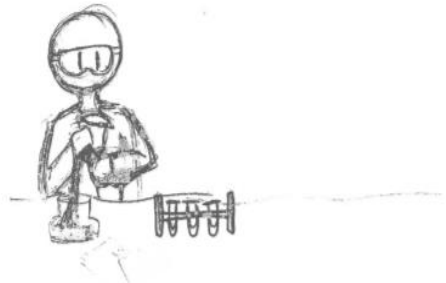
Following the intervention, participants drew STEM professionals representing a greater array of STEM disciplines, including some of the STEM disciplines (biology, chemistry, engineering, medicine/pharmacology) featured in and discussed during the inquiry-based STEM learning activities that were a part of this program (Figure 4). This finding indicates that participants' overall *knowledge of STEM disciplines* changed following participation in this intervention, with several post-test DAST drawings replicating activities and scenes from the inquiry-based STEM activities. Several participants also referred specifically to influences from the day's activities (interactive presentation, inquiry-based activities, posters) in written descriptions of their drawings.

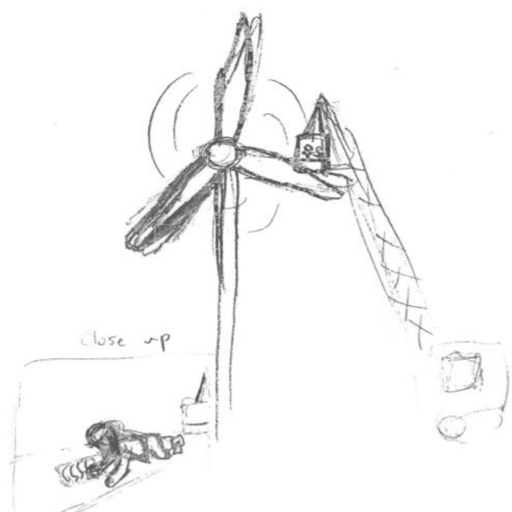
[2] STEM discipline was dichotomized and effect coded as astronomy, biology, chemistry, engineering, medicine, computer science, physics, math, general STEM teacher, technology/robots, and not given (-1) and General STEM job/scientist (1).
[3] STEM discipline was dichotomized and effect coded as disciplines not focused on in the intervention (astronomy, chemistry, computer science, physics, mathematics, general STEM job, general STEM teacher, not given) (-1) and disciplines of focus in the intervention (biology, medicine/pharmacology, engineering, and technology/robots) (1).

Pre-test DAST Drawings	**Post-test DAST Drawings**
 **Chemist**	 **Robotics Professional**
 **Mathematician**	 **Pharmacologist**
 **Chemist**	 **Vaccine Developer**



Chemist **Taste Tester/STEM Professional**





Chemist **Engineer/Wind Turbine**

Figure 4: *Pre-test and Post-test DAST Drawings Indicating Increased Knowledge of STEM Careers*

RQ1 considered the participants' self-reported *sources of information about STEM professionals*. Results from written responses about the sources of information for their *pre-test DAST drawings* indicated that the most popular sources were teachers/school/science classes (27.7%), media (TV, film/movie, video/YouTube) (7.6%), and books/textbooks (6.2%) and for their post-test DAST drawings were the activities for the informal STEM education program (interactive presentation/keynote address, hands-on activities) (50.7%), teachers/school/science classes (12.0%), and books/textbooks (6.0%). Slightly over half of all participants indicated the intervention provided information that inspired their *post-test drawings* of STEM professionals (Table 1). Results from participants' written responses about the sources of information for their images or views of STEM professionals, in general, indicated that the most popular sources were teachers/school/science classes (28.7%), Internet/Google/online information (24.1%), and books/textbooks (18.4%) and for their post-test DAST drawings were the informal STEM education program (interactive presentation/keynote address, hands-on activities) (24.8%), teachers/school/science classes (19.5%), and media (TV, film/movie, video/YouTube) (16.0%).

Observations by the first author provided additional information about interactions with STEM role models during the event. In addition to the STEM role models (primarily women) participants interacted with during the inquiry-based STEM experiments and demonstrations, participants also interacted with guides who were near-peer, high school-aged young women who attended the math and science center. The setting for this event conveyed positive images and messages about women in STEM, highlighting women's contributions to STEM and celebrating women's accomplishments in STEM in several ways. First, the event was held in a math and science center, known regionally for its excellence in STEM education. Second, girls had access to well-equipped laboratories and classrooms at the math and science center and were encouraged to take part in STEM experiments and demonstrations. Third, in the hallways, girls passed by STEM-related displays, aquariums, pennants celebrating the universities and colleges the math and science center alumna have attended, and posters of prominent women STEM professionals of diverse racial and ethnic backgrounds who worked in diverse STEM disciplines.

DISCUSSION

Findings from this exploratory study of an informal STEM education program that included an interactive presentation of gender-STEM-stereotypes in popular media and participation in inquiry-based STEM learning activities indicated its efficacy in decreasing gender-STEM-stereotypes. Both quantitative and qualitative data provided evidence of positive changes in adolescent girls' perceptions of women as STEM professionals. Specifically, participation in this program produced significant increases in adolescent girls' drawings of women STEM professionals from pre-test to post-test, with drawings often reflecting specific images of women STEM media role models shown during the interactive presentation or images of women STEM role models who led STEM activities and demonstrations during this outreach program. In addition, adolescent girls' written descriptions of their drawings often mentioned the influence of this program as they reiterated themes addressed during the program and referred to specific women STEM media role models. These findings were similar to those from other studies that examined the efficacy of interventions featuring real-life women STEM role models (Barakat, 2022; Merritt et al., 2021; O'Brien et al., 2017). The present study also highlighted the effective use of the DAST as a way to assess changes in gender-STEM-stereotypes from STEM interventions. Other studies have highlighted the usefulness of the DAST. For example, one study also found changes in the gender of STEM professionals in DAST drawings by students who participated in a STEM intervention, noting an increase in percentage of women drawn from pre-test (4%) to post-test (33%), a decrease in percentage of men drawn from pre-test (44%) to post-test (22%), and an increase in the number of both women and men drawn from pre-test (4%) to post-test (26%) (Cakmakci et al., 2011).

Differences in the breadth of STEM disciplines represented in adolescent girls' post-test DAST drawings indicated in the present study suggest increases in knowledge of STEM disciplines derived from adolescent girls' participation in the inquiry-based science activities. Further, some of the adolescent girls' written descriptions of their drawings specifically mentioned the influence of these activities. These findings support extant research that has found authentic science learning activities effective for in promoting STEM self-efficacy and STEM identity for early adolescent girls (Aschbacher et al., 2014; Reilly, McGivney , Dede, & Grotzer, 2021) and adolescent students (Aschbacher, Li, & Roth, 2010).

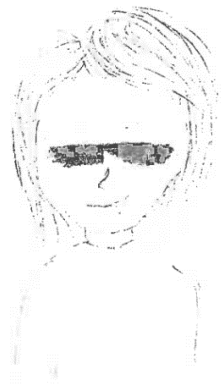
These findings build important connections between the two theories that frame this research. Collectively, these findings are consistent with social cognitive theory in predicting media model influence. As described by social cognitive theory, this study demonstrated the potential influence of "symbolic communication" (Bandura, 2001) by media models and their impact on perceptions, indicating that gendered stereotypes of STEM media models make "salient 'us and them' distinctions" (Hornsey, 2008 p. 206) that can influence the way adolescent girls view STEM professionals (Hornsey, 2008) as well as themselves as potential scientists. As one researcher explained: "The idea behind asking a child to create a picture of a scientist (i.e., the Draw-A Scientist Test) is so that others can externally see how a student may be making sense of the conception of the term 'scientist.' In short, their personal science identity is revealed through the pictures they draw of scientists" (Farland-Smith, 2012, p. 3). Importantly, this study's findings suggest that young adolescents can modify their extant gender stereotypes through observational learning from media role models that are presented as counter-stereotypical and alternative exemplars. Consistent with social identity theory, this study's findings illustrate how media images signal "ingroup" and "outgroup" affiliations for young adolescents through depictions of who is represented as a STEM professional and depicted in STEM careers. Findings from this study suggest that interactions that feature positive ingroup role models, through exposure to media and real-life ingroup role models, can be influential in encouraging ingroup connections. Overall, this study highlights the need to apply theory when considering the best design for ISL programs.

Findings from this study suggest that both media and real-life women STEM role models were important and influential components of this STEM education program as many of the girls' drawings depicted images of women STEM role models featured as part of this program. Findings support those from prior research that has found role model interventions effective in challenging gender-STEM-stereotypes (Barakat, 2022; Buckley et al., 2022; Merritt et al., 2021). Collectively, these findings also suggest that specifically addressing gender stereotypes in media portrayals of women in STEM as well as providing interactions with real-life women STEM role models during inquiry-based STEM engagement opportunities are effective in reducing early adolescent girls' gender stereotypes of STEM professionals. Indeed, these interactions with same-gender role models appeared to be important. A meta-analysis of 45 research studies on the influence of ingroup (i.e., same-gender) role models on STEM interest and performance provided additional support for same-gender role models in STEM interventions focused on broadening girls' participation in STEM (Lawner, Camacho, Johnson, & Pan-Weisz, 2019).

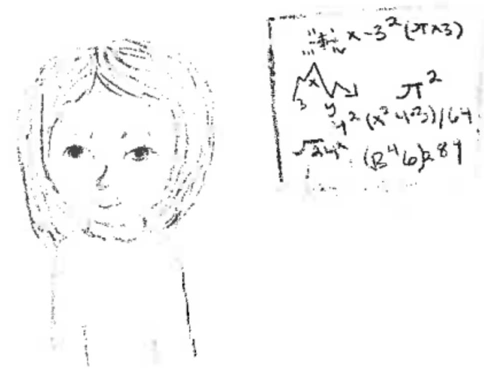
Limitations and Future Research

Findings from the current study should be considered carefully given several limitations. First, this study measured a one-time intervention and changes at only one point in time. While this and other short-term STEM interventions have proved successful (Barakat, 2022; Merritt et al., 2021), future research needs to address the long-term and sustained impact of these observed changes over time. Prior research has noted that "[i]nhibiting stereotype-congruent or prejudice-like responses and intentionally replacing them with nonprejudiced responses can be likened to the breaking of a bad habit" (Devine, 1989, p. 15) and "the attitude and belief change process requires intention, attention, and time" (Devine, 1989, p. 16). Further, "a change in one's beliefs or attitude toward a stereotyped group may or may not be reflected in a change in the corresponding evaluations of or behaviors toward members of that group" (Devine, 1989, p. 15). Thus, it is important to examine interventions that collect longitudinal data over time to assess lasting effects. Second, as is often the case with field studies, the sample size is small and the girls who attended this program were not representative of the larger population. Participants for this study likely represented a group with prior personal interest and/or more teacher and parental support than the general population. While not representative, this group does include girls who show great potential for considering future careers in STEM. Still, future research should increase the sample size and focus on recruiting girls from more diverse backgrounds related to STEM interest, parental and social support, age, race/ethnicity, and geographical location. Third, this study focused on the collective effects of two ISL education program features (interactive presentation, inquiry-based STEM activities). Future research should assess whether the interactive presentation on gender-STEM-stereotypes in popular media and/or participation in inquiry-based STEM activities led primarily by women STEM role models, individually or collectively, was most effective. Fourth, a greater number of features of participants' DAST drawings should be analyzed in future research. Although not the focus of this intervention and study, several DAST drawings from the current study reflected changes related to race and ethnicity (Figure 5) but not age of STEM professionals. In addition, it would be important to consider additional programmatic features that best promote girls' self-identification in DAST drawings. Future experimental research could examine a range of STEM outcomes, including but not limited to STEM self-efficacy, interest, stereotypes, persistence, motivation, and identity. In addition, more in-depth consideration of the STEM context for STEM education and outreach events and their potential effects is needed. Prior research has noted the importance of representational practice in STEM contexts (displays, posters) in promoting STEM identities for students from racial groups historically underrepresented in STEM (Brown, Mangram, Sun, Cross, & Raab, 2017). Despite these limitations, the study provided evidence of effectiveness in ISL for adolescent girls.

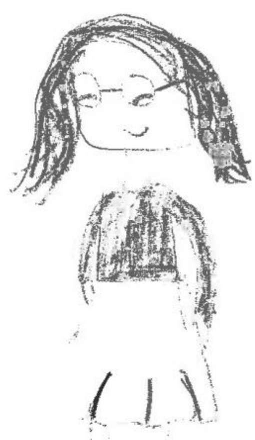
Pre-test DAST Drawings | **Post-test DAST Drawings**



American



Indian American



White

African American
Katherine Johnson from *Hidden Figures*

Figure 5: *Pre-test and Post-test DAST Drawings Indicating Racial and Ethnic Stereotype Change*

CONCLUSION

Overall, findings from this study identified best practices for addressing adolescent girls' stereotypes of STEM professionals and for building their disciplinary knowledge of STEM. This study highlighted a unique ISL experience. Scholars have argued for unique, girls-only, ISL experiences, noting that "[d]iversity in learning experiences allows young people, especially girls, to see possibility for themselves" (Chapman, 2022, p. 172). This study demonstrated the efficacy of a program that integrated three of four strategies identified to promote and sustain adolescent girls' engagement in STEM: messaging, girls-only opportunities, authentic connections, and family involvement (Chapman, 2022). Continued research in this area is important for three reasons. First, ways of involving family members, which was not assessed by the present study, is important to consider (Chapman, 2022) as well as the role of near-peer mentors featured as part of the program. Second, sociocultural factors such as media images need to continue to be examined because early adolescent girls often lack interaction with real-life role models. Adolescent girls' exposure to gender-stereotyped media images of STEM professionals "may be preventing the next generation of potential female scientists from believing they can achieve success in STEM" (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011, p. 661). Third, because prior research found that high-school aged young women perceived authentic STEM learning experiences as valuable and influential on their intent to pursue a STEM-related career (Sasson, 2019), these learning experiences need to be considered carefully. In addition, future research should consider other "identity-relevant" (Steinke, 2017) characteristics of STEM role models, in addition to gender, that might affect early adolescent girls' identification and STEM identity development during ISL experiences. Continued efforts to determine best practices for design of ISL programs are critical for encouraging early adolescent girls to develop more inclusive images of STEM professionals so that, ultimately, they see the possibility of themselves as future STEM professionals.

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APPENDIX 1

Draw-a-Scientist Test (DAST) Codebook

Instructions: Enter number on spreadsheet. based on written comments about DAST Drawing.
PARTICIPANT AGE
Grade Level of Participant
6 6th grade
7 7th grade
99 Not given
PR4GEND/PT4GEND
Gender (#4)
1 Man
2 Woman
3 Neither or none
10 Both
99 Not given
P5RACE/PT5RACE
Race/ethnicity (#5)
1 White
2 African American or Black
3 Hispanic/Latina
4 Native American Scientists
5 Asian or Asian American/Indian
6 Any race or ethnicity
7 No specific race or ethnicity
99 Not given
PR6AGE/PT6AGE
Age of STEM Professional (#6)
1 teenager (middle-school or high school- aged)
2 young adult/college aged (age 18-29)
3 middle age adult (age 30-50)
4 older adult (age 50 and up)
5 dead
99 Not given
PR3JOB/PT3JOB
STEM Job/Discipline
1 Astronomy/Outer space
2 Biology
3 Chemistry
4 Engineering
5 Medicine/Pharmacology
6 Computer Science
7 Physics
8 Mathematics
9 General STEM job/Scientist
10 General STEM teacher
11 Technology/Robots
99 Not given
PR7IDEAS/PT7IDEAS
Ideas for Drawing (#7) (more than one may be selected).
1 teacher/school/science class

2 parent/relative
3 TV
4 film/movie
5 video/YouTube
6 Internet/Google/online
7 book/textbook
8 Keynote address
9 workshop/demonstration from this ISL event (post-test only)
10 list other _________________
11 famous scientist
12 magazine
13 poster/ picture (in general)
14 my brain, my ideas
99 Not given

PR8IMAGES/PT8IMAGES
Source of Images of STEM Professionals (#8) (more than one may be selected).
1 teacher/school/science class
2 parent/relative
3 TV
4 film/movie
5 video/YouTube
6 Internet/Google/online
7 book/textbook
8 Keynote address
9 workshop/demonstration from this ISL event (post-test only)
10 list other ____________________
11 famous scientist
12 magazine
13 poster/picture (in general)
14 my brain, my ideas
99 Not given