Unpacking Secondary School Students' Identity Negotiations Regarding Science and Engineering: A Case Study in the United States

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ABSTRACT

Science researchers argue that students' science and engineering (SE) identity can be improved if they are exposed to scientists and engineers and participate in real world applications within these SE fields (Brickhouse et al., 2000; Carlone & Johnson, 2007; Painter et al., 2006; Polman & Miller, 2010). This type of exposure is particularly important for women and minorities because they are currently underrepresented within these fields and are not often exposed to role models. This study addresses the issues related to the SE identity negotiations of girls and racial minorities through a comparative case study, wherein three adolescent students' SE identity trajectories are studied. This study shows the complexity of how students can develop their SE identity both socially and individually. In particular, it highlights how these social and individual interactions occur on a personal level and can shift due to small interventions and particular interactions. This study also adds to current identity frameworks by using them in informal SE education settings where they have not been used before.

KEYWORDS

identity; case study; informal science education; gender; science and engineering.

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INTRODUCTION

The concept of identity formation is incorporated across many disciplines including education, psychology, anthropology, and sociology. Since identity is the story that we each create for ourselves (Polman & Miller, 2010), its formation is both social and personal (Calabrese Barton, Kang, Tan, O'Neill, Bautista-Guerra & Brecklin, 2013; Wortham, 2006). Research indicates that one's identity affects his/her interests (Brickhouse, Lowery & Schultz, 2000), motivations (Carlone 2004), and beliefs (Painter, Jones, Tretter, & Kubasko, 2006). Science and engineering (SE) fields are interesting domains for research in identity formation due to broader socio-historical frames that cause individuals to perceive scientists as typically male, white, and middle class (Calabrese Barton et al., 2013; Carlone, 2004; Carlone & Johnson, 2007). Additionally, in some SE fields in America (such as physics, mechanical and computer engineering) men significantly outnumber women adding to this broader socio-historical perception of SE as predominantly masculine fields (National Science Foundation (NSF), 2011). Consequently, those individuals who do not fit into the categories of male, white, and middle class find it difficult to fully identify with these fields (Ong, 2005; Syed, 2010).

Science and engineering (SE) identity is often defined as individuals' sense of who they are and who they want to become as it relates to these fields (Brickhouse & Potter, 2001; Robnett, 2013). Science education researchers argue that students' SE identities can be improved if they are exposed to scientists and engineering role models along with relevant hands-on experiences beginning in elementary school (Carlone & Johnson, 2007; Polman & Miller, 2010). This type of exposure is particularly important for women and minorities because they are currently underrepresented within these fields (American Association of University Women (AAUW), 2010; NSF, 2011). The loss of minority students and women in the U.S. SE pipeline occurs well before college. Researchers argue that adolescence (~11-15 years of age) is a critical period where students begin to lose interest in SE fields due to both the lack of role models they see and the lack of relevance they sense that SE has in their lives (AAUW, 2010; Calabrese Barton et al., 2013; Syed, 2010). Adolescence is also a crucial period when young people are developing their core identity (Gee, 2000) and these identity formations can affect the type of career and social support networks young people choose (Brickhouse & Potter, 2001; Olitsky, 2006; Syed, 2010). Consequently, we believe a better understanding of SE identity formation during adolescence is important to increasing the number of minority students in SE.

This study addresses the research question: how do students from underrepresented groups construct their SE identities after exposure to SE role models and careers? To answer this question, the authors utilized an intrinsic

multiple case study approach by focusing on three cases. These three students were part of one of two SE programs in the summer of 2010 in the Southeastern United States. The participants were part of either a co-ed science/engineering camp (COED) or an all-girls science/engineering camp (GIRLS). Both camps were similar in that they exposed students between the ages of 11 and 15 to scientists and engineers and the work that they do. This study focused on three students who showed improved, yet individually complex, SE identity trajectories after participation in the camps.

LITERATURE REVIEW

For our study we specifically chose cases that would allow us to focus on identity trajectories for underrepresented minority students. We chose these students because studies indicate that gender and race can interact to negatively affect one's ability to fully identify with SE. Specifically, the literature points to middle school as a critical development stage where this negative interaction can be seen. Zahra Hazari and her colleagues (2010) found that gendered choices regarding appropriate science courses began in middle school with male students exhibiting higher levels of interest in SE fields which led to more male students majoring in these fields in college compared to female students. Robnett (2013) conducted a study that complements Hazari in that she studied the role of peer support networks on female students' (at the high school, college, and graduate level) identification with STEM and commitment to STEM. Robnett (2013) found that peers at the high school and college level influence motivation to identify with and commit to SE, whereas at the graduate level peers had a positive link to confidence, which then affected identification and commitment toward SE careers.

Carlone and Johnson (2007) moved beyond gender to focus on the role of race and ethnicity on SE identity. In particular, they explored how these categories can complicate an individual's ability to identify with SE. In the study, the authors concluded that their participants' SE identity was affected by each participant's competence, performance, and recognition by other credible members of the community of SE (i.e. faculty). The authors found that the category of recognition was the area where the SE status quo was reproduced. Syed (2010) adds to these conclusions finding that ethnic minorities in SE fields had to either compartmentalize their ethnic identity or exhibit color-blind views to persist in their majors. Syed (2010) explains that identity formation occurs over time and is based on the reflection and internalizations of various experiences over time.

The studies mentioned thus far looked at a longitudinal process but not on potential turning points in an individual's SE identify formation. Our study is not a longitudinal study, but this does detract from the benefits of identity studies that focus on potential turning points in students' SE identity formation. Polman and Miller (2010) studied the identity trajectories of African American secondary school students who participated in a program wherein they were exposed to SE professionals. In their work they use the concept of border crossing (Tan & Calabrese Barton, 2008) or borderlands wherein individuals must change or alter their identity to fit-in with one borderland (domain). Polman and Miller (2010)

found that providing minority students with opportunities to interact with peers and SE professionals allowed them to feel like valued members within borderlands. The students were able to be recognized by SE professionals and to see the relevance of SE to their own lives. The authors concluded that exposure to SE professionals allowed multiple aspects of the students' identities to be acknowledged and respected, resulting in improvements in their SE identity trajectory.

Our study builds on these previous studies by focusing on the SE identity trajectories of secondary school students as they participate in one of two summer informal education programs in the US. We focus on informal programs wherein students learn from actual SE professionals and are exposed to various borderlands as a way to study the effect of this exposure on their SE identities.

CONCEPTUAL FRAMEWORK

The conceptual framework for this study is based on the work of Calabrese Barton and colleagues (2013), Wortham (2006), and Syed (2010). Calabrese Barton and colleagues highlight how individual decisions, social interactions, and interpretation of these interactions impact identity formation. As individuals encounter new communities of practice they use lessons learned in previous experiences to create new hybrid practices that can position them within the community of practice (Lave & Wenger, 1991).

Calabrese Barton and colleagues' (2013) focus on the individual's interpretation of experiences over time that ultimately result in a progression towards or away from central participation in the SE community of practice or a positive trajectory towards SE identity formation. Wortham's (2006) work highlights the space where social identification occurs when individuals and/or groups are publically recognized as categories of people. Wortham's work focuses on the two domains in which identity development occurs: socio-historical and local. The socio-historical domain references specific sets of characteristics that are readily recognized by the public as belonging to a particular group of people. Local identities are typically categories such as "nerds", "jocks", or "popular" students, but these local identities can be affected by historical identities as well. Individual trajectories of social identity can draw from familiar socio-historical models (Wortham, 2006). These models must be lived and enacted in order for them to become social identification models for individuals. Wortham argues that identity formation should always be analyzed within the context in which it is occurring (both historical and local) because "social identification always involves contributions from both the focal individual and others, but the proportion of these contributions varies from case to case" (2006, p. 36). In addition to these two frameworks we also looked at whether these individuals saw SE as central to their personal identity and how they assimilated SE into their personal identity. According to Syed (2010) one of the ways that identities can be assimilated is through the compartmentalization of conflicting identities forcing individuals to cross between two identities depending on the experience and peer group.

These frameworks portray identity development as a gradual accumulation and internalization of events over time. This process may result in an evolution of one's identity but it may not be recognized at the exact time of the event. Our study observes students over the length of their participation in an informal SE education program; however, the quantitative and qualitative data collected indicates that the program improved students' perceptions of SE careers and professionals; resulting in students' increased interest and understanding of SE careers. Our study describes the process of identity development in three minority students and is the first to combine these three frameworks to focus on the identity development of students during participation in a program aimed at improving positive SE identity trajectory development. This study adds to these frameworks by situating the work inside a non-formal program and provides an opportunity to see how non-formal science education programs can impact SE identity development.

RESEARCH METHODS: Data Collection and Analysis

This study was a comparative intrinsic case study (Creswell, 2013) that focused on students who participated in two different SE summer camps in 2010. The camps are similar in that they were: created by the same director, housed within the same national lab facility, the authors worked as participant observers in both camps, and the mission for both camps was the same – to expose students to SE careers and professionals. One camp was a co-ed camp (COED) and the other was a single sex (GIRLS) camp. Since the focus of the research question was on the role of exposure to SE careers and professionals, the comparison of participants from both camps is applicable. Participants in both camps were given the same pre and post Likert surveys that ascertained their interest in SE and SE careers, and their confidence in their science and math abilities (Assessing Women and Men in Engineering (AWE), 2008). The surveys also contained open-ended questions focusing on students' pre and post perceptions of SE professionals and SE fields.

This study focuses on the experiences of three intrinsic cases out of an initial set of fourteen students. A brief introduction of our cases can be found in Table 1. The data collection included: documents (pre/post survey results); archival records (application data); interviews (with students and camp teachers); and participant observations throughout the duration of both camps by both authors. The participant interviews lasted on average one hour and were conducted on the final day of the camp. The fourteen initial cases were chosen to provide a representative sample of all participants based on the following continuums which have been highlighted in the literature as critical to students' SE identity trajectories: high interest to noncommittal interest in SE before camp (Olitsky, 2006); strong family background to no family background in SE (Settlage & Southerland, 2007); high socializer support to low socializer support for SE interests (Polman & Miller, 2010). We also selected a representative sample of race/ethnicity and gender (NSF, 2011). Interviews focused on the students' SE life history, including information on: family background; level of participation and interest in science and math classes; description of friends and their level of participation and interest in science and math; perceptions of SE professionals; career goals; and the role that their

participation in the camp had on their perceptions, interest, and commitment to SE careers.

Interviews were coded based on each student's trajectory: individual decisions, social interactions, interpretations of these experiences; the perception of SE; their perceptions of their own identities; the role that their peers and family played in their identity; and the way the camp affected their identity development. During observations, researchers focused on students' level of interaction and participation in activities and discussions.

Table 1: Participants for Case Studies

	Alice	Darren	Sarah
Camp	GIRLS camp	COED camp	GIRLS camp
Race/ethnicity	Asian American	African American	White
Age	13	14	13
Grade completed before camp	8	8	8
Gender	F	M	F
School	Private	Public	Public
Taking advanced classes in previous school year	Yes	Yes	Yes
Support from socializers	Yes	No	No
Parent/guardian attended college	Yes	Yes	Yes
Mother's occupation	Nutritionist	Office manager	State worker
Father's occupation			Eyeglass Technician
Career interest pre camp	Lawyer, unsure	Not sure	Vet
Career interest post camp	Unsure but leaning toward science	Not sure	Vet
Pre SE ID score	48	49	39
Post SE ID score	50*	50	46**

Half of a standard deviation increase
**Two standard deviations increase.*

During the respective camps, participants were briefly exposed to the community of SE through hands- on activities prepared by SE professionals and by observing SE professionals in their work environment. It is our contention that this camp and its exposure to the SE community is just one experience for these participants in a much longer path of exposure to the community of SE. Hence, our observations of

their identity development are located within one particular point along a longer trajectory. Through these various methods, participants provided examples of the issues affecting SE minorities in their SE identity trajectories. The three cases were selected because they highlight the complexity of SE identity formation—participants showed positive gains in their SE identities yet still struggled to see themselves as scientists and/or engineers.

Qualitative data analysis collected on each participant focused on how each individual developed their SE identity especially where participants demonstrated individual decisions regarding their social interactions. Interviews clarified the reactions, interpretations, and actions demonstrated during the camp. Each of the cases created hybrid spaces within the community of practice of science. These spaces were occurring locally as each individual made their decisions and reacted to the social interactions occurring; however, these decisions do not occur in a vacuum, rather their individual socio-historical frames also played a role in the identity process as our results section highlights. After analyzing the within-case themes, we then compared the thematic analysis across cases to determine how each trajectory compared (Creswell, 2013).

RESULTS

In regard to the overall effect of the camp on quantitative measures studied (SE interest and confidence in math and science, the SE ID score is the sum of these two scores), T-test comparisons of means indicated that there was a significant positive increase from the pre-test to the post-test in both of these categories (Hughes, Nzekwe, & Molyneaux, 2013). This indicates that both camps were successful in positively influencing the students' interest in SE and confidence in math and science. However, what these quantitative measures do not show is how these changes relate to identity trajectories and the complexity of identity formation. The three participants we highlight had positive quantitative changes in their SE identity, yet their resulting levels of interest in SE fields/careers were different. The case studies provide an in-depth understanding of how individuals internalize and develop their identities and the role that exposure to SE practices can have on this development.

Alice
Pre-Camp SE identity: Low Awareness of gender or ethnicity within a socio-historical domain of science careers as "not cool"

A few days into camp, Alice confided to her peers and teachers that she had grudgingly come to the camp because her mom had told her she "had to something educational over the summer".e She stated that she chose GIRLS because it appeared to be the "funnest-looking" of all the options her mother suggested. While Alice's mother, a single non-SE professional, pushed Alice in her summer academic pursuits Alice complained saying, she would rather have "stayed home instead" of going to camp.

This disinterested reaction to the camp combined with a sense of being forced to attend was compounded by her need to separate herself according to her perceived maturity to other participants. She expressed a socio-historical domain that science is not "cool" (Wortham, 2006) and stereotyped scientists: "When I picture a scientist, I picture someone in a lab coat with a pipette dripping it into a chemical in a test tube". In her post interview she re-verified these pre-camp stereotypes, "Before camp, I thought scientists were giant brainiacs who knew everything". Consequently, her local identity at the beginning of camp appeared to be someone who was not interested in SE combined with her socio-historical concept that scientists are nerds.

During Camp – Positive social interaction leads to changes in SE identification

Alice did not participate in activities or respond to questions during the first three days of camp. As the camp progressed, Alice began to demonstrate more of an interest and by the end of week one she was asking questions of all presenters and participated in discussions with her peers. Based on informal conversations between Alice and researchers, it became apparent that Alice had a genuine interest in science and a strong knowledge base, but she was worried about appearing nerdy. It took her a week to begin to see that her peers were interested and supportive of her interest in SE, which made her more willing to actively participate (Calabrese Barton et al., 2013).

It was through her exposure to both scientists and peers that were both smart and interested in SE that she began to see scientists in a different way. In her post interview she explained: "Scientists do not always work in lab coats, they can be interested in various things besides just their work, and they can use their imagination during their work". Through the camp experiences Alice began to show an increased willingness to express her interest in science. These observations were supported by the camp teachers during their post interviews.

The combined data collected from observations, participant and teacher interviews, allowed us to see the development of her trajectory during the camp. At the end of the first week, Alice began to feel more comfortable in expressing her competence in science by asking questions that demonstrated her knowledge base and that engaged SE professionals about pursuing SE careers, and the type of preparation she would need to work in particular SE fields. Her movement toward developing a more positive SE identity was evident even after the camp ended through her participation in other GIRLS events.

Alice's Identity Trajectory

Alice's identity trajectory during the camp demonstrates the complexity of identity development. Despite Alice's initial *indifferent* persona, we quickly learned that she and her friends are in fact good students who value academics and college. In both her pre survey and post interview, she described that her friends were very supportive of her academic pursuits and her interest in science – and yet at the beginning of the camp she acted as if SE was a nerdy occupation and interest. Her

mother, a health nutritionist, supports Alice's academic pursuits and expects her to go to college. The camp, with its exposure to the community of SE, improved her perception of scientists and helped her to see SE careers as a possibility. This was indicated in her post interview comments:

> [The camp] definitely made me more interested in science. Now I actually know things that you can actually do. Now I picture a scientist as somebody that has a passion to discover new things and change the way everybody sees things. [During camp] I just saw all…the different scientists who do different stuff and the way they talk about it, you can tell that they actually love what they're doing and that they're not just smart but they have fun.

Alice's comments indicate that her interactions with scientists and peers interested in SE positively affected her interest in SE (Calabrese Barton et al., 2013). These interactions within the community of SE allowed her to see examples of scientists that challenged her socio-historical model of scientists (Wortham, 2006). She was then able to better align her new perception of scientists, people who love what they do and have fun doing it, with her own local identity as a smart student who is interested in math and science and likes to have fun (Wortham, 2006).

Alice's identity as a good student could fit with her *indifferent* identity, just as Calabrese Barton and colleagues (2013) found. Being a good student has its own cultural and social norms within school settings. For example, girls – particularly white middle class girls as Calabrese Barton et al. found – tend to see being a good student as an accepted position because girls tend to score higher in classes. The constraint that Calabrese Barton et al. also found was that being a good student also meant sitting quietly in class and completing work on time. Alice's concept of a good student fit within these cultural norms. Before camp her ability to identify with science was negatively affected by her own stereotype of what scientists are like (e.g. scientists are smart but "not cool" whereas she was smart and "cool"). She provides an example of a student who originally found it difficult to combine her local model of herself with her perceived socio-historical model of scientists "as nerds" (Wortham, 2006). After the camp she saw how the scientists' varying identities could fit with her own local model of a popular and smart girl. This positive alignment was evident throughout her increased participation in camp and a stronger interest in SE careers.

Alice's improved SE identity trajectory did not lead to a full commitment to a SE career. This lack of commitment has three possible explanations: (1) the two week time frame for the camp was not enough to affect SE career decisions; (2) students in middle school are too young to fully understand career options and measures of career commitment are difficult at this age, or (3) career commitment may not be as important to positive SE identity as simply seeing SE and scientists as fitting in with one's own interests and identity trajectory. In other words, using middle school career commitment as an indicator for SE identity may not fully capture the reality of an individual's ability to identify with SE as a future career option.

Darren
Pre-Camp SE Identity – Compartmentalization built around the local domains of athlete, scientist/engineer, and good student.

Before camp, Darren was interested but not fully committed to a SE career. The school that Darren attended is a U.S. federally designated Title I school. Title I designates populations of low income students and provides these students free or reduced price lunches. For a school to have a Title I designation, 60% or more of the students must be eligible to receive free or reduced price lunches. Darren lives within the zone of this school, which is comprised of relatively low-income families. Darren articulated his own desire for his future by stating: "My goal is to have a better lifestyle than what I grew up on, for instance, a car, a house". This desire motivated him to think about college and possibly a SE career in order to make more money and improve his standing in society. All of the campers in the COED camp came from the same public school that Darren attended and many of them were part of the pre-International Baccalaureate (IB) program at his middle school and planned to continue with the IB program in high school. (The International Baccalaureate is a designation for pre-university courses of study that meet particular criteria.) Once students have taken the courses and passed the IB examinations, they receive an IB diploma. The coursework is rigorous and schools must earn their IB designation. Darren was friends with some of the pre-IB students that joined him during the camp but he himself was not part of the pre-IB program. Most of the students in the pre-IB program lived outside of the zone for this public school but attended it to be part of the prestigious program.

Darren was a successful athlete (varsity track and basketball), a good student (achieved all A's in coursework), and somewhat interested in SE fields. However, he could not see these various local identities (e.g. athlete, good student, SE professional) combining into one identity (Wortham, 2006). Instead, Darren compartmentalized these various identities (Syed, 2010). This compartmentalization was evidenced by a separate set of friends for each of his interest areas. During his interview, he described how his personality was affected by which group of friends he "hangs out with":

> I have no one group of friends, you know. I hang out with the general kids [non-pre-IB general education students], ESE kids [special education]…and the IB kids....you can't really group my friends as one type, cause they're all different. You would think I'm a totally different person or something because [it depends on] who I hang around [with]. What we do depends on who I'm with.

Darren seemed to believe that these various local domains could not be integrated into a whole identity (Syed, 2010).

During Camp – SE exposure does not challenge compartmentalized views.

Darren's SE interest was evident through his application to the camp and his consistent participation during the camp – asking questions and participating in

discussions with the various scientists and engineers. In his post interview he stated that science was probably his favorite subject, crediting his interest to his elementary school teacher. By tying his interest in science to an individual who made science interesting, he is removing his own interpretations from the scenario; indicating that science is only as interesting as the teacher who teaches it. This framing of his interest indicates a lack of individual agency in the process of developing a SE identity (Calabrese Barton et al., 2013).

In addition to the compartmentalization of his friends and interests, Darren also held stereotypical views of SE professionals. On his pre-survey he described SE professionals as "someone with a tool, building something or someone in a lab mixing different things together". And his responses did not change in his post survey where he stated that a scientist is "a person with a lab coat on doing research". Despite these stereotypes in his survey responses, in his interview Darren described scientists in a slightly less stereotypical way. "I always describe a scientist as a very smart person trying to better life for us and it may be exhausting research but it's gonna be worth it in the end." In this comment, Darren began to explain one of the conflicts he had with scientists/engineers and their work. Darren was uncertain about the perceived time commitment scientists/engineers had to put into their research:

> Most of the scientists here [at the national lab] sometimes stay
> overnight, just to get the job done. I like science. I like working with
> my hands and everything. But the long hours, that's a turn off.

Due to the experiences and interactions Darren had during the week of camp, his view of SE careers became blurred in that he saw the benefits these individuals can bring to society but he did not see the work as worth the long hours. He believed that all careers in SE required long hours—an idea that then deterred him from fully committing to a SE career.

Another conflict Darren had in terms of his SE identity was his perception of the types of people who become scientists:

> I guess the smarter people [become scientists]. I would say that, the
> higher people, the people that make better grades in science [are
> those that will become scientists].

Darren further described the type of people that go into SE as:

> Most IB kids are more geared towards science fields. Most general
> [class] people aren't, you know. They're probably worried about sports
> and stuff.

This comment re-articulates the compartmentalization of his peer circles (Syed, 2010). Darren saw himself as smart and capable of taking advanced classes, and yet, he had not taken any of these yet. To compound this, he also saw the "higher people," meaning the students in advanced classes as more likely than those in

general classes (himself) to go into SE. This view further prevented his SE identity trajectory from moving forward.

Darren's Identity Trajectory

Darren's SE identity did not show significant positive improvements during the camp, in fact it became more muddled. In his description of advanced students, he described them in a way that was negative to his own local model of a student who embraces multiple types of people and wants to be challenged. Instead he described the pre-IB students and teachers as follows:

> It's like the teachers, even the kids seem to think they're smarter, you know. Like they try to flaunt their knowledge out to everybody, like they're smarter than everybody. And I will just be like, well I can't say you're not smarter than me, you take advance classes so it's not my fault that we didn't get the same knowledge or opportunity to get the same knowledge. So, I guess that is a division.

Even during the camp activities and tours, Darren exhibited physical manifestations of being on the periphery (Calabrese Barton et al., 2013). It was obvious based on his questions and vocabulary that he was very knowledgeable about SE and not afraid to pose questions to both scientists and engineers. These questions also demonstrated his curiosity and interest in SE. However, during the tours, he stayed at the back of the group and sometimes did not even enter smaller exhibits. His camp teachers supported these observations in their post interviews.

One reason for his conflicting identities could be that his mother and family did not support him in his academic pursuits. Darren explained that his grades in middle school qualified him for the pre-IB program but his mother was not supportive of him joining:

> My mom said "don't do any pre-IB classes…it's going to be too much work, you might as well just take general". So I did. I kinda regret it, but at the same time, I don't think I woulda been the same person I am right now if I didn't take general classes. But I know IB classes had more to offer, more things that coulda benefitted me.

This lack of academic support from his mother may have simply been because she did not understand how the tracking system of middle and high school classes feed into college majors or that she did not fully understand Darren's desire to be challenged by his classes. Darren explained during his interview that he did not discuss academic matters with his family. When he was asked whether his family would support him if he chose to become a scientist, he said they would be "shocked". This comment provided further evidence of the compartmentalization of his various interests and identities: keeping his academic pursuits in one group, his athletic pursuits in another group, and perhaps both of these identities separate from his family life (Syed, 2010).

Despite this lack of family support, Darren was interested in taking advanced classes due to the challenge that the higher level courses would provide. Darren did however find support among his peer group. He explained that these friends would not be surprised by his interest in SE stating: "They already tell me that I should be a scientist when I grow up". Darren maintained a muddled trajectory unable to connect two local domains: non-academics versus academics (Wortham, 2006). During the camp we did not observe that these two worlds ever came together which could indicate that Darren will eventually have to choose between them, affecting his decision to pursue a SE career (Calabrese Barton et al., 2013). Darren represents the extremely difficult domain crossing that occurs for students, in their decisions regarding SE pursuits (Ong, 2005; Wortham, 2006). We would like to note that Darren never discussed his race as central to his career decisions or identity. Additionally, like Alice, Darren may be too young to fully understand the educational requirements of a SE career, but unlike Alice, he seemed to have less of a sense of himself as the type of person who does SE, despite being competent in the subject.

Sarah
Pre-Camp SE identity – Low awareness of gender within an internal perception that she is dumb.

Sarah had a definite interest in SE as evidenced by her application to GIRLS two years in a row, despite not being accepted after her first application. In her pre-survey she expressed how excited she was about the camp and learning more about her desired career of being a veterinarian. Sarah did not perceive herself as popular like Alice or Darren. She believed that she struggled socially in school, claiming she did not like many of her peers. "I hated my school because everyone was mean to me. It was one of those snobby schools only for the rich people". This comment demonstrated her perception of self as "not rich". Sarah lived with her grandparents but saw her parents regularly. Her mother worked as a state worker and her father worked in a sales job. Sarah appeared much closer to her grandparents than her parents and they are actively supportive of her goal of attending college. However, regardless of their support they also seemed to give her pragmatic advice when it came to her career interests. When she told her grandparents about her goal of becoming a veterinarian, she said they often responded by saying things like: "Well great, but you might end up going for a different career" or "That requires a lot of schooling". Although these comments could just be a way for her grandparents to tell her to keep her options open and/or avoid disappointment, Sarah herself interpreted these comments as evidence that her family did not think she could succeed as a veterinarian. Consequently, Sarah's local SE identity was conflicted in that she wanted to succeed but sensed that she might not be able to due to a lack of confidence in her abilities (Wortham, 2006).

Sarah's local conflicted identity was further affected by her socio-historical belief that one had to be naturally gifted in math to succeed in science. Sarah's camp teachers and the researchers observed Sarah often apologizing for being "*dumb*" or describing herself as "*dumb*" at least once a day during the first week of camp. And yet, she was enrolled in all gifted and honors classes in school. Her local domain

appeared to be that of a good student: spending much of her free time doing school work, taking advanced classes, and doing well in these classes similar to Alice. The only subject that she feels she struggles in is math. Sarah's local domain was that of a person interested in science, and yet she recognized the conflict between her struggles with math and her desire to become a scientist. During her interview she said, "you can't be a scientist without math, and you can't really be in math without science". Consequently she acknowledged the conflict she had and that they could prevent her from achieving her goals of becoming a veterinarian.

During Camp – Positive interactions with SE professionals leads to changes in SE identification

During the camp Sarah's SE identity trajectory improved due to an improved confidence in her academic abilities. This change was evident in her qualitative data, teacher observation data, and the quantitative data. Her quantitative Likert score for math and science confidence showed the largest increase of any other participant - two standard deviations. The teachers also supported these positive changes through comments in their post interviews. Sarah's interactions with a female veterinarian allowed her to see that she could succeed in her chosen career path if she worked hard in her classes. These interactions allowed her to improve her sense that math was not something she was simply not competent in rather it was a skill she could develop.

Sarah's Identity Trajectory

Sarah's career goal was based on her desire to help animals, a part of her local domain (Wortham, 2006) and extrinsic motivations of wanting to prove to her family that she could do it:

> I want to be a vet because I love animals and science. It is important to me because I want to show my parents that I am smart enough to get into vet school and I love the idea of helping animals.

Yet, just like the other cases, Sarah's trajectory was more complex than mere interest could explain. Although Sarah wanted to be a veterinarian at the beginning of camp she did not see herself as the type of person who succeeded in this field due to her doubt in her math abilities. This sense of doubt was exacerbated by the stereotypical views that scientists are naturally good at math.

Sarah struggled with her own belief that she was the type of person who could succeed in SE because of her doubt in her math abilities and her original stereotypical view of SE professionals (Calabrese Barton et al., 2013). As evidenced through these observations and Sarah's interview and survey responses, along with her quantitative score on SE identity, Sarah had the largest transformation in her SE identity trajectory. She saw that her local domain of wanting to be a veterinarian could work if she was motivated to work hard in her math and science classes (Wortham, 2006). For Sarah, the interactions she had with scientists during

camp in the community of SE – particularly the veterinarian – helped her to see how her local identity could fit within the field of science. Despite the improvement in Sarah's SE identity made during the camp, research suggests that if she experiences struggles in her math courses, she may revert back to her belief that she cannot succeed in SE (Williams and Ceci, 2007). Sarah, like Alice, did not see her gender as central to her identity or career decisions (Syed, 2010). Sarah's persistence in SE will depend on future confirmations that she can be successful, including support from her family and friends (Calabrese Barton et al., 2013). At the point of this study, Sarah did not mention any close friends and she also interpreted her family's career advice as lack of support, two realities that negatively impact her persistence. Sarah highlights the complexity of identity as it relates to social interactions and the support of socializers. Like all of these cases, it will be beneficial to follow them longitudinally to see how their SE identity trajectories expand and contract over time.

DISCUSSION

The question that drove this study was: how do students from underrepresented groups construct their SE identities after exposure to SE role models and careers? Each of our case studies exemplified the complexities within the process of constructing SE identities, and each highlighted the ways in which an informal SE education program can improve (Alice and Sarah) or stagnate (Darren) SE identification. Each of these students existed within specific socio-historical domains and local domains prior to their camp participation (Wortham, 2006). For all three participants, the pre-camp local domains appeared to be in conflict with their perception of SE professionals and SE careers, ultimately affecting their abilities to fully identify with SE. None of these participants discussed the broader socio-historical domains that prevent minorities from persisting in SE fields (Calabrese Barton et al., 2013; Syed, 2010). This could be because the study was not longitudinal and we were therefore unable to observe the negotiations that occur in the process of college major and career choice.

The common theme across the three cases was self-perception as the type of people who succeed or want to succeed in SE fields. For these three participants, their race/gender/ethnicity was less important to this decision than their sense of being smart enough or seeing the SE careers as worth the cost. For Alice and Darren, the cost was being seen as nerdy and the long hours required for success, respectively. Camp participation helped Sarah and Alice overcome their negative perceptions of math competence and SE professionals, respectively. Alice was able to see that she could be popular and yet still be a scientist. Sarah gained confidence through her interactions with other participants and her experiences with the female veterinarian. For Darren we were able to see the role that compartmentalization plays in SE interest and identity configuration (Syed, 2010). Darren's inability to see his various interests/identities as fitting together could potentially cause him to lose interest in one of them.

Alice appeared to develop a strong SE identity, which shifted her belief in the socio-historical domain of scientists as nerdy. Her exposure to practicing scientists and

like-minded peer groups helped her to see that multiple domains can be simultaneously enacted (Calabrese Barton et al., 2013; Wortham, 2006). Therefore, for Alice, participation within such a setting allowed her to renegotiate her own personal identity around SE. This experience was similar for Sarah, who showed improved trajectories in her perception of scientists which helped her to renegotiate her views and more fully situate them within her own local domain (Calabrese Barton et al., 2013; Wortham, 2006). However, she also exhibited the conflict that occurs for young women who struggle with the socio-historical domain of men being naturally better at math and/or science (Calabrese Barton et al., 2013); and struggled with the idea that in order to succeed in science, she would need to also succeed to some degree in math. Sarah's exposure to scientists allowed her to gain confidence in her abilities and also negate the impact of both internal (her lack of confidence) and external (family members who did not support her goals) factors in her daily life domain (Calabrese Barton et al., 2013; Wortham, 2006). In this way, the camp experience allowed her to renegotiate her identity around scholarly abilities and to increase her confidence through acceptance from both her peer group and scientists. On the other hand, Darren highlighted the largest gap between his local identity and a possible SE identity in that he did not think he was like the "smarter" students who pursued SE careers. Part of the reason for Darren's gap between local identities could be that he was not exposed to African American SE professionals. Despite an attempt to find a variety of professionals to work with students, the camp did not have an African American male mentor. This could have strengthened Darren's continued compartmentalization.

CONCLUSIONS

This study shows the complexity of how students can develop their SE identity both socially and individually. In particular, it highlights how these social and individual interactions occur on a personal level and can shift due to small interventions and particular social interactions. There are two limitations to this study. First, we focus on one intervention that is part of a much longer identity trajectory. A longitudinal qualitative study would allow us to more fully understand the ways in which these individuals interpret and renegotiate their own identities over time; allowing us to better understand how the interactions within this camp play into their larger SE trajectory. In addition, we recognize that social context matters (Deaux & Major, 1987; Wortham, 2006). Each of these camps was different in terms of some of the activities and the fact that one was co-educational and one was single-sex. We recognize that these differences can have effect on participants' social interactions and gendered performances. However, we could not test how Darren would respond in an all-male environment or how Sarah and Alice would respond in a co-education environment because of the structure of our study. Despite these limitations, these findings are useful to science education research and informal science education program developers because it is one of only a handful of studies that use an identity lens to describe how an informal SE education program can influence the SE identification of adolescent students. However, there are limitations.

Few studies provide in-depth coverage of a potential turning point in SE identification as it is occurring. Knowing how students internalize aspects of

programs that expose them to SE role models and careers, allows program directors to improve programs by providing opportunities for overcoming misconceptions about SE fields and exposing students to role models who can challenge perceptions (Polman & Miller, 2010). In addition, this study highlights the idea that minority status may not be as crucial to SE identity development – at the adolescence age range – than local domains related to SE competence and perceptions of SE careers (Wortham, 2006). Future studies could build on this work and improve the conceptual framework regarding SE identity formation in middle school students particularly in informal education settings where they are able to interact with scientists and engineers.

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