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The Single Sex Debate for Girls in Science: a Comparison Between Two Informal Science Programs on Middle School Students' STEM Identity Formation

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Abstract Currently, there are policy debates regarding the efficacy and legality of single sex formal and informal education programs. This issue is particularly poignant in science education due to the historical marginalization of women in these fields. This marginalization has resulted in women being positioned as a stigmatized group within many science, technology, engineering, and mathematics (STEM) related fields. Research points to adolescence as the age where this sense of marginalization begins to develop. As a result, policy responses have utilized various frameworks such as: increased access for women, changing pedagogy to address women's learning styles, changing the language and culture of science to prevent marginalization of stigmatized groups, and finally exploring the role that individual identity plays in the marginalization of women. This study adds to the policy debate as it applies to single sex education by comparing middle school participants' STEM identity formation during two informal science learning environments (an all girls' STEM camp and a co-educational STEM camp). Additionally, this study focuses on the influence of camp activities within two informal science education programs: particularly the provision of role models and authentic STEM research activities, as means to improve STEM identity and make these fields relevant to the lives of middle school students. The results indicate that both camps improved girls' STEM identities. These findings suggest that the single sex environment is not as important to STEM identity as the pedagogy used within the program.

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Introduction

Over the last 50 years, the issue of girls' and women's underrepresentation in science, technology, engineering, and mathematics (STEM) fields has been a major focus for science educators. Historically, women were discouraged from pursuing STEM fields due to gender bias perpetuated within the STEM culture and institutionalized sexism within K-12 and higher education (Anderson 1995; Calabrese Barton 1997; McGrayne 2005). The Second Wave Feminist movement of the 1960s helped to make the public aware of the existing cultural and institutionalized gender bias that prevented women from competing with men in many career fields—including STEM (Anderson 1995). In the USA, this awareness eventually resulted in the passage of the Educational Amendment Act (Title IX) in 1972. Title IX aimed to prevent sexual harassment and gender inequities by holding American federally funded programs, such as universities and public schools, accountable by law (Salomone 2003). Although this policy has primarily been used in women's sports (i.e., helping women gain more access and opportunities to athletics), in recent decades it has also been used to increase women's access and opportunities within U.S. STEM departments and programs in an effort to improve women's underrepresentation (Brotman and Moore 2008). Although increased access to STEM programs provides momentum for gender parity, many feminists and science educators argue that simply opening access does not address the underlying culture of STEM that continues to marginalize women and girls (Bianchini et al. 2000; Brickhouse et al. 2000; Brotman and Moore 2008; Burkam et al. 1997; Calabrese Barton 1997; Carlone 2004; Jones et al. 2000; Lee and Burkam 1996; Zohar and Bronshtein 2005).

While debates regarding women's access to STEM have occurred at all educational levels (AAUW 2010), this study will focus on middle school age students—10 to 15 years of age. Research shows that middle school is the age during which students, in particular girls, begin to lose interest in science and mathematics (AAUW 2010). It is also during the middle school years that the gender gap begins in terms of standardized STEM test scores and STEM course taking (AAUW 2010; Spielhagen 2008). Educators and policy makers argue that keeping girls interested in STEM at this age is important for improving their overall persistence in STEM at the college and career level (AAUW 2010; Spielhagen 2008). However, while it is known that middle school is a crucial age for keeping girls interested and engaged in STEM, there is still no consensus as to the best way to do this.

One proposed solution is to improve students' STEM identity—their ability to see themselves as the kind of people who could be legitimate participants in STEM through their interest, abilities, race, gender, and culture (Brickhouse et al. 2000; Carlone and Johnson 2007; Ong et al. 2011; Polman and Miller 2010). This focus on STEM identity has developed because of its link to STEM persistence. Two of the prominent researchers in the field of STEM identity are Carlone and Johnson. These authors define STEM identity as the concept of fitting in within STEM fields, specifically, the way individuals make "meaning of science experiences and how society structures possible meanings" (Carlone and Johnson 2007, p. 1187). Consequently, STEM identity involves an individual making personal meanings associated with their identity along with the cultural impact of social meanings on these various identities.

Scientists and informal educators argue that STEM identity cannot be fully developed unless students have opportunities to observe and participate in authentic research with scientists, often referred to as apprenticeship (Barab and Hay 2001; Bell et al. 2003; Lave and Wenger 1991; Sadler et al. 2010; Wenger 1998). According to Sadler and colleagues, true apprenticeship programs should have learners working with expert mentors in authentic contexts over an extended period of time. Because of this time necessity, some programs that have been described as apprenticeship may fall under the category of quasi-apprenticeship in that they provide learners with authentic experiences to work with mentors; however, they occur over a very short time frame (e.g., 2 weeks) which can affect the impact of the results. Studies have demonstrated mixed results as to the benefits of author defined apprenticeship programs for middle and high school students, with the results dependent on the types of outcomes measured and length of time of the program (Barab and Hay 2001; Bell et al. 2003).

Bell and colleagues measured changes in views of science for high school students participating in an 8-week apprenticeship program and found that this particular apprenticeship program did not affect the participating students' understanding of the nature of science (NOS) unless these concepts were discussed explicitly. Barab and Hay (2001) focused on a 2-week long summer camp, which they found was too short a time for students to fully experience apprenticeship; yet, they did see observable changes in students' understanding of the NOS over this period, which is a very different result than Barab and Hay's study. Polman and Miller (2010) conducted a qualitative study that focused on the effects of a science apprenticeship program on African American middle school students' STEM identity trajectories during an 8-week program. The authors concluded that the program had a positive impact on student identity trajectories over their summer experience because the program served as a mediator between past and future identities. These three studies show that different programs have differing results on the concepts being measured (e.g., NOS or identity).

Polman and Miller's study focused on the added issues of race and ethnicity on STEM identity development. Many STEM careers are still perceived as predominantly white and male; as a result, girls and students of color are still struggling to see themselves as potential STEM professionals (National Science Foundation 2011). Polman and Miller's study, like others, discussed the issues that girls and students of color face due to their gender and/or race and ethnicity—all of which affect their ability to fully identify with STEM fields (Brickhouse et al. 2000; Carlone and Johnson 2007; Ong et al. 2011; Polman and Miller 2010). These studies, despite the conflicting results, point to the important role that informal education can have on STEM identity and students' persistence in STEM.

A key addition to the literature on girls' persistence in STEM and STEM identity was completed by Brotman and Moore (2008). In their article, the authors discussed how historical trends in STEM education research related to the underrepresentation of girls and women in STEM have mirrored feminist theories emerging during the same time period. The authors reviewed over 100 articles on girls' engagement in science from 1995 to 2006 and developed four themes: (1) equity and access—articles that advocated access and more equitable policies and practices to improve girls engagement in science; (2) curriculum and pedagogy— articles that concluded girls' engagement in science can only be improved with changes to curriculum and pedagogy that recognize the "experiences, learning styles, and interests of girls" or gender inclusive education foci (p. 974); (3) nature and culture of science—articles that advocated a change in how science is perceived and defined in the larger society as well as in schools; and (4) identity—articles that advocated the need for opportunities and studies that focus on helping girls identify with science.

Brotman and Moore found that the focus from 1995 to 2006 moved from equity/access to identity over time. This change in focus over time coincided with the broader feminist lenses that were being put forward over this time period as well (see also Calabrese Barton 1997; Harding 1997). Equity and access were the major points of the liberal and second wave feminist movements. Equity policies aimed to improve women's access to STEM opportunities but did not challenge the underlying practices of STEM that were preventing women from persisting. In the late 1970s, feminists began to focus on gender differences that result in different ways of knowing, but this did not become a major part of STEM education literature until the 1990s (Harding 1997). This change in focus highlighted how access policies continued to prevent women—who could not align their world view with the androgynous or masculine culture within STEM—from becoming legitimate members of this culture. Hence, the curriculum and pedagogy of STEM needed to be changed to address women and girls' underrepresentation. As response to the changes in curriculum and pedagogy, Third Wave Feminists (including multiracial feminists) emphasized the need to explore the intersections between race, class, gender, ethnicity, and sexual orientation. These expansions of feminist theory resulted in political action and calls for change through challenges to the status quo (Brotman and Moore 2008; Zinn and Dill 1996). Challenging the STEM status quo was further supported by post-structural feminism which questioned the previously held beliefs that STEM was based on objective, rational, truths (Brotman and Moore 2008; Calabrese Barton 1997).

This evolution of feminist theories and their use in STEM education research show where the literature and research currently exist. The current focus on identity highlights the need to unpack assumptions made by access policies which assume all girls and women have the same experience in all STEM fields. The latter feminist theories showed that girls and women have unique experiences and trajectories within STEM based on their gender, ethnicity, race, socioeconomic status, and overall identity. These unique trajectories allow some individuals to feel that they belong in STEM fields dominated by masculine cultures, whereas others are unable to move beyond the periphery of these fields. Consequently, these ideas regarding gender and its role in the culture of STEM have affected both educators' and policymakers' ideas about the best ways to address women's underrepresentation in STEM fields.

Single Sex[1] Schools: a Policy Debate

As the theories driving studies of women's underrepresentation in STEM have begun to focus on identity and its role in the culture of STEM, policy responses have tended to remain in the access and equity realm. In the last 15 years, single sex STEM education programs have become a prominent policy response to women's historical lack of access to many STEM fields (Salomone 2003). Many of these programs emphasize the empowerment of girls by focusing on math and science. However, most of these single sex programs in the USA have met with protests and legal action by the American Civil Liberties Union and the National Organization of Women (AAUW 2009; Gandy 2006; Salomone 2003). These organizations cite that single sex programs are purely discriminatory in their separate but equal status because they are rarely equal. These organizations also argue that single sex programs do not prepare students to function in the real world, they reinforce stereotypes and discrimination, and are a violation of the *Brown vs. Board of Education* Supreme Court decision (Salomone 2003).

[1] The authors chose to use the term sex for this type of schooling because assignment into these is based on biological sex and does not take into account the more complex and social issue of gender.

Despite these protests, informal educators have promoted single sex programs as a response to the gender gap regarding girls' persistence in STEM. Informal education offers an opportunity to expose students to authentic STEM research—whether through observation of scientists at work or actual opportunities to work with STEM professionals in some form. Directors of such programs and science education researchers argue that school science can reproduce stereotypes through science teaching, pedagogical techniques, topics, or simply through the teacher's own personality (Carlone 2004; Gilmartin et al. 2007). Often students who are competent in science still struggle in their ability to identify with science because they cannot find connections to their lives and goals. This inability to fully identify with science—whether because of sex, race, ethnicity, or overall relevance—prevents many students from pursuing STEM careers. This is often compounded by the lack of personal relationships that students have with science in the typical science classroom setting (Kozoll and Osborne 2004).

The debate surrounding the legality of single sex formal and informal education programs has coincided with a call for more research on their efficacy. The results of formal (Bracey 2006; Halpern et al. 2011; Mael et al. 2005; Salomone 2003) and informal (Aschbacher et al. 2010; Demetry et al. 2009; Fadigan and Hammrich 2004; Jayaratne et al. 2003) education studies have been mixed. Reviews of these studies have indicated that it is difficult to do pure scientific studies in educational settings because random assignment is often unethical (Darke et al. 2002). Furthermore, it is difficult to link the effects of single or coeducational programs to student achievement, interest, or confidence. Additionally, the complexity of measuring these factors highlights the multiple and diverse variables that are measured by each study (Bracey 2006; Halpern et al. 2011; Mael et al. 2005; Salomone 2003). Research results have been mixed mainly because studies are based on single programs that are highly contextualized: different programs focus on different outputs, and participants self-select into these programs (see the discussion of Barab and Hay (2001) and Bell et al.'s (2003) studies earlier). It is "hard to determine whether students fare better in these programs because of the single sex environment itself or because of some other elements thrown into the mix" (Salomone 2003, location 2904).

Despite the contentious debate and mixed effects, single sex programs have increased at both the K-12 level and the higher education levels (Spielhagen 2008). The mixed results on informal education programs aimed at increasing students' interest and ability to identify with STEM fields indicate a need for more research. This study is grounded in current research that discusses the important impact of STEM identity, particularly for marginalized students, on STEM persistence (Buck et al. 2007; Brickhouse et al. 2000; Painter et al. 2006).

The informal education programs in this study focus on three aspects of STEM identity: STEM interest, science and math self-concept, and the influence of role models on perceptions of STEM professionals. For our study, we differentiated between self-efficacy, which is considered task specific, and self-concept, which is considered domain specific (Rittmayer and Beier 2009). Our study utilizes the idea of self-concept over self-efficacy because we are focusing on students' evaluations of their ability in an overall domain not on a specific task (Hence, we will reference self-concept throughout.) This study also adds to the debate in science education policy in an important way by comparing the effects of two informal science programs (one a single sex setting and the other a co-educational setting) on participants' STEM identity.

Both camps exposed middle school students to STEM fields during the summer of 2010. One camp was a co-educational STEM camp (Cultivating Opportunities in Engineering

Disciplines—COED[2]) and the other was an all-girls STEM camp (Getting Involved in Research and Learning in Science—GIRLS). The COED camp has been running since 2009, and the GIRLS camp has been running since 2006. The Director of Educational Programming at the National Lab where these camps took place is the director of both camps. Her goals for both camps are to expose students to careers in STEM and provide them with authentic experiences that will inform their decisions about STEM careers (personal communication with the Director, August 12, 2010). These two camps were chosen for comparison because they occurred at the same location with two of the same teachers (acting as participant observers in both camps). The camp participants had similar ranges in age, science and math abilities, and science and math interest as measured by survey instruments. Both camps exposed participants to local STEM professionals and their careers through authentic research activities, presentations by STEM professionals on their research, and tours of local facilities. The goal of the study was to answer the following research question: How does a single sex program compare to a co-educational program in its effects on students' STEM identity as measured through STEM interest, science and math self-concept, and perceptions of STEM professionals?

Conceptual Framework

For this study, we defined STEM identity according to three key areas: (1) interest in STEM and STEM careers (Eccles 2007; Hazari et al. 2010; Gilmartin et al. 2007); (2) self-concept as it relates to STEM domains (Eccles 2007; Hazari et al. 2010; Rittmayer and Beier 2009); and (3) the influence of role models on students' perceptions of STEM professionals (Aschbacher et al. 2010; Eccles 2007; Fadigan and Hammrich 2004; Gilmartin et al. 2007). Research demonstrates that when all three of these concepts occur in a positive way, there is a strong potential for students to develop a positive STEM identity. A person will be less likely to develop a sense that they fit in with STEM fields and a desire to pursue these fields without: a positive interest in STEM, a sense that they can succeed in these fields, and a positive view of STEM professionals (typically developed through exposure to role models). For underrepresented groups in these fields, the added component of role models is even more important in that these individuals need to see that there are people like them persisting in STEM.

Gilmartin et al. (2007) defined a positive science identity as "a combination of students' self-perceptions and interest in science and science related work" wherein students see themselves as individuals who enjoy science, find it relevant to their lives, feel confident in their science abilities, and want to have a career in science (p 982). Eccles' has found that intrinsic interest has a major impact on individuals' persistence in careers, particularly STEM careers (Eccles 2007). According to Eccles', this interest combines with one's career goals and the perceived value of that career in comparison to the cost of said career. Individuals will compare these values with their expectations of success in the given field and their sense that they are the type of person who can succeed in these fields to determine whether a STEM career is a legitimate option.

A person's expectation of success relates to self-concept in that one would need to believe that they have strong abilities in a particular domain in order to believe that they can be successful in that domain/career. Consequently, interest in STEM and STEM identity development are also affected by one's perception of his/her abilities in the domain of math

[2] Pseudonyms have been used for both camps and any names mentioned for participants.

and science—or self-concept. Research has shown that an individual's self-concept evolves depending on individual assessment based on various achievements and recognition from others including teachers, peers, and other socializers (Aschbacher et al. 2010; Eccles 2007). Researchers have found that self-concept affects individuals' long-term goals in that if they have a high self-concept in a domain they will be able to see that a failure in one task does not indicate an inability to achieve their long-term goal (Eccles 2007; Rittmayer and Beier 2009; Williams and Ceci 2007).

Finally, the third influence on STEM identity that we will discuss is the influence of role models on students' perceptions of STEM professionals. Socializing agents, including parents and teachers, play a role in students' STEM identity by supporting, encouraging, and/or exposing young people to STEM fields and careers (Aschbacher et al. 2010; Eccles 2007). Studies also show that having a parent who works in a STEM field can positively impact children's interest and persistence in STEM (Eccles 2007). But for those students who are underrepresented in STEM—whether through sex, race, or ethnicity—exposure to role models is difficult. According to Aschbacher et al. (2010), STEM identity is affected by the cultural and historical view of STEM as white, middle class, and male. This view affects the role of gender, ethnicity, and economic background on students' decisions to persist in STEM fields. Aschbacher and her colleagues found that those students who had support at school (teachers and courses), encouragement from family, and exposure to STEM role models tended to persist. In regard to role models, researchers advocate the use of informal science programs to provide opportunities for students to meet STEM professionals and learn about STEM careers (Fadigan and Hammrich 2004). Research shows that by interacting with STEM professionals and trying on those identities, students can better decide whether their own identities can and do fit within STEM (Buck et al. 2007).

This conceptual framework describes the three main constructs that affect STEM identity and eventually, persistence in STEM. This framework also highlights the added complexity that underrepresented minorities have in STEM fields. Studies show that students often see STEM fields as predominantly white, male, and middle class (Anderson 1995; Calabrese Barton 1997; McGrayne 2005). Consequently, girls, students of color, and those from lower socioeconomic households struggle in terms of overcoming this perception to see themselves as the type of people who can succeed and participate legitimately in STEM fields (AAUW 2010; Calabrese Barton 1997; Carlone 2004; Jones et al. 2000). These additional hindrances to the development of a positive STEM identity explain why simply providing access to these students does not always lead to improved persistence. This study focuses on girls who participated in one of two informal STEM camps to see what effect exposure to role models and their research—through hands-on authentic STEM activities—has on their STEM interest, self-concept, and views of STEM careers, which subsequently affects their overall ability to see themselves as the types of people who fit in with STEM.

Methodology

Camps

Both camps (GIRLS and COED) were housed within a national laboratory facility that specializes in high magnetic field research. Both camps were organized so that participants would be exposed to authentic STEM research, STEM activities that were relevant to their lives, and STEM professionals who could talk about their work and serve as possible role models. These activities and their relevance to STEM identity can be found in Tables 1 and 2. Both camps

Table 1 Coeducational camp activities COED

Day	Activities
1	1. Tour of facilities at National Lab, led by Director of Facilities (male—non-scientist).
	2. Introduction to renewable energy resources (male camp teachers).
	3. Introduction to daily challenge: Participants were broken into four groups wherein they competed to see who conserved the most energy at camp and at home (i.e., turning off water and lights when not in use, recycling, etc.). This occurred each day in the last 30 minutes of the camp (male camp teachers).
2	1. Introduction to electricity by teachers. Then worked in teams to construct wind turbines utilizing electricity concepts previously discussed (male camp teachers).
	2. Tour of nearby science museum: Participants saw an exhibit on the history of computers and arcade games and were able to play with some of the games (female non-scientist tour guide). Then, they participated in a hands-on activity where they learned about local marine life and the effects of energy uses (such as gas, coal plants, etc.) on their ecosystem (female science teacher).
	3. Daily challenge competition.
3	1. Toured local engineering facility that is a combined partnership between the US Military and the local universities. The participants learned about the projects that the engineers and scientists were working on (all male scientists/engineers). Worked in small groups to create electric motors using Lenz's Law. Background science information was presented by three undergraduate participants (male scientists) and assisted by camp teachers (two male teachers).
	2. Tour of local power plant where the head engineer discussed the varying eco-friendly ways in which the power plant is trying to address local energy needs (female engineer).
	3. Daily challenge competition.
4	1. Tour of local hydroelectric power plant. Participants watched a movie describing the role of the man-made damn on local waterways and the efficacy of hydroelectric power (male engineer).
	2. Daily challenge competition.
5	1. Tour of local electronics recycle center. Participants were able to see the sheer mass of items often considered un-recyclable. Learned the process of recycling various electronics and the economic/environmental benefits of electronic recycling to the local area (female engineer).
	2. Final daily challenge competition during which awards were given to the teams who had conserved the most energy.

accepted participants who are marginalized within many STEM fields whether by their sex, race/ethnicity, or economic background (NSF 2011). The single sex camp (GIRLS) focused entirely on girls, who often battle the multiple identity conflicts among gender, STEM, and their own cultural background (Brickhouse et al. 2000; Brickhouse and Potter 2001). The coeducational camp (COED) focused on applicants from Title I schools,[3] particularly participants of color who also struggle with identity conflicts based on race/ethnicity, socioeconomic status, and gender. The tables below describe each of the daily activities in the camp.

The two camps met daily beginning at 9 am and ending at 4 pm. The COED camp was 1 week long, while the GIRLS camp lasted 2 weeks. The participants chose to attend these camps because of their prior interest in STEM. For the GIRLS' participants, there was the added component that they chose to attend a single sex camp. Campers in both camps expressed an interest in STEM as part of their application. Therefore, we note the self-selection aspect of both camps. The camp activities attempted to increase this initial STEM interest by exposing students to STEM research and professionals. The activities for both camps (see Table 1 and Table 2) included authentic research opportunities designed by STEM professionals (such as

[3] Title I schools refers to a program that is part of the United States Elementary and Secondary Education Act that distributes funding to schools and school districts with at least 40 % of the student population from low income families (family of four earning less than $45,000 annually as defined by the US Census Bureau).

Table 2 Single sex camp activities—GIRLS

Day	Activities
1	1. Tour of national laboratory facility where camp is housed. Tour guides included teachers and another educator familiar with laboratory (female and male teachers).
	2. Water testing. The participants learn about the effects of pollutants on local waterways and the role of observation in research. They then test the pond behind laboratory and record data and discuss why these results could be this way (female teachers).
2	1. Two representatives from the state Environmental Protection Agency and one representative from a local engineering firm, specializing in water testing, led the girls on a hike on local trails. They discussed the ecosystem, the role of water, the type of waterways. The girls then tested the water at two locations. Discussed the ecosystem and its role in their data (1 male scientist, one female scientist, 1 female science graduate participant, 4 female teachers).
	2. Tour of local waterway and ecosystem by marine biologist (female scientist)
3	1. Toured local animal shelter. The veterinarian took participants on tour, had them watch and assist in a spay surgery, during which she explained the importance of such processes, learned about various diseases that affect animals within pets and larger local ecosystems, and observed parasites under a microscope. At the end, the veterinarian explained her life history as it relates to science and answered participants' questions (female veterinarian and female veterinarian technician staff).
4	1. Toured local organic farm to learn about the role of pesticides on produce and how organic farms attempt to fit in with the local ecosystem. Discussed sustainability in organic farming and the science behind organic farming (i.e., soil and water testing, native species versus invasive species; male and female farmer.)
5	1. Visited local marine laboratory facility. The participants learned differences between inference and observation, the role of the moon on the tides, and observed various species under the microscope. Then they snorkeled in a local marine waterway, observed various ecosystems (sea grass, oyster beds).
	1. The older girls also conducted a survey of mole crabs, measuring where they lived along the coast and counting the number of each sex and age. Then spoke with a female marine biologist and did a hands on activity related to her research, testing the best conditions for periwinkle snails to live (female facilitator with background in marine biology).
6	1. Visited a local wolf preserve and learned about the role that science understanding can play in policy changes, like wolves' presence on the endangered species list (owned by a female non-scientist).
7	1. The girls worked in groups to analyze and create a presentation on the water testing data that they had collected throughout the camp. Participants were encouraged to make inferences based on their observations and data regarding the health of the local waterways (female teachers).
8	1. Older girls listened to a presentation and various demonstrations by a female engineer who discussed her work with nanotechnology. After the presentation, the girls constructed nanotubes out of balloons and hula-hoops. In her discussion, the female engineer related nanotechnology to items used by the girls (female engineer).
	2. The younger girls learned about water filtration and the design of man-made structures that would help purify water in local parks. Then, the girls constructed their own filtration systems (three female engineers).
9	1. The girls visited a local quarry where they were able to explore and collect specimens of bone, teeth, fossils, and rocks. At the end of the day, they showed each other what they had found, and the three scientists/engineers explained what it was and how they determined how old these specimens were (female geologist, male engineer, male paleontologist).
10	1. Girls finalized their poster presentations that showed the research activities they had conducted during the camp.

collection of data, designing or constructing STEM-related products) with the facilitation of teachers and scientists, visits to laboratories both at the national laboratory facility and other nearby facilities on the university campus, and presentations by STEM professionals on their research. The campers participated in a variety of activities that were aimed to affect their

STEM identity according to the three categories: STEM interest (by showing participants possible STEM careers and the relevance of these fields to their lives), STEM self-concept (by having participants work on hands-on problem solving activities to practice their STEM abilities and to interact with STEM professionals and have their abilities recognized by experts), and perceptions of STEM professionals through their exposure to possible STEM role models (by meeting STEM professionals and seeing their work and daily jobs). The authors recognize that not all activities addressed all three of these at one time, but we feel that overall both camps addressed these concepts as a whole. Also, the authors recognize that in some instances, negative perceptions could potentially be reinforced, for example, in COED during a tour of one of the facilities there were no female STEM professionals present which could implicitly support participants' perceptions of STEM as male. We will address these issues in more detail in our "Results" section.

The demographics for both camps can be found in Table 3. COED had 27 participants participate in the camp, 13 of whom were female and 14 of whom were male (48 and 52 %, respectively). The GIRLS camp was all female and had 32 participants.

Research Methods

This study was a mixed methods study that utilized: pre/post surveys (with Likert scale and open-ended questions), post-interviews with teachers, select post-interviews with students (the selection will be discussed later in the this section wherein we discuss the qualitative methods in more depth), observations of all camp activities, and student application responses. The surveys were administered through Survey Monkey © (an online survey hosting website, www.surveymonkey.com) so that the answers would immediately be stored in a database. Pre-surveys were administered on the morning of the first day of each camp so that participants would not be influenced by any camp activities. The posttest was given on the afternoon of the final day of each camp. Additionally, all student interviews were conducted on the final day of the program, and teacher interviews were conducted the week after each camp concluded. This was done so that teachers could still remember their observations from the camp but would also have time to reflect on the camp activities.

Table 3 Demographics of each camp

	COED (n=27) (%)	GIRLS (n=32) (%)
School type		
Public	100	78
Private	0	22
Grade student completed before summer 2010		
5th	0	22
6th	11	28
7th	52	25
8th	37	22
9th	0	3
Race/ethnicity		
Asian American	20	9
African American	32	22
Hispanic/Latin(o/a)	16	3
White	32	66

Although there were varying ranges of interests and career goals, all participants entered their respective camps with a general interest in STEM and listed STEM as a career possibility. For this study, participants' level of interest was based on open-ended responses to questions on the application and pre/post-surveys, including: *What is your favorite subject in school? What is your least favorite subject in school? What career are you interested in?* A student would be labeled as having a high interest in STEM if she or he referenced STEM fields and only STEM fields as a response to all of these questions. A student would be labeled as having a low interest in STEM if she or he mentioned science or math as their least favorite subject and mentioned non-STEM careers as one of their career goals. Participants who referenced a STEM career goal along with other non-STEM options and did not mention science and/or math as their least favorite would be labeled as having a medium interest.

The open-ended questions were also used to gauge participants' self-concept. Questions that focused on self-concept on the pre-survey asked participants to *list their average grades in their science and math class in the previous year, whether they had taken honors classes, and how they would rank their abilities in their science and math classes* (above average, average, and below average). The survey also asked them *if they believed that they could be successful in a STEM career and why*. On the post-survey, the participants were asked *what science and math classes they planned to take in the following school year, if they planned to take honors/advanced classes* (a positive response to this indicated a higher self-concept), and *how they would rank their abilities in science and math* (above average, average, or below average). The post-survey also asked *if they saw themselves as able to be successful in a STEM career and why.*

Finally, perceptions of STEM professionals were referenced through pre-survey questions asking participants *if anyone in their family worked in a STEM field and whether they had ever met a STEM professional* (both questions asked participants to describe the STEM field and what these individuals were like). The post-survey asked *if any of the STEM professionals they met during their respective camp could be seen as role models and why*. We also included an open-ended question on the pre- and post-survey that asked participants to *describe scientists and what type of people become scientists*. The responses were coded based on three categories: a positive view, a stereotypical view (i.e., lab coat, test tubes, crazy hair), and a combined stereotypical view AND reference to scientists as male. The authors focused on changes in perceptions of STEM professionals as part of their observation protocols. And the interview participants were asked about their perceptions of STEM professionals.

Our quantitative (four-item Likert scale) surveys were taken with permission from the Assessing Women in Engineering (AWE) website (AWE 2008). We chose to use their measures for STEM interest and self-concept because our literature review utilized the same references that AWE used to develop their surveys and because this organization specializes in the development of assessment tools for underrepresented minorities in STEM, which was also the goal of the camps. Some examples of the STEM interest questions included: *I look forward to science class in school; I like to get science books or science experiments as presents; I like learning how things work*. The pre/post STEM interest scale (four-item Likert scale) was based on a sum total of 14 questions where 56 would be the highest score and 14 the lowest. Students were given this portion of the survey as a pre- and posttest. (See Appendix 1 for the entire list of survey questions.) This quantitative portion helped to triangulate the open-ended questions that sought to identify each student's level of science interest.

The self-concept portion was based on nine questions where the highest score would be 36 and the lowest would be 9 based on the sum total of responses. Some examples of the self-concept survey questions were: *When I see a new math problem I can use what I have learned to solve the problem; In lab activities I can use what I have learned to design a solution; I can get good grades in science; and I can get good grades in math*. A high score in this scale indicated a student who had a high self-efficacy in science and math (See Appendix 1 for list of all questions.)

The middle school surveys on the AWE website are derived from undergraduate surveys that have undergone reliability and validity tests (Personal Communication with AWE Director, August, 2011). However, the middle school surveys have not been administered to enough participants to be declared reliable and valid—this process is currently occurring. As a result, we chose to do our own reliability tests and use the quantitative data as a source of triangulation for the qualitative data. First, we reviewed open-ended questions on the application, pre-survey, and post-survey from all campers plus the interview data from the ten campers to identify participants in the following categories: pre-camp and post-camp levels of STEM interest, self-concept, and exposure to role models. After categorizing each camper's pre- and post-response according to these three categories, we checked each of these codes with their respective quantitative score for the same categories (self-concept and science interest). The qualitative codes matched the quantitative categories in 90 % of the instances. With this triangulation using our qualitative data, we were confident in our decision to use these measures. We also ran an internal consistency reliability analysis on the pre- and post-items for the self-concept category and for the science interest category. The Cronbach's alpha for the pre-self-concept items was .638 and the post was .761. For the pre-science interest items, Cronbach's alpha was .798, and the post was .811. We recognize that the sample size was low (n=53), but these alpha scores are still relatively high demonstrating reliability in the survey categories.

The total scores for each of the quantitative measures were compiled and averaged using SPSS (version 19): Science interest (score range, 14–56) and science and math self-concept (score range, 9–36). The pre- and post-mean scores in each category were compared via paired sample t tests (in SPSS) for each camp and then for each sex to determine whether significant changes occurred for each category. Then, the means were compared via paired sample t tests to determine if there were significant differences between each camp and each sex in regard to the changes in mean scores.

To complement these measures, two of the authors acted as participant observers during both camps. As participant observers, the authors worked as teachers in the camps. Each day they observed camp activities and kept field notes related to participants' interest in STEM fields and activities, and perceptions and views of STEM and STEM professionals. These notes were written in a camp notebook that all campers received so as not to look conspicuous. The authors then transcribed these notes and added observed themes in the form of memos (Creswell 2006). Additionally, the researchers interviewed the camp teachers to check the field note observations with the teachers' observations and triangulate teacher observations with the data collected from the participants focusing on observed changes in STEM interest, self-concept, and the perception of STEM professionals. The teachers were asked what changes they observed in the campers. (See Appendix 2 for full list of interview questions.) These responses were then compared to the authors' observed changes to determine how closely related they were. And finally, these transcribed interviews and observations were compared to the data collected from the students to further support participants' perceived changes.

In addition to these methods mentioned above, the researchers also selected five participants from each camp to interview. These interviews served as qualitative evidence of the influence of the camps on the selected students' STEM identity as measured through STEM interest, STEM self-concept, and perceived influence of exposure to STEM role models. (See Appendix 2 for the interview questions for campers.) The interviews were conducted on the last day of each camp. The participants were selected based on their ranges within the following criteria: sex (if applicable), STEM self-concept, parental education, and STEM role model exposure. Each student's category level was determined based on pre-survey data and observations during the camp (We tried to select students who represented the lowest, average, and highest scores in self-concept). The authors purposely selected more participants of color to focus on the issues that underrepresented groups face in terms of STEM identity (Aschbacher et al. 2010; Eccles 2007; Fadigan and Hammrich 2004; Gilmartin et al. 2007; Hazari et al. 2010; Rittmayer and Beier 2009).

These participants were selected to highlight the varying types of participants who came to the camp in that they represented varying levels of STEM interest; STEM self-concept; parental background; and exposure to STEM role models—all of which affect STEM identity. The pre-survey responses indicated each student's level of self-concept and interest in STEM as well as their exposure to STEM role models. Then during the camp, the authors identified those participants who showed observed changes in their STEM identity as indicated through verbal and observed cues that highlighted their interest, self-concept, and the influence of exposure to role models. Examples of these changes and the participants' own explanation of these will be discussed in the "Results" section. But to help the reader, we will provide an example that explains how we operationalized these concepts. During observations, we were looking for participants' discussion of interest in topics. Changes in interest were determined by participants discussing this with each other and their teachers, e.g., "I never realized how interesting nanotechnology could be." Also, participants were asked specifically if the camp affected their interest in STEM and STEM careers. Participants' self-concepts were noted based on original scores and then researchers looked for evidence of participants' improved confidence in their science and math abilities—realizing that there are limitations to the time frame of the camp. And finally, the perception of STEM professionals was observed by looking for participants' responses to interactions with scientists and then their discussions afterwards, e.g., "She was so cool. I would love to work in her lab." Also, participants were asked on the post-survey and in their interviews whether any of the scientists they met could be considered a role model (A full list of the participants interviewed and their respective demographics and quantitative scores/ qualitative designations for the various constructs can be found in Appendix 3).

The qualitative data were coded using Nvivo 8. The authors analyzed the data focusing on the codes related to STEM identity: STEM interest, science and math self-concept, perceptions of STEM careers and professionals, these individuals' position as role models, and changes in these perceptions. The inter-coder reliability averaged 95 % for all qualitative data sources (i.e., interviews, open-ended questions on surveys, and field notes). The codes for the various qualitative data can be found in Table 4.

Results

Participants from both camps were asked why they chose to attend their respective camp and none of the GIRLS participants explicitly referenced the all-girls aspect; rather, the responses

Table 4 Codes and examples for qualitative data

Code	Example or rationale
High STEM Interest	Science and/or math was a favorite subject; participated in science and math activities outside of school; STEM career was the only one mentioned
Medium STEM Interest	Science and/or math was a favorite subject but other subjects mentioned as well; STEM career along with others mentioned.
Low STEM Interest	Science and/or math was a least favorite subject; no STEM career mentioned
High STEM self-concept	"I've always been good in science." Darron final interview
Medium STEM self-concept	"Sometimes I struggle with my math classes. But if I work hard I can get it." Raquel final interview
Low STEM self-concept	"I am really bad at math. I am just not a math person." Sarah informal interview during camp
Positive perception of STEM professionals	"At first I imagined a man in a white coat with chemicals but now I see regular people outside testing water and just doing thing that we do on a normal basis. But take it a little further." Raquel posttest
Stereotypical perception of STEM professionals	"A tall figure with crazy white hair, a white lab coat, and white glowing gloves holding a test tube." Raquel pretest
Stereotypical and male perception of STEM professionals	"A guy wearing a lab coat holding chemicals and wearing goggles." Darron pretest

for both camps fell into the following categories: (1) because they were interested in STEM and STEM careers; and (2) because they wanted to be around other participants who were interested in STEM and STEM careers. This indicates that participants in both camps had similar motivations for their attendance. It also indicates that the single sex aspect of GIRLS was not a major reason for their attendance. At the conclusion of the GIRLS camp, the girls completed post-survey questions that asked them about the differences between an all-girls environment and a co-educational environment. All of the girls said that they enjoyed the all-girls environment because they felt "less self-conscious" about what they said or looked like and because they were "not as embarrassed to show their interest in STEM." It is difficult to say whether the GIRLS participants would have had the same positive trajectory if they had participated in the COED camp or vice versa because of these selection issues. However, this does not detract from the importance of the following results that explain how each of these camps affected girls' STEM identity.

We raise this point because one criticism of single sex program studies is the self-selection issues wherein the positive outcomes girls experience in single sex programs may simply be because they chose to participate in this program and not because of the single sex aspect. We acknowledge that the interest of all participants in STEM before the program is a self-selection issue as well. But there were significant positive changes in participants' interest in STEM, self-concept in science and math, and perceptions of STEM professionals which indicate that informal programs play a major role in improving participants' STEM identity, even for those participants who already have an interest in STEM.

We ran paired sample *t* tests comparing the pre- and post-responses for all three STEM identity measures (STEM interest, science and math self-concept, and role models) in each camp (see Table 5.) There were significant differences between the

Table 5 Paired sample *t* test results for pre- and post-measures in each camp

	Mean	Std Dev	S.E. mean	Paired *t* test		
				t value	*df*	Sig (two-tailed)
GIRLS						
Self-concept pre	27.03	3.78	.69	2.14	29	.04
Self-concept post	28.30	3.88	.71			
STEM interest pre	45.90	5.88	1.09	3.08	28	.00
STEM interest post	48.21	4.69	.87			
COED						
Self-concept pre	27.35	3.39	.71	1.56	22	.13
Self-concept post	28.13	4.20	.88			
STEM interest pre	44.00	6.59	1.44	.08	20	.94
STEM interest post	43.95	6.52	1.42			

pre- and post-responses for the participant means in the GIRLS camp but not the COED camp. The GIRLS camp difference in means was significant at the .05 level for both STEM interest and self-concept. Based on these results, it would appear that GIRLS was more successful in positively affecting participants' interests in STEM and self-concept in STEM. However, to test this conclusion we also compared the pre- and post-means for all of the female participants from both camps and then compared the pre- and post-means for the male participants. These results can be found in Table 6.

The results found in Table 6 indicate that girls from both camps had significant positive changes in their post-means for both categories that were used to infer STEM identity transformation. It is also useful to point out that the males had a higher self-concept mean compared to the females on the pretest, but this difference was not significant. The difference between males STEM interest mean on the pretest was significant for the females at the 0.10 alpha level (We analyzed these results by race and ethnicity using a one-way ANOVA and found no significant differences). This

Table 6 Paired sample *t* test results for pre and post measures by sex

	Mean	Std Dev	S.E. mean	Paired *t* test		
				t value	*df*	Sig (two-tailed)
Female						
Self-concept pre	26.88	3.42	.52	2.74	42	.01
Self-concept post	28.12	3.59	.55			
STEM interest pre	44.45	6.18	.98	3.08	39	.00
STEM interest post	46.30	5.80	.92			
Male						
Self-concept pre	28.40	4.2	1.33	.36	9	.73
Self-concept post	28.70	5.6	1.77			
STEM interest pre	47.7	5.85	1.85	-.80	9	.34
STEM interest post	46.9	6.42	2.03			

difference between males and females in self-concept and STEM interest mirrors the broader population studies of students at this age (AAUW 2010).

The next section highlights positive changes in STEM identity trajectories that were evident from the qualitative data collected during the programs. The "Results" section will highlight five examples that demonstrate how all three components were operationalized and were analyzed by the authors as evidence of positive STEM identity trajectories for some participants and not others, thereby demonstrating how STEM identity is an individual trajectory and how these trajectories were experienced by individuals in each camp.

Example 1: Stereotypes Confirmed

In Table 5, the *t* test comparisons demonstrated that the COED campers had no significant changes in their interest in STEM and self-concept in science and math means from pre- to post-survey. Some of the participants provided qualitative evidence for this lack of change in their surveys and in their post-interviews. This first example highlights how misperceptions and stereotypes could be maintained. On the morning of day 3, the COED participants visited a local research facility that focused on power systems. As they entered the lobby, they were led into a conference room, wherein they were introduced to three undergraduate participants who had volunteered to work with the camp. The three participants were male, and all were electrical engineering majors. The participants were split into two groups, one group stayed in the conference room with the undergraduate participants and built electromagnetic motors, and the other group toured the facility with a male member of the public affairs staff (groups switched places after their respective tour/activity was completed). The participants were given opportunities to ask undergraduate students, graduate students, and faculty questions about their daily activities during the tour.

During all of the activities at the research facility, the participants only saw male scientists and engineers. There were no female scientists/engineers present in any of the labs that were visited. Also, during the tour, each male scientists/engineer was working alone, either at a computer or on some form of equipment. Although, this is only one activity, and not all of the COED activities were missing female representation, in this particular activity the COED participants saw only male scientists working alone in their laboratories; an experience which could reinforce stereotypes about STEM and lower participants' interest in STEM careers.

These stereotypes were exhibited in the participants' interviews as well. In his post-interview, Darron—an African American student—discussed being dissuaded from pursuing a career in engineering because of the long hours they have to put in to their work—a perception that he held after participating in the tour.

> [The tour] kinda confirmed some of my thoughts that, you know [sic] scientists do work very hard, and sometimes even long hours. Like most of the scientists here, they would sometimes stay overnight, just to get the job done. And when we were at the power plant, I think some people worked twelve hour shifts, just to get the job done.

When Darron was asked how this experience affected his interest in a STEM career he explained:

> I'm not sure anymore. I like science, but, I think I like a nine to five type job. I wouldn't mind working later but, I guess twelve hours, and then waking up in the morning, twelve hours again, probably ain't for me. The long hours are a turn off.

In his interview, Darron referenced the engineers that he met on the third morning of the camp as examples of this type of work ethic. His experiences during the camp and in this particular activity made Darron believe that engineers work long hours alone in their laboratories—behaviors that he was not interested in doing. He believed that he could not be an engineer and pursue other interests and consequently stated a loss of interest in engineering as a career option after the camp. Darron's experience demonstrates how some camp activities could fail in improving participants' interest and perceptions of STEM professionals.

John—an African American camper—was an example of a student who believed the stereotype of STEM—a scientist working long hours alone in their laboratories—but also wanted to emulate it. John, like Darron, maintained a stereotype of engineers in his post-survey, but this misconception actually reinforced his desire to pursue engineering as a career option. John's father is an electrical engineer, and as a result, John had a strong amount of engineering knowledge prior to camp. He repeatedly referenced scientists using male gendered terms but did not appear to recognize the underrepresentation of minorities in STEM fields. This was due to the fact that he saw his father—an African American—as an example of someone succeeding in the engineering field. John spent a lot of time in his father's engineering lab, and in fact would depart from camp each day and walk to his father's lab across the street. It was clear, in his interviews and observations, that this relationship with his father had a positive effect on his desire to become an engineer and his understanding of the engineering field. Therefore, even though he was exposed to female scientists, it was his daily exposure to a male African American engineer—his father—that allowed him to maintain his strong STEM identity through his interest, self-concept, and exposure to role models.

Example 2: Stereotypes Challenged

In the *t* test comparison above, the GIRLS campers showed significant positive changes in their STEM identity. The participants also provided qualitative evidence of their improved trajectories in both their post-surveys and their interviews. One example that highlights how this could occur through camp activities occurred on the fifth day of the GIRLS camp. The campers visited a marine biologist who worked at a local university-sponsored laboratory. She gave the girls some background on how she became interested in marine biology and her research interests. The girls spent the morning conducting data collection on snails and sea grass for part of a project the marine biologist was working on. In the afternoon, the girls analyzed the data and toured the marine facility. During all of the activities, the girls could see that women scientists outnumbered male scientists at the laboratory, perhaps challenging some of their stereotypes that scientists were white and male. During the tour, they also visited various labs where female graduate students were working. While visiting these labs, they witnessed the scientists listening to popular music as they conducted their research. These researchers were dressed in shorts and t-shirts and were wearing rubber gloves as they sifted through samples and counted specimens under microscopes. This encounter is one example of a day of activities that challenged the girls' previously held stereotypes of scientists (lab coat and goggles) and affected their interest in STEM since they were able to see science in a setting that was relatable.

Althea, an African American girl, mentioned this example in her final interview, citing it as one example of why she was considering a STEM career after the camp despite not being interested in one before participating in the camp. "I mean, I was always interested in [science], but never really considered a career [in it]. But since going into this, I was kinda like, 'Maybe I could be a science professor.'" Similarly, Brenda (an Asian American girl from a low socioeconomic family), whose interest was primarily in chemistry before the camp, used this example to explain her broadened view of STEM fields:

> Well I just saw all the different people, all the different scientists who do different stuff and like the way that they talk about it you can tell that they actually love what they're doing and that they're not just smart.

When asked to explain how this experience (and others) affected her STEM career interest she explained that "it definitely made me more interested." Similarly, Arlene (a white student) cited this example when she referred to scientists as cool:

> After seeing Dr. _____'s lab …I mean I always thought scientists were people who really enjoy what they do and are enthusiastic about it. And I never pictured the white-haired glasses sort-of Einstein thing, but now I see them as regular people who are really smart and cool.

All three of these girls highlighted the increased interest they had in STEM careers after participating in the camp. Although the examples mentioned here are few, we chose them because they were such a stark contradiction to the stereotypical view of STEM professionals—particularly in relation to the example from the COED camp. All of these girls articulated responses mentioned by all of the GIRLS participants regarding an increased interest in STEM fields and careers based on their exposure to role models. This increased interest and role model exposure allowed these young women to improve their STEM identity even if the exposure was only over a relatively short period.

Example 3: Self-Concept

These first two examples did not reveal the role of self-concept that we observed during the camp. Self-concept was much more difficult to measure because the participants were not taking tests or forced to demonstrate their understanding of STEM explicitly. Also, most of these participants had relatively high self-concept scores before coming to the camp, so it was difficult to observe major changes in self-concept. Therefore, the evidence of self-concept changes was based on observations and interviews along with the pre- and post-survey responses.

During the GIRLS camp, the participants visited a local animal shelter. Each year, the female veterinarian at the shelter prepares activities for the GIRLS camp with her veterinary technicians. The activities included: watching the veterinarian perform a spay/neuter surgery, learning about diseases that affect animals, observing these organisms under the microscope, and a question-and-answer session with the veterinarian and her staff. During this trip, participants were also able to see women in roles that they may have previously seen as male dominated (such as working within animal control units). During this session, the veterinarian gave a brief personal narrative of her own struggles growing up with an interest in science. She explained to the participants that as a middle school student she had thought women and girls could not be "good at science." She explained that she spent a brief portion of her high school career pretending to be "dumb in math and science" because that was her perception of what men expected of women—women were not supposed to succeed in or be “good at” math or science. She claimed that she hated the way she acted when boys were around and disliked the way she was consequently treated by these same boys. This made her realize that she preferred the respect her peers gave her when she demonstrated her abilities in math and science. This conversation explicitly highlighted the position that women and girls are sometimes put into by the social stereotypes related to STEM fields and how women fit into these fields. In this conversation, the veterinarian not only exposed these issues but also discussed openly and honestly how and why she challenged them.

It was during this visit that we observed one student in particular discussing the changes in her self-concept related to science and math. Sarah (white student) was a GIRLS camper who entered camp believing that she was “dumb,” particularly in math. This low self-concept in math affected her STEM identity as well since she realized that “you can’t be a scientist without math, and you can’t really be in math without science.” Sarah showed a positive improvement in her math self-efficacy as evidenced by her pre/post self-efficacy score which increased by two standard deviations. This quantitative increase was also supported in the qualitative analysis. One of the teachers explained both her improved STEM identity and self-efficacy in the following comment:

> Sarah had been told by her family that she would not become a veterinarian because she was young and would change her mind a lot before she got older. The vet explained that she had known since she was 3 years old that she wanted to be a vet and that although she changed her mind some when she got older…she always came back to this career as her desired path. I think that really influenced Sarah’s view. I was able to see a visible change in the way she participated [in the camp] and the way she talked about her future career. She had several conversations in the car where she would say “I am going to be a vet, and I know it will be hard, but I really want to do it.”

Sarah also articulated how her improved self-concept correlated with her improved interest in STEM based on her exposure to STEM role models, thereby improving her STEM identity. She stated that after meeting the veterinarian, she was “even more passionate about pursuing a career in science than before.” Sarah was able to observe a practicing veterinarian and hear her explain that being a veterinarian was a possible career goal. After meeting the veterinarian and watching her work, Sarah discussed planning to work harder in math classes in order to accomplish this career goal. Although this is just one young woman, we use this example to highlight the qualitative evidence that complements the quantitative results—the significant changes in mean scores from pre- to post-survey for self-concept—which would indicate that more girls than Sarah had these changes. We chose to highlight Sarah because she provided the best qualitative evidence.

We recognize that both of the examples from the GIRLS camp thus far represent STEM fields that have made positive gains in the representation of women over the last few decades (NSF 2011). We chose to include these examples for two reasons: first, the campers were not aware of the strong representation of women in marine biology or veterinary medicine—as evidenced by pre-survey responses. Prior to camp, two thirds of these young women described scientists and engineers using stereotypes. Therefore, any exposure to non-stereotypical representations of STEM fields would be new to them. Second, just because these fields are better represented (for women) compared to others fields does not mean that they should be ignored by informal STEM education programs. If two thirds of these female campers held stereotypes about STEM professionals, then this exposure is still necessary to challenge stereotypes and increase girls’ interest in all STEM fields. The next two examples highlight positive STEM identity trajectories in engineering—a field where women are underrepresented at a much higher rate than the life sciences (NSF 2011).

Example 4: Positive Changes for Girls in COED Camps

Although analysis of the pre- and post-means for the COED camp shows that there were not significant changes in STEM interest and science and math self-concept, when these means were compared by sex, we did see significant changes in these categories. Therefore, we can conclude that the girls (and boys, just not significantly so) in the COED camp were positively impacted by the camp. The following example provides qualitative evidence of these impacts.

On day 3 and day 5 of the COED camp, the participants visited local engineering plants wherein a female engineer was the administrator of the entire plant. On day 3, the participants toured a local power plant where the female engineer who ran the plant was also their tour guide. During the tour, she discussed the eco-friendly ways in which the plant was generating power. On day 5, another female engineer led the participants on a tour of a local electronics recycling plant. During both tours, the engineers discussed the relevance of their daily work to the participants' daily lives. Both settings were factories wherein mainly men were working in small groups in various rooms that were large, noisy, and appeared unstructured (i.e., equipment strewn about, recyclable material in large piles among tables). All of these adjectives were in direct contradiction with the stereotype of STEM labs as cold, quiet, and spotless places. For example in the electronics recycling plant, the men were working to separate materials, strip them for parts, and then process them for recycling.

In both activities, the participants were able to see that not only can women be successful in engineering but also that there are a variety of opportunities within engineering fields—including leadership positions. One of the female participants, Julie (white camper), recognized this in her comment:

> Scientists and engineers can manage big companies and not just do experiments, which is good. It just gives you more options if you decide not to just do experiments. And plus, you need people like that too—to manage companies and recycling centers and things like that.

Here, Julie articulates the change in career options that she was able to see as a result of the camp. She was able to increase her interest in STEM since she could see possibilities within STEM careers besides just research. Therefore, her exposure to female role models and their careers helped her to broaden her awareness of engineering fields (a career option that she was interested in) which increased her STEM identity.

An African American female student, Jenna, discussed the broadening of her awareness of career options and her own ability to succeed in these fields. Jenna said during her interview that her favorite part of the camp was "learning about the power plants" because she "didn't know anything about power plants." She went on to explain why:

> How everything works is so interesting. I never knew about this stuff, especially the hydroelectric plant. I didn't know it existed. So yeah, that's something I'll always remember. The tour turned my whole entire idea of engineers… because before I really didn't know the true definition of engineers, but now I do. I mean I am interested in the field but I don't necessarily want to have a career in it.

Jenna's comments from her interview demonstrate that her understanding of STEM careers was broadened even though she did not necessarily want to become an engineer (Jenna's career goal before and after camp was to become a veterinarian). Her increased interest in engineering fields demonstrates a broader understanding of STEM fields/careers. This interest in engineering as a field, if not a career, helped her to broaden her STEM identity by making her more aware of STEM fields and by increasing her interest in such fields.

Example 5: Engineering as a Career Option

The previous example highlights how participants are often not aware of engineering fields or careers. Participants in both camps cited the idea that after participating in the camp they could see engineering as a possible career option. In the GIRLS camp, the participants were exposed to female engineers who came to the participants rather than the participants going to their place of work. The women discussed their daily work with the girls and created a variety of hands-on engineering activities for them. For example, a group of civil engineers facilitated a filtration design activity wherein the girls built their own water filter, performed pre/post-filtration pollutant testing on the water, and then discussed ways to improve their filtration designs. Another activity involved a chemical engineer who discussed nanotechnology with the girls and then facilitated a nanotube building activity using balloons and hula-hoops. In both activities, the girls were actively engaged in learning the social relevance of engineering. Additionally, the girls were also able to see various female engineers and broaden their understanding of what these careers entail. One camper, Arlene (white), discussed being "very interested in nanotechnology" after the activity. Like Jenna, Arlene maintained her original career interest (marine biology), but her increased knowledge of other STEM careers and fields increased her overall interest in these fields and positively affected her STEM identity.

In regard to other specific participants' discussion of STEM identity changes, one student, Brenda, strongly articulated the positive changes derived from her participation in these STEM education activities. In her interview, she discussed how her negative perceptions of STEM fields and STEM professionals before camp had affected her own STEM identity. She explained that throughout elementary school she had "hated science because it was so boring." However, during the previous school year (8th grade) she had begun to develop an interest in chemistry and physics. During camp, this interest was increased because of the exposure to the STEM professionals and their research, which changed her perception of STEM careers and helped her to see STEM as a career possibility. This was indicated in her post-camp interview:

> [The camp] definitely made me more interested in science. And it gave me an idea… like before I knew that there were careers in science but I didn't actually know what you could do in science, and now I actually know things that you can actually do. Now I picture a scientist as somebody that has… Okay this [picture] changed over this week… but now I picture [a] scientists as somebody who has a passion to discover new things and change the way everybody sees things because they get to do that, and it's like their thing. Before camp, I thought scientists were giant brainiacs who knew everything. [But during camp] I just saw all the different people, all the different scientists who do different stuff and …you can tell that they actually love what they're doing and that they're not just smart but they have fun. I think actually being a scientist takes a lot of imagination.

In this quote, Brenda indicates that meeting the scientists during camp challenged her stereotypes and helped her to see that scientists were people who "love" what they do—something that she could identify with. Brenda discussed how the camp challenged her stereotypes which allowed her to see herself fitting in with STEM fields. These various experiences within the camp also improved her interest in STEM fields.

Discussion

The above examples have highlighted the qualitative evidence that supports the quantitative results in Tables 5 and 6. Both camps offered participants a variety of opportunities that exposed them to STEM professionals and their research. And although the COED camp did not show significant changes in the means for STEM interest and self-concept from pre- to posttest, the analysis by sex did show significant changes. The girls in both camps were significantly influenced by their participation in terms of their interest, self-concept, and perception of scientists. In the discussion, we make the argument that these indicate a positive trajectory in their STEM identity.

These results raise the issue of access and STEM identity. Current science education programs and policies that focus on students' persistence in STEM are moving away from simply providing access—which is based on second wave feminist theories—to focusing on the role of individual identity in the process of STEM persistence (Brotman and Moore 2008). The results of this study show that the girls' increased interest and improved self-concept were affected by their exposure to positive STEM role models. The combination of these influences enhanced their STEM identity, in that they could see themselves as someone who was interested in STEM and had the potential to be a legitimate participant in STEM careers. Both camps explicitly focused on providing the participants with opportunities to meet STEM professionals from various backgrounds and participate in or at least witness their research, so that participants could see the various opportunities in STEM. We argue that it was these choices of activities and role model exposure that affected the participants (particularly the female participants) more than the single sex or co-educational aspect of the program.

If one program (GIRLS vs. COED) was better at improving STEM identity, we would have seen those results in our data. But in our data, the means for STEM interest, self-concept, and perceptions of STEM professionals for girls in both camps improved, indicating both camps were successful in improving girls' STEM identities. In our discussion of the qualitative examples, the first example shows that simply showing participants a lab and giving them opportunities to witness and/or participate in STEM activities (e.g., access) does not lead to positive improvements in STEM identity if the STEM professionals involved do not represent the varying personalities, races, sexes, and ethnicities in STEM professions. In the first example, participants who had stereotypical views of STEM professionals would not have their misconceptions challenged regarding the stereotype of STEM as white and male since that was all that they saw in this lab. Darron actually lost interest in an engineering career because the tour strengthened his conception that engineers work long hours alone in their lab. Therefore, the explicit introduction of role models who represent various fields and backgrounds is important to improving STEM identity.

Although this paper focused mainly on girls STEM identity, we believe it is important to briefly mention the role of race. There were only two African American STEM professionals (one male and one female) who worked with the participants during the COED camp—whereas almost 40 % of the STEM professionals were women. This lack of racial representation may have been partly the cause of Darron's loss of interest in STEM careers (along with his perception that engineers work long hours). John, however, had a father who worked as an engineer, so despite not seeing many African American STEM professionals, he could return home each night seeing a role model which would positively affect his STEM identity more than Darron's. Again, this provides evidence to the importance of role models to middle school participants' STEM identity development. There were only two African American STEM professionals, yet there were many female STEM professionals represented. Therefore, female participants in the camp could see various representatives of their gender despite—for those who were non-white—not seeing many representations of their race. Darron's trajectory highlights how this lack of racial representation could still affect him as an African American male despite the positive improvement for the females who met many female role models.

The explicit exposure for girls to various role models also supports the camps' choices to include life science representatives despite this being a field where women have gained almost equitable representation (NSF 2011). Most of these participants were not aware of women's underrepresentation in STEM fields. Therefore, exposure to the various fields was important. By seeing the career options and the relevance of each field to their own lives, they were able to see possibilities within these fields for themselves. They improved their interest in STEM (even if it was not a career interest) and they improved their self-concept through their exposure to the STEM activities, thereby improving their STEM identity.

These findings also highlight the complexity of identity formation and its effects on STEM career goals. Each of these participants was uniquely affected by the activities in each camp. The quantitative data show us that the girls in both camps had positive improvements in their identity. But this study clarifies the deeply personal trajectory of STEM identity through its qualitative results. We have already highlighted Darron's negative trajectory based on his perception that engineers work long hours alone in their laboratories. And yet, the girls from the COED camp were exposed to the same experiences and did not come to the same conclusion. Rather, the girls that we highlighted in the examples left camp with a broadened view of STEM fields and a strong sense that they could fit in with these fields, despite tours where there were no female STEM professionals. These results demonstrate that each individual interprets experiences differently leading to different STEM identity trajectories. Since STEM identity is the focus of current policy initiatives and programming in STEM education, it is important that studies like this one continue to explore the ways in which informal STEM education programs can influence STEM identity—particularly underrepresented groups within STEM.

Limitations and Future Research

This study has some limitations that we have recognized throughout. First, we recognize the issue of self-selection into the camp, which is a common limitation in most informal education studies. Perhaps, a future study could compare the trajectories of STEM identities of students who applied to the camp and those from similar schools. For this particular study, this limitation was not severe since we were looking at the differing and significant results for girls compared to boys. Consequently, the self-selection was similar for both sexes, making the comparison justified. The results are especially important for the COED participants in that both boys and girls self-selected into this camp and yet the female participants demonstrated significant positive changes in their STEM identity.

Second, it is difficult to say whether the GIRLS participants would have had the same positive trajectory if they had participated in the COED camp or vice versa because of these selection issues. Based on self-reported survey responses, the GIRLS participants did not apply to the camp for the single sex atmosphere. Even if this were a self-selection issue, it does not detract from the importance of the study. The results indicate that all of the campers increased their self-efficacy, with the female participants from both camps having a significant change. Consequently, exposing students to STEM professionals who represent both sexes and varying races/ethnicities as well as allowing the students to learn about STEM careers by working with STEM professionals on their research or hearing about their research had more of an impact than the presence or absence of peers of the opposite sex. These young people were able to meet scientists and engineers that (for some) broadened their perceptions of scientists/engineers and allowed them to move beyond the stereotype of a white male holding a beaker. These changes in perceptions and the exposure to a variety of careers in STEM allowed them to see the possibility of their own success in these careers and reinforced their confidence in their abilities to succeed in future STEM endeavors.

The final limitation is one that can be addressed with future research. The study occurred over a short period of time—2 weeks. As we discussed earlier, 2 weeks does not allow this program to fit into the literature on authentic apprenticeship (Sadler et al. 2010). And due to the limited time of our observations, we cannot say whether these changes will last over time. A future study should investigate the participants in these camps over time to determine whether these positive effects in the female participants remained. Despite this being a short time frame, we can say that there was an immediate positive effect on the female participants. We believe that participants would need to be exposed to activities like the ones highlighted in our study over a much longer period of time in order to see true changes in STEM identity. Yet, even with this exposure to STEM professionals and their careers in the camp, the female participants were able to change or alter their perceptions regarding STEM. Additionally, these participants were also able to see STEM careers as a possibility as evidenced by the improvements in their STEM interest, self-concept, and perceptions of STEM professionals throughout the camp.

Conclusions

The current debate regarding single sex programs has focused on whether these programs are effectively reaching participants. In this study, the participants self selected into both camps based on their interest in STEM. While the GIRLS participants indicated on their post-survey that they enjoyed the comfort level in the all-girls environment, they—like their COED counterparts—originally chose the camp because they wanted to be around other participants who were interested in STEM. Therefore, in this study, it was not that one setting (single sex or co-educational) was more effective, rather it was the type of pedagogy used that affected the results. Consequently, this study demonstrates that pedagogy must be part of the larger debate regarding the benefits and drawbacks to single sex and co-educational programs—particularly as it relates to adolescent girls' STEM identity and women's persistence in STEM fields (Calabrese Barton 1997). These results suggest that the debate should focus more on the efficacy of strategies utilized in science education as opposed to oversimplifying the complexity of learning as being affected by a single sex or co-educational environment.

Finally, this study adds to the current dialogue regarding the role that informal science agencies can have on girls' ability to identify with STEM professionals. The results indicate that the length of the camp, diversity of participating scientists and engineers, and educational theories behind the activities are important to a camp's overall effectiveness. This study situates itself within the current literature on the role of identity in science education strategies in improving girls' persistence in STEM fields, particularly in the unique context of informal science settings.

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Appendix 1

STEM Interest

1. I look forward to science class in school.
2. I look forward to math class in school.
3. I would rather solve a problem by doing an experiment than be told the answer.
4. More time should be spent on hands-on projects in science or technology activities at school.
5. I would like to (or already do) belong to a science or technology activities club.
6. *Recoded: I get bored when I watch programs on channels like Discovery Channel, Animal Planet, Nova, Mythbusters, etc.
7. I like to get science books or science experiments kits as presents.
8. I like learning how things work.
9. *Recoded: Science is too hard when it involves math.
10. *Recoded: Science is a difficult subject.
11. *Recoded: Doing experiments in science class is frustrating.
12. I feel comfortable with using a computer to make graphs and tables.
13. I am interested in learning more about how computers work.
14. I like to learn to use new computer software.

Pre-Cronbach's alpha=.798
Post-Cronbach's alpha=.811
Self-concept

1. When I see a new math problem, I can use what I have learned to solve the problem.
2. I can use what I know to design and build something mechanical that works.
3. In lab activities, I can use what I have learned to design a solution.
4. I can effectively lead a team to design and build a hands-on project.
5. I know where I can find the information that I need to solve difficult problems.
6. I can use what I have learned to teach myself how to program a computer game.
7. I can explain math or science to my friends to help them understand.
8. I can get good grades in math.
9. I can get good grades in science.

Pre-Cronbach's alpha=.638
Post-Cronbach's alpha=.761

Appendix 2

Teacher Interviews

1. Did you notice any changes in the participants from start to finish? Can you give examples?
2. Did you notice any changes in the participants' views of science? Can you give examples?
3. Did you notice any changes in the participants' views of scientists? Can you give examples?
4. Did you notice any changes in the participants' confidence levels? Can you give examples?
5. What activities do you think had the largest effect on participants? Why?
6. Which activities were your favorites? Why?
7. If you could do everything over, what would you do differently? Why?

Interviews with Campers

1. What is your favorite subject in school? Why?
2. What is your least favorite subject in school? Why?
3. What extracurricular activities do you participate in? Are any of these science or math related?
4. How would you describe your family and friends?
5. What is your earliest memory of science?
6. What was science like in elementary school/middle school/high school?
7. What are your current science and math courses like? What do you enjoy and what do you dislike about these classes?
8. Have your attitudes toward science changed since elementary school?
9. Are any of your friends interested in science or science careers?
10. What would your friends say if you told them that you were interested in a career in science?
11. Do any of your family members work in STEM fields?
12. How do you think most people see scientists and engineers? What do you think most people would picture when they think of a scientist or engineer?
13. How do you picture a scientist or engineer?
14. Do you think there are certain people or certain traits that make people more successful at being a scientist or engineer?
15. What do you think they do on a daily basis?
16. What do you see yourself doing after high school?
17. What career would you like to have? Why?
18. Have you had any experiences that made you think about being a scientist or engineer?
19. Have you had any experiences that made you think that you couldn't be a scientist or engineer?
20. Why did you choose to attend this camp?
21. If given the chance, would you attend this camp again? Why?
22. Did the camp have any effect on your interest in science?
23. Did you see any of the scientists you worked with as role models?

Appendix 3

Table 7 Interview participants

Name	Camp	Age	Race/ethnicity (self-reported)	Sex	STEM interest qualitative coding/ quantitative score (low=below 28, medium=29–41, high=42–56	STEM self-concept	View of STEM professionals	Family member who worked in STEM
John	COED	14	African American	M	Pre: high/56 Post: high/56	Pre: high/34 Post: high/34	Pre: stereotype and male Post: stereotype	Father
Darron	COED	15	African American	M	Pre: high/49 Post: medium/41	Pre: medium/26 Post: medium/24	Pre: stereotype Post: stereotype	NA
Jenna	COED	12	African American	F	Pre: medium/39 Post: high/43	Pre: medium/26 Post: medium/26	Pre: stereotype Post: positive	NA
Jessica	COED	12	African American	F	Pre: high/50 Post: high/51	Pre: high/29 Post: high/30	Pre: positive Post: positive	Mother
Julie	COED	13	White	F	Pre: high/44 Post: high/49	Pre: high/30 Post: high/27	Pre: positive Post: positive	NA
Althea	GIRLS	14	African American	F	Pre: medium/41 Post: high/49	Pre: high/28 Post: high/33	Pre: stereotype Post: stereotype	NA
Raquel	GIRLS	13	African American	F	Pre: high/53 Post: high/51	Pre: medium/23 Post: high/30	Pre: positive Post: positive	NA
Brenda	GIRLS	13	Asian American	F	Pre: high/48 Post: high/50	Pre: high/30 Post: high/29	Pre: stereotype Post: positive	NA
Arlene	GIRLS	14	White	F	Pre: high/43 Post: High/46	Pre: high/28 Post: high/29	Pre: positive Post: positive	Aunt
Sarah	GIRLS	12	White	F	Pre: medium/39 Post: high/46	Pre: medium/23 Post: high/28	Pre: stereotype and male Post: positive	NA

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