

# Encountering and Becoming Role Models: Combating Underrepresentation in STEM

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**Abstract:** Neuroscience Education Outreach (NEO) is a program sponsored by a large public university located in the mountain west region of the United States which employs undergraduate students pursuing degrees in Science, Technology, Engineering, and Mathematics (STEM) to perform outreach and be liaison to community and university partners. Undergraduate instructors perform roles of preparing and teaching age appropriate lessons in local classrooms, thus brokering relationships among the university and K-12 students. Three case studies show how, through participation in outreach, undergraduate instructors from groups historically underrepresented in STEM are positioned as neuroscientists and gain professional skills which contribute to the development of their personal and professional identities in their STEM field. By using the Zone of Proximal Identity Development (ZOPID) framework, I analyze how identity development occurs incrementally within an authentic outreach community setting.

**Keywords:** Community Engagement, Outreach, Informal Learning, Identity

## Research problem

There is a considerable lack of similar role models for women in Science, Technology, Engineering, and Mathematics (STEM) as (white) men make up the majority of STEM faculty in universities in the United States (National Science Foundation, National Center for Science and Engineering Statistics, 2013); and women are also more likely to leave STEM majors as compared to their male peers (Strenta, et al., 1994). Along racial lines, representation of women of color in STEM is further limited. According to the NSF (2013), White women comprised 20% of the STEM workforce, Black and Hispanic women made up 2% respectively, while Asian women comprised 5% of the STEM workforce and 1% of women who self-selected “other category” comprised the US STEM workforce.

This gender and racial disparity in STEM may signal to women they do not belong or cannot succeed in these fields (Walton & Cohen, 2007; Hermann et al., 2016). And because women entering STEM fields tend to underestimate their self-efficacy (Correll, 2001; Meece et al., 1982; Deaux & Emswiller, 1974), non-stereotypical role models, or historically underrepresented role models in STEM, have been thought to improve female students’ sense of self-efficacy and success in fields of STEM. In fact, in a psychological study examining effects of stereotypes, Cheryan et al. (2011) found differences in women’s sense of self-efficacy in STEM were mediated by the perceived dissimilarity from stereotypical role models. In addition, female role models have been shown to increase retention of women in STEM fields (Hermann et al., 2016); therefore, work on the effects of seeing one’s self as a STEM role model for women and minorities needs to be further explored.

Studies have also shown women and minorities in STEM are more likely to succeed in institutional environments with social and academic support systems such as mentorship opportunities (MacPhee et al., 2013). In a study conducted by Griffith (2010) using data from the National Longitudinal Survey of Freshmen (NLSF) and the National Education Longitudinal Study of 1988 (NELS:88) fewer women and minority STEM students persisted in their majors as compared to male and non-minority students, however differences in persistence also correlated with differences in college preparation and educational experiences. Institutional characteristics and opportunities for women of color in STEM to frequently engage their peers about course work, to be involved in STEM-related student organizations, and have access to participate in undergraduate research programs can positively impact female and minority student retention in STEM (Espinosa, 2011).

Finally, outreach programs have been shown to play a crucial role in the engineering education of graduate and undergraduate student instructors by fostering communication skills, leadership skills, and self-confidence among women who participate in delivering outreach (Pickering et al., 2004). Community outreach and engagement thus provides a perfect place to explore how participation in STEM related programs in an institution support undergraduate STEM education and professional identity development. By having nondominant students discuss their experiences, educational researchers can better understand how outreach is taken up by those students and what effect participation in outreach has on students and their identification with STEM. The purpose of this paper will be to examine, through case study, how individuals underrepresented in STEM participated in outreach, leading to their own development as “non-stereotypical” role models in STEM.

Furthermore, understanding how “non-stereotypical” role models develop can better aid in retention and engagement of groups underrepresented in STEM.

## **Scholarly significance**

In this study, I tracked 10 students’ academic trajectories and observed students interacting with their peers and with K-12 youth. Preliminary data analysis suggests students in this program are learning leadership skills, being provided with networking opportunities, building self-efficacy in their respective fields, and going on to become professionals in STEM after graduation (Hinojosa, Torres, Callejas, & Speer, 2016). This paper describes how serving as a role model in outreach contributes to professional identity formation in First Generation College Students (FGCS), a group underrepresented in STEM and higher education. Key components of the student experience appear to be: encountering and being mentored by role models (program leaders) and peers (more experienced students) from underrepresented groups in their field of study, and then assuming the position of being a non-stereotypical role models themselves for youth of similar backgrounds. Understanding how non-stereotypical role models develop can better aid in engagement and retention of groups historically underrepresented in STEM by demonstrating to younger generations that scientists are as diverse as the people who populate this planet; thus, aiding to dispel negative stereotypes which may cause students to perform poorly in school (Marx, Ko, & Friedman, 2009).

The contribution of this study to the Learning Sciences community is to extend the theoretical framework of identity formation as a result of being mentored and mentoring others. The authentic outreach community works as a model for learning and identity development using 2 layers of mentoring and role modeling. In the context of the outreach program, NEO, the undergraduate instructors spend the fall semester preparing lessons and activities for outreach into K-12 local classrooms and developing their understanding of content knowledge in neuroscience topics. This is done with peers, the program leader, and guest faculty speakers doing current research in neuroscience. In the following semester—in the Spring—undergraduate instructors go out to local communities positioned as experts in neuroscience and as representatives of the university. Because program recruitment is focused on diversity, the majority of participants are women from underrepresented groups in STEM. This mean they are directly positioned not only as role models in neuroscience, but as non-stereotypical role models in that field. In this paper, I examine how this positioning of being a non-stereotypical role model contributes to identity development as a role model and as a professional in STEM.

## **Theoretical framework**

The distance measuring the individual’s actual identity to a future possible identity imagined by self and others is represented by the Zone of Proximal Identity Development (ZOPID; Polman, 2006, p.246). Using the ZOPID—similar to Vygotsky’s (1978) Zone of Proximal Development (ZPD)—identity development is viewed as tied to the participant’s past positioning and positioning by self and others during social activities. Positioning within the outreach program is structured within a mentorship model which has two main components of mentorship: (1) mentoring from both faculty/staff; and (2) mentoring from more knowledgeable peers to newcomers in the program. A third component also emerges when undergraduate instructors go out to the classrooms as they are placed in the position of role models to youth from similar backgrounds, thus modeling to youth that a scientist can appear as they do. Figure 1 (below) is a diagram of how undergraduate instructors move between the different stages of the outreach program and how their positioning and identification changes in moments of time. The red highlights the portions of the outreach program where participant’s identity positionings are incrementally scaffolded to become more knowledgeable peers to newcomers as well as experts in neuroscience to the local communities. This contributes to the development of a professional STEM identity and a non-stereotypical role model in STEM. By using the ZOPID, I seek to unpack how this development occurs over time for three NEO instructors who identify as Latina women and the first generation to attend college in their families.

Neuroscience Education Outreach (NEO) is an outreach program sponsored by a large public university located in the mountain west region of the United States. The goal of NEO is to empower and engage K-12 students to take charge of their mental and physical health through neuroscience education. Lessons are designed to teach children and adolescents about their brain through a series of fun activities around lessons which demonstrate how the brain works. Undergraduate students in STEM serve as the instructors who prepare the lessons and activities, go into the surrounding schools and communities (in pairs or more), and facilitate the age appropriate lessons and activities (see figure 1 for NEO program structure).

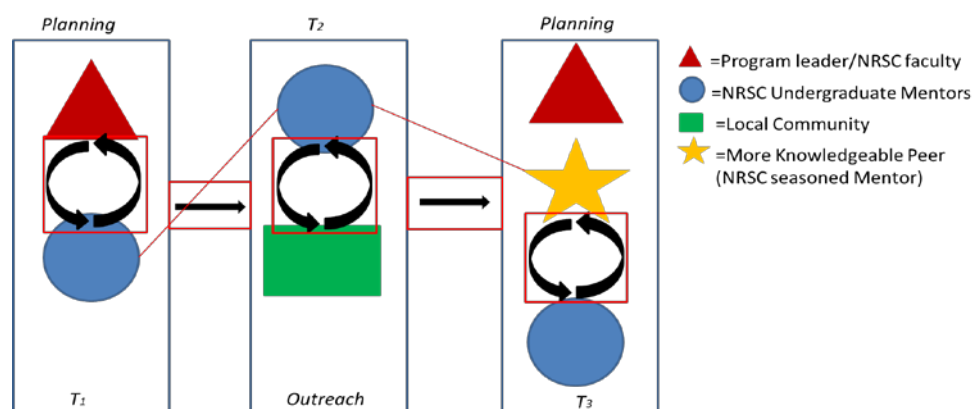


Figure 1. The outreach model is structured to accommodate both newcomers into the program as well as more seasoned peers I refer to as More Knowledgeable Peers (MKP). In the fall semester timepoint 1 (T<sub>1</sub>) outreach instructors, who are recruited in a manner which is focused on diversity, prepared age appropriate lessons and activities to go out into the local classrooms. They are scaffolded by the program leader, who invites university neuroscientists to discuss current research, as well as by the MKPs. In the Spring semester, or timepoint 2 (T<sub>2</sub>), outreach instructors positioned as the experts go into local classrooms and facilitate the lessons and activities. By doing so they become MKPs themselves and assist other undergraduates in planning future sessions in the following Fall semester, or timepoint 3 (T<sub>3</sub>). I seek to explain identity development as the undergraduate mentors move through this model in real time.

## Methods and data sources

Participants at the time of the study included 10 undergraduate instructors, however for the scope of this paper I elaborate on 3 instructors (Sarah, Zena, and Abby), who identify as first-generation college students (FGCS). Sources of data include annual surveys and interviews as well as peer and classroom observations of interactions conducted throughout 2 academic years: Fall 2015- Spring 2017.

*Analytic Approach: Trajectories of Identification.* I use sociocultural theory (Wertsch, 1998) to conceptualize learning environments as places where participants connect their past, present, and future selves, and in this way, make sense of who they are which further leads to how they participate in those environments. Using the *trajectories of identification* framework (Polman & Miller, 2010) I theorize participation and identity as dynamic and co-constructed via participation in social interactions and activities. To further analyze trajectories of identification, I looked at the parameters of prolepsis, positioning, agency, and scene.

*Prolepsis* occurs on the individual, cognitive level, and refers to how participants (and those they interact with) make sense of and act out connections between the participant's past (prior lived experiences and memories), present, and their imagined future (Cole, 1996). This imagined future can be either imagined for the participant by others and/or by the participant him-/herself. Prolepsis therefore can lead the participant toward, or deter away from different types of imagined individual trajectories or pathways. The parameter includes "proleptic references" to the participants' past (or similar types of people); to possible futures (for self and others similar); and finally, analyzes how present-day activities and interactions connect to either past or future selves. These *proleptic references* include stories which refer to role models and mentors, as well as imagined stories of themselves and others. Prolepsis can therefore be seen in the narratives participants tell about themselves and/or others, as well as seen in the actions and interactions of the individual participants during social activities. Prolepsis can also lead to *positioning* as identity is dialogically negotiated, and the enactment of envisioned identities and trajectories (both by self and others) shapes directly how that individual participates in that community. In the analysis, I distinguish between how one positions self and others, as well as how they are positioned by others within the outreach community. The individual can then either resist or accept forms of positioning which can be seen in social interactions and actions. How the individual reacts to positioning constitute forms of resistance to, or acceptance of certain trajectories of identification.

Positioning also refers to *identifications from society and community*. Society and community position individuals, either explicitly or implicitly, within that society before that individual begins to act in society. Even before one is born, there is an imagined future by parents (prolepsis) and one is positioned by culture and society (e.g., "girls' clothes, toys, colors, etc.) to be something imagined for that person (Turner & Reynolds, 2010). Therefore, prolepsis and positioning are also shaped by societal factors and influences which further shape

trajectories of identification. These influences at the societal level may refer to identifications such as stereotypes (which are often negative, promoting a deficit view based on race, gender, etc.), or may refer to lack of representation or role models, and are recognized by individuals as they participate in social activities and interactions (Peteet et al., 2015; Steele, 1997; Clance & Imes, 1978). Therefore, identity is constantly being negotiated and renegotiated during interactions with others; and with how the individual is positioned by self, others, and also society. *Agency* refers to the capacity of an individual to act independently and be an agent in their own decision making (and thus identification and participation). In demonstrating competence in neuroscience content and outreach responsibilities, undergraduate instructors begin to position themselves as agents in their own trajectories of identification.

Lastly, learning environments are both structured and constrained by community and institutional goals and ways of positioning, referred to as *scene*. The STEM environment is not a-cultural, but instead STEM practices are embedded in deep cultural contexts which may be taken for granted as “norms” by insiders; and this is further embedded in a university environment. The community and institutional environment (and embedded norms) are referred to as the *scene* or *place*. Analyzing scene included looking at how particularly types of people and practices are taken up or not by the university outreach program. In conclusion, prolepsis, positioning, agency, and scene interact to form trajectories of identification for the individual leading to identity development.

Because identity is constantly evolving in time and is situated in context, I used narrative analysis to examine expressions of identity (de Fina, 2015) in multiple interviews trajectory of identifications framework. I examined interviews and field notes of interactions with public and peers to look for positioning cues and proleptic references. Salient social categories began to emerge. One particular category, first generation college student (FGCS), encompassed other traditionally underrepresented groups in STEM and presented elements of social influences (i.e., lack of role models or college preparation) contributing to that identification. Using the ZOPID (Polman, 2010) and trajectories of identification framework (Polman & Miller, 2010), I analyzed trajectories of identification in the development of non-stereotypical role models for three FGCS instructors as they progressed in their role in outreach and in their college career.

## Background

Women and other minoritized groups are lumped together when NSF and other institutions discuss underrepresentation in STEM disciplines and submit proposals to aid in bolstering that representation, yet the term “underrepresented” is never explicitly clarified other than its inclusivity of women (including white women) and minorities (people of color). Through analysis of interview data and examining the role the category of FGCS plays, one can see members of FGCS tend to also share other categories which are considered underrepresented in science and engineering. For instance, Sarah, Zena, and Amber in this study share the categories of FGCS and Latina and have similar tensions and experiences when adapting to the college environment. In addition, these women of color find encountering and becoming role models exciting and inspiring for their own persistence in STEM. In fact, atypical of the current demographics of the university and its STEM programs, the majority of the instructors in NEO are women and/or minorities in the STEM field.

This type of environment is referenced by Amber as providing guidance and mentorship in academia, as well as providing a community of women in science with similar goals of outreach (i.e., a social and academic support system). In the case of Sarah, outreach to those with “similar backgrounds” is especially appealing as she begins to take on the identity of role model. Lastly, while the majority of the instructors are women from nondominant communities, there is also a mix of men and women from dominant communities.

## Results

Examining FGCS more closely from the point of view of FGCSs, one can see the main associative factor is lacking knowledge of the college experience, lacking role models, lacking economic resources, and being a minority (and/or woman) student in STEM, which resonated in the narratives of Amber, Zena, and Sarah (Hinojosa, 2018). A first-generation college student is a student whose parents have not obtained a degree from a higher learning institution. This implies a lack of family resources or role models when students go into college. In all excerpts Sarah, Amber, and the program leader make connections to social factors which further contribute to attrition from STEM: being female, being from a lower SES background, being Latina, being a first-generation college student, as well as lacking role models in STEM. Sociohistorical factors influence the present-day scene in higher education and these factors contribute further to the academic achievement gap and STEM underrepresentation (Spring, 2016; Solomon, 1985). While this does not disprove any profound finding previously about underrepresentation in STEM, it does provide evidence outreach and community engagement is an effective medium to create more non-stereotypical role models of students who are underrepresented in science.

The NEO program structures itself as a mentorship model, and has two main components of mentorship: (1) mentoring from both faculty/staff; and (2) mentoring from more knowledgeable peers to newcomers in the program. A third component also emerges when undergraduate instructors go out to the classrooms as they are placed in the position of role models to youth from similar backgrounds, thus modeling to youth that a scientist can look like they do. Brooke (all proper names are pseudonyms) is the director of the outreach program, and is frequently referred to by the instructors as being a role model, resource and mentor. While NEO's goal is to disseminate neuroscience information to the public, the instructors are receiving a level of role modeling and guidance which ultimately contributes to their persistence in STEM. Preparing instructors to teach lessons and facilitate activities is akin to an apprenticeship model whereby a novice is introduced to the content knowledge, and scaffolded on how to manage classroom interactions and activities by more knowledgeable peers (experienced instructors) (Rogoff, 1995) to practice science communication and public speaking skills. Lastly, Brooke positions the instructors as expected to succeed in their college careers, and as young scientists and role models.

### Case Study 1:

Sarah is a double major in biology and philosophy in her third year at the university (after much uncertainty and switching majors), and currently works in a neuroscience and psychology lab on campus studying the effects of physical activity on the brain. She regrets not starting out in neuroscience, and attributes her decision to lack of knowledge about neuroscience before starting college. She is interested in pursuing a career in medicine yet has expressed uncertainty in her future career plans. Below she discusses neuroplasticity to high school female students and how first-generation students may struggle more in college compared to the traditional student (due to “inequalities”, perhaps referring to low SES or lack of knowledge/college preparation). She remarks how this was frustrating at first, but the brain can learn and adapt.

[Excerpt 1]:...I kinda spoke about my experience as a first generation college student how academia is—especially at the higher levels—is really challenging...[a]nd how often times you just wanna kinda say like...“Oh my gosh, I’m so dumb”, or “I’m so behind” but neuroplasticity kinda gives you evidence to suggest that you can improve inequalities that you’re not happy about... like studying habits and stuff and... neuroplasticity...helps you become better at something that you wanna do (Sarah, Interview, August 2016).

The above excerpt is from an interview with Sarah about her teaching experience in a college prep group for high school girls from low socioeconomic background, primarily from the local Latino communities—these students are on the college track and would be the first in their families to attend. Prolepsis was apparent when Sarah expressed her feeling “connected” to the students instantly because she holds membership in a social category the students are likely to share in their near future. Sarah also stated she was from a “similar background” and later stated she felt this connection due to the shared category of being Latina and low SES, as well as being a FGCS. Sarah noted that she saw herself as a role model to students (who reminded her of herself in high school) that day and even exchanged emails with one student interested in neuroscience. This went beyond the requirements of outreach as Sarah took a more personal interest in the imagined trajectories of the students with whom she interacted.

### Case Study 2:

Amber graduated from the university with a degree in Biology in December 2016. Amber positioned herself as a FGCS during her college career. After she graduated she took a job as an analytical chemist in order to gain lab experience and go into the health field. Her desired career and projected identity is a diabetes researcher. She saw Brooke and other female professors as role models and found a supportive environment of peers in her outreach community.

[Excerpt 2]: [I]n my opinion...we really down-sell the mentorship part of this program because there's a huge, through [Brooke], through the other students, there's a huge mentorship part...(Amber, Interview, May, 2016).

This was in stark contrast to the university scene for Amber, as she lacked a sense of belonging at first, which she attributed to her dissimilarity from the average university student. Amber remarked that she could not quit school, despite typical FGCS challenges, because she wanted to be a role model to others, especially to young girls interested in science. As noted in the next case, Zena shared similar sentiments.

### Case Study 3:

Zena was a psychology major (after much uncertainty and switching majors) in her fifth year at university, and wanted to pursue a career in education. She attributed her motivation to teach as tied directly to her participation in NEO. During outreach, she was positioned as a neuroscientist by the NEO director and by classroom teachers and students. Zena also used her social categories of FGCS and Mexican to connect to communities with people sharing a similar background. In this way, Zena was positioned as a non-stereotypical role model in the Latino communities she interacted with.

In Spring 2017, Zena organized events for the Latino community to involve parents to discuss educational neuroscience and how that related to childcare. Many of the parents and community members positioned Zena as a role model for their children, and were very interested in hearing the story of a FGCS succeeding. Parents began to see their own kids' possible futures as being similar to Zena's. Zena felt she could give the Latina mothers advice based on her own hardships and adversities as a FGCS, and in this way, was positioned by her community and herself as a role model of a successful university student. "Telling [the community] what I do I feel... gives them a broader sense of what they can do" (Zena, Interview, April 2017).

Zena continued to express a sentiment Amber expressed in her 2016 interview:

So like I mentioned before, letting other people down... 'Cause you know I want to be an inspiration to someone... to at least one person and so being able to say, "yeah, I came here and it was hard and difficult, but I did it and look at where I am now" kind of thing. I want to be able to say that and the kids that we go and teach are like: "wow, you go to university, you go there! How did you make it that way?" And so if I didn't, if I decided no, maybe I'll go here instead cause it just feels safer or closer to whatever then I would feel like I kind of gave up on something and I was not what I thought I was (Zena, Interview, April 2017).

In the above excerpt Zena's identity of being a successful first-generation college student is linked to her success at the university she attends, which is known for its excellence in STEM. By doing service work as a student representative of a major university, which lacks in diversity and in her experience, has had professors discourage her from pursuing her degree, Zena is combating those institutional and societal identifications and positionings imposed upon her in the university setting. She resists this scene by being a role model to others who might face similar challenges in pursuit of a higher degree at a major STEM university. Zena thus gains inspiration from outreach, as she inspires youth she interacts with, to continue her degree in this particular university: "...the kids I teach have been really inspiring to me 'cause... I wanna work hard and fight [for them] (Zena, Interview, April 2017)." Themes of connecting to youth from similar backgrounds, seeing one's self as a role model to youth and simultaneously building confidence and inspiration to continue in school are shared among Zena, Amber, and Sarah.

This bias of having lower expectation for poor students (and students of color) speaks to a larger deficit discourse of teachers, administrators, and policy makers (Benner & Mistry, 2007; Diamond et al., 2004; Cooper et al., 1982). In the U.S., where K-12 teachers are predominantly white and from middle class backgrounds, this can be devastating as classrooms are becoming increasingly diverse (Steele, 2001; 2008). Furthermore, this assumption resonates with teachers from nondominant backgrounds as in the case of Zena. Zena sees this as important to her projected future trajectory as a K-12 teacher:

I guess, the assumption that like lower income kids don't know as much... those were definitely challenged. I was like "oh my gosh, why have I been thinking this?" They definitely know as much and they are definitely interested and want to learn this stuff and... that was helpful and it really challenged me and totally changed my mind and now I'm like "oh my gosh, I cannot be thinking this way if I'm going to be a teacher" (Zena Interview, April 2017).

Zena specifically points out her challenged assumptions of low income students not knowing as much as students from more affluent groups (i.e., lower expectations of the knowledge lower income students bring to the classroom). This was a shock to Zena as she herself is from a lower income background, wants to work with those youth, and is on track to become an educator. These biases and assumptions are deeply embedded and can remain unconscious; only when those biases are challenged by our immediate interactions with those we don't normally interact with do the biases come to the surface. The outreach instructors in NEO, including Zena, spent time after each lesson writing their reflections after performing outreach for both program feedback as well as for their own personal learning and growth. The reflexivity afforded by this practice may have contributed to her asserting agency in social awareness to overcome personal bias.

## Discussion of major findings

By examining identity formation through moments in time within an authentic outreach model using the theoretical framework of the ZOPID, the practices associated with STEM retention and student achievement in their STEM degrees can be seen as encountering and becoming non-stereotypical role models. In the cases of Sarah, Zena, and Amber, these Latina women share the category of FGCS and have similar tensions and experiences when adapting to the college environment, or the university scene. The motivation behind doing outreach for all three participants was to empower communities with less access to pertinent neuroscience information to effect change in their own lives, and to inspire others to do science by being role models to youth like themselves. Evidence shows the outreach instructors both found role models in their field (in the program supervisor and more knowledgeable peers), as well as saw themselves as role models during interactions with K-12 students. Thus, prolepsis may occur in the K-12 youth's mind as they see themselves in the outreach instructors, leading to the development of trajectories of identifications involving science in the future for the youth. Hence, the distance between their imagined identity and their actual identity (the ZOPID) diminished. During outreach participation, the three instructors were positioned by themselves and others as scientists and role models for youth from nondominant communities interested in exploring or pursuing a science career. Some instructors explored other challenges in participating in outreach in nondominant communities, and upon further examination, a larger negative stereotyping discourse of low income, non-white communities can be seen in the educational scene. Zena mentioned this tension even though her own background is low income, non-white, and first generation to go to college. As noted elsewhere, unconscious biases related to students' membership in minoritized groups can be harmful for students as teacher expectations affect student outcomes (Benner & Mistry, 2007; Diamond et al., 2004; Cooper et al., 1982). Using reflexivity, Zena began to draw connections from her assumptions and actual interactions with youth from nondominant communities, thus allowing her more agency in her conceptions of low income youth. This allows her to see youth in new imagined trajectories, leading to a different positioning of the youth which links their pasts to present and ultimately to imagined futures of being a successful college student in STEM. This provides room for a rippling effect of role models begetting future role models.

## Conclusion and further implications

This study provides evidence of how mentorship models within university outreach can be an effective site for the development of non-stereotypical role models in science. In order for Amber, Zena, and Sarah to continue with their college careers they all had to overcome the scene of the university environment and how those in the environment positioned them differently than how they were positioned during outreach. For example, professors intimidated the FGCSs during classes often remarking "you should already know this," referring to domain content knowledge, leaving Zena and others to equate their lack of college preparedness to lack of intelligence. During outreach, instructors found a group of similar and supportive peers, as well as found female role models in science who positioned them also as such. The three FGCS instructors have since learned how to talk to faculty members (networking) and how to navigate STEM institutions contributing to their engagement and retention in STEM. Zena and Amber attribute their networking skills to having a strong social network of peers, mentors and non-stereotypical role models. This impact, i.e., empowering youth to effect change in their lives, is something all instructors pointed to as their personal motivation to perform outreach work. This study thus demonstrates personal growth and professional identity development during participation in community outreach. Future implications involve bringing this model and framework to university settings to foster student success and bolster diversity in STEM higher education and ultimately into STEM professional fields.

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