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I Lead, Therefore I Am: The Impact of Student-mentor Leadership Opportunities on STEM Identity Development and Sustainability

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Abstract
The national imperative to increase the production of computer science and engineering professionals has garnered the attention of both public and private sectors of the economy. As such, private companies, such as Verizon have begun to fund what they call Innovation in Learning (VIL) initiatives that aim to increase participation in these fields. Initiatives such as these, also recognize the need to diversify the engineering workplace by focusing specifically on engaging, inspiring, and motivating underrepresented minority (URM) youth by exposing them to engineering and other STEM concepts. During summer 2017, a southeastern university participated in hosting one of the seventeen Verizon sponsored STEM Camps. The university hosted 144 URM middle school boys for three weeks on campus to explore engineering habits of mind, engineering design principles, and computer science application development fundamentals. The camp was primarily facilitated by fourteen student mentors. One of the principle elements of the camp was to have mentors that reflected the demographics of the student population. As such, the mentor demographics consisted of 12 URM male mentors and 2 URM female mentors. Upon conclusion of the summer camp all of the student mentors were asked to participate in an open-ended survey that inquired about their experiences as student-mentors. The research questions guiding this study were: What role does race and gender have on the development of student mentor relationships? What are the implications of those mentor relationships on STEM identity development of the student-mentors? These research questions were answered through the use of thematic analysis, yielding two main themes: 1) barriers and connections associated with race and gender and 2) development of role identity - specifically the sub-constructs of performance/competence and interest. The results of this study suggest that engaging in mentoring relationships, while motivated by altruistic desires, strengthened STEM role identity development of the student-mentors. Previous literature has demonstrated that salient STEM identity development can contribute to persistence in these fields. Promoting engagement in mentoring opportunities, like summer camps, could aid in increasing and sustaining URM STEM majors.

Introduction
In order for the nation to continue its prominence in a global market, many scholars have deemed the need to increase the participation of underrepresented minorities (URM) in engineering and other STEM related fields imperative[1]. This push to increase the participation of URM has launched efforts at the K-12 through graduate level[2-8]. Within the K-12 space the national academies have deemed the need for equity and diversity in science and engineering a priority for the nation, labeling it a “democratic ideal worthy of focused attention”[9]. This call to action was made when they published their K-12 Framework for Science Education[9]. The government, however, is not the only sector focused on increasing the participation of URM in STEM fields.

Private industry has also begun to recognize the value and necessity of diversity in the engineering workforce, spawning over $164.2 billion in diversity initiatives at private companies in recent years[10]. These initiatives include everything from bias training[11] that addresses company culture, policy, and hiring practices to community outreach with the goal of engaging the next generation of STEM professionals[12].

One such program is the Verizon Innovative Learning (VIL) program. The Verizon Foundation has developed an outreach initiative focused on increasing interest in STEM fields through experiential learning opportunities. While VIL has a number of initiatives, the focus of this summer camp and study was minority males, namely African-Americans and Latinos, due to their low representation in most STEM fields. Although the number of science and engineering bachelor's degrees awarded to minority males increased 45 percent in 2012, minority men as a proportion of all science and engineering bachelor's degree recipients has remained essentially unchanged, at 6.1 percent in 2002 and 6.2 percent in 2012[13]. Census data show that while African-American men make up 6.2 percent of the population between 18 and 64 years old, they represent 3 percent of the scientists and engineers working in those fields[13]. Meanwhile, Hispanic men comprise 7 percent of scientists and engineers working in those fields[13].

In an attempt to garner more interest in STEM fields of Hispanic and Black males, a summer camp was developed that not only served the Black and Hispanic populations of the local community it was also facilitated largely by minority male engineering, computer science, and STEM education undergraduate students. Leveraging existing literature around the impacts of mentorship and, more specifically, same gender and same racial/ethnic identity mentorship as a factor in garnering interest in STEM of minority middle school boys, the camp leaders were deliberate in their pursuit of minority male and female mentors. The camp leaders recruited and hired student-mentors that were representative of the students served - minority male undergraduates. The aim was to surround the minority middle school boys with role models and mentors that reflected their image and background. An unexpected benefit of this model of same gender, same racial/ethnic mentorship was the increased salience of STEM identity in the student-mentor upon completion of the three-week STEM camp.

Literature Review

In the attempt to better understand representation in STEM fields, scholars have begun to explore the diverse factors that increase participation, graduation rates, and ultimately, persistence of students including the role of mentorship[14,15]. Within this space, research inquiries have posed questions largely focused on: how mentor relationships help students and why should mentor relationships be studied[16]? The current body of literature acknowledges that mentorship relationships are often mutually beneficial for both the mentee and mentor[15]. Likewise, scholars have reported the benefits of same gender/same race mentoring relationships[17,18]. Scholars such as Wright and Wright[19], contribute to this body of literature by keenly observing the implications and benefits of same gender and race mentor relationships reporting findings that suggest that, within same gender and race mentor relationships, there are improvements (among the mentors) in: communication skills, confidence and identity. That same study noted that mentors benefit from passing knowledge to their mentees and developing a legacy[19]. Given the role that mentors play as "teachers", there is also an academic gain, one in which mentors improve or solidify their skills and previous knowledge in their subjects (the affective academic). When exploring mentoring relationships of women (to women), one research study reported that such mentoring relationships helped women feel less isolated and experienced decreased fears of failure in male dominated fields[17]. These benefits of mentoring have also been expanded to identity development and salience[20]. Largely in the domain of business and leadership, scholars have suggested that mentoring and identity are connected. Identity scholars that believe that identity is malleable and fluid also ascribe to the idea that identity is influenced by social and cultural factors, such as discourse and relationships; in this case mentoring relationships. This research study leverages the work of these scholars to explore the implications of same race/same gender mentoring relationships on identity salience of mentors. As such, the research design aims to analyze the implications of mentorship on the mentor rather than the mentee by answering the following research questions:

1) How does gender and race play a role in the development of student mentor relationships?
2) What are the implications of those mentor relationships on STEM identity development of student mentors?

Theoretical Framework

Social identity theory provides an established theoretical framework that has been utilized effectively in science and engineering education research for understanding participation in science, engineering, and other related fields[21-28]. This form of identity exploration is considered role identity and can include roles such as physics, chemistry, engineering, science (more broadly), researcher, etc. Engineering education scholars have successfully transferred the operationalization of role identity to engineering in order to better understand the impact of identity on engagement, retention, and persistence in college and industry[24-28]. Researchers have measured identity in their participants through the ways in which they talked about engineering, how they acted/participated in the engineering world, how they described being in the engineering world (classroom)[27], how they described themselves[26-28], and how they related to others in the community[23,25,29].

Identity theory has also been used as a predictor for persistence in the context of physics and engineering[28,30]. These same scholars have disaggregated identity in to three sub-constructs: performance/competence, interest, and recognition[28]. Their work has defined performance/competence as a person's perception of their own performance or competence in a field of study. Meanwhile, interest is defined as a person's perceived interest in a field of study.

Lastly, recognition is the measure of a person's perceived level of recognition by others of their ability or role identity. Recognition can be given in the traditional sense - awards, accolades, and grades or in a less traditional sense - other's asking for their help in a class or subject.

Identity development and sustainability have also been linked to participation in a community[31]. In science and engineering education these communities were explicitly learning communities[31]. In those learning communities there are often peer-to-peer relationships as well as mentoring relationships. Research suggests that mentoring relationships aid in developing and sustaining role identity development in the mentee[20]. Leveraging social identity theory, more specifically role identity, this study was designed to better understand the perceived impact of mentoring on identity salience of the mentor. In particular the research team was interested in the interplay between social identity and role identity in the mentor-mentee relationship.

Design and Methods

In the summer of 2016 a southeastern university hosted a Verizon Innovation in Learning Summer STEM Camp for three weeks with 144 minority middle school boys in attendance. The camp was on the university campus Monday through Friday, from 8:30 a.m. to 3:00 p.m. The camp was facilitated by 16 minority undergraduate STEM majors, of which 14 participated in this study. There were thirteen undergraduate STEM majors and one graduate STEM major.

The camp was designed with two student mentors assigned to a class for the entire three weeks. They mentored on average 25 - 40 students each day. The student population they served were 87% free and reduced lunch recipients from diverse ethnic backgrounds (51% Hispanic, 17% Black, 13% White, 4% Native American, and 16% Multi-racial) that were transported by bus from their respective schools daily. The student-mentors, likewise, reflected the demographics of the students with 40% Hispanic, 44% Black, 13% White, and 6% Asian. And while the campers consisted of only males, there were three female student mentors. The student-mentors received a two-day training prior to the beginning of the camp in order to familiarize them with the curriculum. The curriculum consisted of engineering habits of mind, design thinking, 3-D design and printing, and foundations in computing. The student-mentors themselves majored in various engineering fields, computer science, and science education. The camp was designed and structured to expose local students to STEM curriculum and provide role models or mentors in the space that reflected their demographics in order to garner interest in the STEM fields.

Methodology

In order to capture the experiences of the student-mentors from the camp a nine question open-ended survey was developed to explore past STEM mentoring experiences, expectations of the camp, identity (race, gender, and role), and the perceived impact of mentoring on role identity. While this was not a validated measurement tool, it did provide insight into the perceptions of the student-mentors that participated in the camp. Each student-mentor was asked to complete the survey upon completion of the camp. All participants signed an IRB-approved consent form and were assured of anonymity. There was an 88% participation-rate by the student-mentors. The surveys were analyzed using thematic analysis leveraging both inductive and deductive coding. The deductive codes were centered on the sub-constructs of identity - performance/competence, recognition, and interest. Meanwhile the inductive coding allowed for the emergence of themes, such as - altruism, race, and gender. These categories, evidenced by quotes, provide a rich description of the students' perception of the impact of race and gender on their mentoring and the impact of mentoring on their own STEM identity development or salience.

Findings

Almost all of the student-mentors from the summer camp entered the camp with some sort of STEM identity. Their different ways to and through STEM resulted in identities that ranged from physics, math, engineering, to computer science. Only one student mentor answered "no" to the question of whether they saw themselves as a math, science, computer science, or engineering person. All of the other student-mentors felt as if their previous life experiences - coursework, community, or major contributed to their ability to identify as a STEM person or having possessed a STEM identity. The findings that were most prominent in their discussion of identity was the impact altruism (in this case mentorship) had on strengthening their role identity salience. This altruistic endeavor was, in some cases, undergirded by racial and gender similarities with the student population they were mentoring.

The findings of this study are presented by first demonstrating the variation in the acknowledgement of STEM identity by each student, evidence of the identity sub-constructs - performance/competence and interest, the role race or gender was perceived in mentoring dynamics, and the implications of the opportunity to mentor on identity salience.

Role Identity

When students were prompted to talk about how they perceived themselves situated in the world of STEM, their responses ranged from *I study STEM, therefore I am* to very thoughtful reflective self-assessments that reflected the sub-constructs of perceived performance/competence (**bold**) and interest (<u>underlined</u>) in their respective STEM field.

> *Yes, I've studied engineering since high school all the way up to my junior year of college before switching to physics.* ***I'm not the best at math*** *but a little practice never hurts, since the engineering I studied in college was computer engineering was a bulk of computer programming style courses I'd say* ***I'm pretty proficient in computer science*** *as well (11).*

> *I am definitely more of a mathy computer science person.* ***I've always been great at math*** *since I was in elementary school, which has helped further my studies in computer science. I enjoy solving problems using words and math and I find it particularly useful in solving society's problems (2).*

> *I consider myself a math, and a computer science person. Math has always been the class I enjoyed the most* **since math makes a lot more sense than other classes**, *and is not all about memorization. And Computer Science person because I love to create things and solve problems. I believe it's more about the combination of the two that make me like computer science (4).*

> *Yes,* ***I think in a logical way using the concepts and theories of math, science and engineering****. I have studied these subjects for four years and* ***have adopted them as my main process for dealing with information and situations*** *(5).*

All of the participants of the study ascribed some STEM identity to themselves. Some participants elaborated on the factors that contributed to this identity such as, prolonged exposure to content, personal performance in the subject area, and genuine interest in the discipline. However, the guiding question to this study was how did their experience in the summer camp program influence this identity? Most of the students talked about how this altruistic opportunity, coupled with racial and gender similarities further strengthened their identity through increased perceived performance as a presenter of the material, increased passion for the subject, and a desire to help kids like them, see themselves in STEM.

Increased identity salience

Most of the student-mentors believed that explaining the complex concepts associated with engineering and computer science improved their overall understanding of the materials as well as contributed to their confidence in the area. Some saw this opportunity as the biggest test of their content knowledge. They had to understand the material enough to present the material, ask meaningful questions, and spark interest. Some commonly noted side effects were also increased comfort with public speaking and teamwork.

> *This program definitely made me a* **better "public speaker"** *and allowed me to build my confidence for speaking in front of large crowds. [...] I also feel it helped me improve my teaching skills. Asking the students tons of questions is essential and a great way to teach a concept. I definitely learned that from this camp. It also helped me to be* ***more assertive and improve my teamwork capabilities****. I found myself explaining concepts to students that I wasn't particularly well-versed in with a passion that I didn't really know that existed. I wanted the students to understand how things worked, especially now that we live in a world where we can know anything at the press of a button. I wanted them to*

know how that button worked, how a computer works, what the internet is, how servers work, etc. It made me realize that this stuff really is important and that while I may not be fluent in more programming languages that ***my knowledge of these subjects is strong*** *and I feel passionate about them (2).*

I have become ***a more comfortable public speaker*** *and have become* ***better at explaining concepts. Having to explain computer science and engineering concepts to kids made me learn them even more.*** *(4)*

My experience as a student-mentor has made me even more confident that my interest of computer science keeps growing every day. My reasoning behind this is because of the way I would feel when ***teaching computer science concepts vs. non-computer science concepts****. I would feel much more comfortable, passionate and even proud when teaching the children about computer science (3).*

I was excited to show the kids these concepts and I could see they didn't care, but I was happy to do it since I liked the concepts (4).

Most of the students articulated that their participation positively influenced their belief that they were a STEM person. Translating their STEM content knowledge to a middle school audience with varying interest, while difficult, provided them the opportunity to demonstrate their own understanding of the material. This challenge increased their passion or interest in the subject matter and increased their confidence and perceived performance in the domain of STEM.

Altruism

The motivation for participating as a summer camp student-mentor differed from student-to-student including financial need, alignment with background (education), or desire to help out. Regardless of the motivation, all of the students mentioned an altruistic reward associated with their participation in the summer camp.

I think that I may have inspired 2 or 3 students to pursue STEM options when they go to high school but it's much harder than I expected to do this because my group, in particular, had so much against them. (9)

These students motivated me to keep helping them because, really , if only three guys from every group take what we give them to the next level, then we're good! (5)

I believe it changed me. It gave me a greater emphasis that I am at a point in my life in which I have to take command of my life and better influence the lives of future generations. (8)

I don't think I want to be a teacher, lol. But I would like to continue to give back in this capacity. (9)

As mentioned, the motivation to participate in the summer may not have been precipitated by a desire to "give back" but after being involved in the camp they now had a strong desire to influence or inspire STEM interest in other young people.

Race and Gender

Another guiding question of the study was - How gender and race influence the development of student mentor relationships? This question was complicated by many factors. The student-mentor population was diverse with regards to race and ethnicity, as was the student population. This resulted in a range of perspectives on how race influenced relationship development between mentors and mentees.

Yes, most of my kids were black males, I'm a black guy, in terms of that we related pretty well, and didn't have many issues in terms of being able to respect each other (1).

While it is possible that, on a subconscious level, my gender and race may have impacted my experience with the summer camp, I currently do not really feel it did. Whenever I was interacting with the children, I felt very comfortable and I felt like I was at home. This is most likely because I grew up around other children, especially boys, who were also Hispanic (3).

I feel my gender and race did influenced the way I experience the camp. It helped confirm the narrative that it is possible for the kids to enter STEM fields (3).

At times it seemed like my race helped me connect to the Latino students (4).

Absolutely, it hits home for me because I come from a similar situation since I am a minority (8).

Yes, as a black male unfamiliar with the cultural experiences of the Latin/Hispanic community my experience was somewhat limited in connecting with students. I was not completely uncomfortable, but they were certainly some barriers in helping the students understand the relevance and relatability of the content being discuss (13).

In some cases, student-mentors believed that race did not influence their experience at the camp. Meanwhile, others saw the racial similarity as a means for establishing relationships with the students because it made them more "relatable." Likewise, a student-mentor articulated that his difference from the majority of the student population made him less capable of connecting with the student population. Similar findings emerged when exploring the role of gender in connecting with students at the camp.

> *I don't feel that my gender influenced the way I experienced camp that much. Being a female in a group of mostly males was intimidating at first, however, I felt I had just as much authority as my male peers. My students listened to what I had to say just as much as they listened to my male partner. I definitely feel that it helped the students because they might not necessarily know that women are also figures in engineering and computer science, so that was a bonus (2)!*

> *Yes, being a male made it easier for me to bond with the students and understand what they are going through (11)*

Conclusion/Discussion

As aforementioned, there is an ongoing initiative across the nation, within private and public sectors, to increase participation in STEM professions. As such, our study was motivated by the necessity to better understand how mentoring relationships could contribute to the persistence of minority undergraduate STEM students through the lens of identity. The student-mentor participants of this study shared their self-ascribed STEM identity (or lack thereof), their perceptions of the role of race and gender on their mentoring relationships, the impact of the mentoring experiences on them as mentors, and their increased desire to participate in altruistic opportunities.

Most student mentors self-identified as having a STEM identity. They attributed this identity development to past and present experiences, performance, and interest. Most of the student mentors also discussed feeling more comfortable engaging with their mentees with shared races and ethnicities, attributing this comfort to ease of connection with their students due to having the same race or ethnicity and also having an easier time gaining respect from their students. Scholars have long noted the benefits to mentees of this sameness mentoring relationship[15,18,32]; however, the results of this study suggest that such dynamics enable mentors to readily and easily move into the mentoring role because the barrier to connection is lessened. This was important given the short duration of the camp - three weeks. Mentors described feeling as if the sameness allowed them to relate to their mentees, arguably making empathy and translation of the content to a context that the students could relate to an easier transition. This is noted by the one student-mentor that felt his race/ethnicity was a barrier. As a black man he felt like he could not relate to and transfer content to a context that the Hispanic students could find relatable.

In regards to role identity, we saw an increase in performance/competence as well as interest amongst the participants. First, considering performance/competence, student-mentors indicated that by being placed in the role of teacher, they were given an opportunity to improve the foundations of their knowledge. By doing this, student-mentors became more confident in their performance in their role identities. Second, the construct that increased the most was interest. By sparking interest in other students, as one mentor noted, mentors found their own interest increase. This finding suggests that summer camps and learning initiatives that have student-mentors in mentorship roles strengthens their STEM identity. This is in alignment with the minority engineering program (MEP) research by Good[15], that stated that acting as a mentor in MEP programs could be a mechanism for retaining minority students in undergraduate programs. This altruistic act of helping others in the domain of STEM and more specifically same race/ethnicity mentoring relationships has positive implications for the retention and persistence of URM STEM students.

This leads us to the final emergent theme of the study, altruism. All of the student-mentors mentioned their growing need to encourage and inspire those coming behind them. Whether they volunteered for the effort for reasons beyond "giving back" they all remarked how this experience inspired them to be more engaged with others like themselves in order to share their passion for STEM and encourage others to see STEM as an occupational pathway. Similar findings were uncovered by Ko and colleagues[33] when they found that women of color that persisted in careers in science did so by participating in altruistic activities tied to their profession. This included recruiting, talking to students about science as an occupation and mentoring junior scientists[33]. Historically, participation in altruism has been viewed as less than a priority within the profession of engineering[34]. This diminished value of altruistic efforts has largely been leveraged to penalize underrepresented minorities in engineering (e.g., women and people of color) at all stages (e.g., academy, industry, etc.)[34]. This is unfortunate for two reasons: 1) URM often feel compelled to act as mentors to others like them in order to influence the demographics of the profession[18]; 2) the findings of this study suggest that participation in such mentoring capacities has a positive impact on STEM identity development.

The findings of this study culminate in the importance of initiatives like the Verizon Innovative Learning program to mentors (undergraduate STEM student) and the mentees (curious middle school students) alike. Providing an altruistic opportunity for URM undergraduate STEM majors to share their content knowledge and passion with young people with shared racial and ethnic identities not only potentially inspired young students to consider an occupation in STEM but also increased the identity salience of the mentors. This opportunity not only brought about an interest in STEM in younger generations, but also potentially cemented the STEM identities of currently engaged students to ensure that we not only have a graduating class of today but a future class of tomorrow.

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