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STEM Graduate Students' Multiple Identities: *How can I be me and be a scientist?*

Minh C. Tran
Felisha A. Herrera
Josephine Gasiewski

University of California, Los Angeles

Contact: Josephine Gasiewski, 405 Hilgard Ave., 3005 Moore Hall, University of California, Los Angeles, CA 90095-1521; Phone: (310) 825-1925.

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Introduction

According to the National Science Foundation (2009) women accounted for only 21 percent of doctoral degrees in engineering and computer science. While graduate degrees for women are beginning to reach parity with men in the biological sciences, women still earned only 30–40 percent of the doctoral degrees in most other science fields (NSF, 2009). This is especially concerning given that women earn slightly more bachelor's degrees in science, technology, engineering, and mathematics (STEM) than men. The NSF (2009) also reports that graduate participation rates for underrepresented racial minorities (URM) in STEM fields range between 6 and 10 percent. This is well below the already small proportion of STEM bachelor's degrees earned by URMs at 17 percent. In comparison, Whites earned 64 percent of STEM degrees. Discrepancies in degree attainment are not necessarily due to the perceived lack of motivation and interest in STEM. For instance, equal percentages (44 percent) of African American and White college-bound high school students intend to major in STEM fields (College Board, 2005). However, retaining students in STEM is a major challenge, as only 27 percent of URMs, compared to 46 percent of Whites, who intended to major in STEM actually complete a STEM degree (Huang, Taddese, & Walter, 2000).

Cobb (2004) insists that a fundamental reason students who demonstrate success in the sciences choose not to continue is that they experience conflict between their emerging science identity and "the enduring sense of who they are and who they want to become" (p. 336). As we seek to expand STEM education and degree attainment, it is critical to understand how students come to view themselves as scientists. Thus, the concept of ''science identity'' is receiving growing attention in science education literature (Tan &Calabrese Barton, 2007; Carlone, 2003, 2004; Boaler, 2002; Brickhouse & Potter, 2001; Hughes, 2001; Brickhouse, Lowery, & Shultz,

2000; Eisenhart & Finkel, 1998). However, the concept is not fully developed and requires a more nuanced understanding and conceptualization, especially in light of the vast range of students' social identities. The ultimate goal of this study is to begin to expand STEM educators' understanding of science identity and explore the ways in which students navigate their multiple identities and come to see themselves as scientists. We can learn from successful students by identifying the strategies and supportive mechanisms that have allowed them to persist in STEM to reach the graduate level and beyond. Students at the graduate level in particular will be targeted as the population of interest as they can offer insights regarding the key experiences that permitted them to transition through early education and college to become research scientists in graduate school.

A number of scholars have pointed to the culture of science as a major source of disruption for science identity formation, as socialization into STEM departments traditionally requires students to assimilate into the disciplinary culture, which tends to reflect the traditional norms and values of the dominant groups in U.S. society (Johnson, 2007; Carlone, 2003; Davidson & Foster-Johnson, 2001; Seymour & Hewitt, 1997; Becher, 1989). This dominant disciplinary culture generally dictates scientific teaching, learning, and practice and therefore has the ability to promote dominant groups while marginalizing minority identities (Cobb, 2004). The culture of math and science are "often depicted as monolithic and as involving the disembodied voice of objectivism and rationality" (Cobb, 2004, p. 333). This perpetuates the myth that STEM education must be divorced from everyday knowledge, situational concerns, human interests, social conventions, and other aspects of students' lives. As students attempt to affiliate or identify with the sciences, they can experience conflicts with the traditional science culture, which is incorrectly portrayed as a finished body of knowledge and does not allow the

possibility for individuals to construct their own meaning or make unique contributions to the discipline (Boaler, 2002; Eisenhart, Finkel, & Marion, 1996). A lack of congruence with between students' lived experiences and the prevailing values of these disciplines suggests a need for further examination regarding how the contexts (e.g., campuses, departments, classrooms, and labs) in which students learn science and become scientists can support their multiple social identities.

Thus, this paper will address the following research questions:

1. How do graduate students experience conflict and/or convergence between their social Identities and emerging science identities?
2. How do these students negotiate conflict between social identities and science identities?

Literature Review

Scholars have investigated a number of other reasons for disparities in URM STEM persistence, including negative racial experiences (Chang, Eagan, Lin, & Hurtado, in press; Seymour & Hewitt, 1997), highly competitive academic environments (Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009), inadequate program support (Seymour & Hewitt, 1997), and institutional selectivity (Chang, Cerna, Han, & Sàenz, 2008; Chang et al., in press; Hurtado, Han, Sàenz, Espinosa, Cabrera, & Cerna, 2007). These studies tend to concentrate on the structural barriers URM students encounter in STEM departments and institutions.

In addition, previous research has explored how the culture of science can negatively affect the retention of women and URM students in STEM disciplines. Seymour and Hewitt (1997) found that low persistence in STEM majors was largely attributable to the unsupportive and discouraging aspects of the disciplinary culture (i.e., the weeding out process), rather than

inadequacies in performance, motivation, or preparedness on the part of students. Their study examined 335 well prepared STEM students who all earned scores of 650 or higher on the mathematics portion of the SAT. Students who left the major, including many women and students of color, consistently reported that science faculty made courses unnecessarily difficult and were unsupportive in order to uphold the reputation of science as a "hard" major, thus, maintaining its power and status. Also, instructors in the introductory, or gatekeeper, courses perpetuated a competitive classroom environment by grading on a curve (Seymour & Hewitt, 1997). According to Epstein (2006) grading on a curve tends to discourage students' interest in collaborative activities, such as study groups, and instead engenders a "survival of the fittest" mentality. Therefore, survival in STEM courses required students to elevate individual interests over collaboration and the preservation of relationships. Seymour and Hewitt (1997) concluded that these individualistic and competitive features of science departments closely aligned with White masculine norms but were at odds with the socialization of many women and students of color, whose values tended to be more cooperative and community oriented.

A number of other studies have also examined how White male norms in the culture of science can affect the retention of women and URM students. Bonous-Hammarth (2000) found that URMs often leave the sciences due to the perceived lack of social value, or relevance to improving conditions for communities of color. For instance, URMs who were aspiring physicians or civil engineers found the STEM curricula to be deficient because it reflected the values of the White majority and excluded discussions aimed at understanding the needs of the racial/ethnic communities whom they envisioned serving. Several studies have also explained how women's decisions to enter or leave the sciences are often driven by different factors than for men (Huang, Taddese, & Walter, 2000; Sax, 1994). According to Huang et al, the higher

value women place on social relationships relative to men can at least partially explain women's lower probability of entrance and persistence in STEM. As such, women may tend to dislike the highly abstract nature of STEM-related knowledge and the strong competitive environments in STEM departments. These studies underscore the need for further examination of the relationship between students' emerging science identity and their racial, ethnic, and gender identities.

In recent years, research focusing on identities in science education has become more common, especially as it relates to student departure from STEM programs. Researchers have been able to use science identity as a way to depart from the dichotomized perception of the persistence problem in order to examine how racial stigma can cause students to dis-identify with the sciences (Chang, Eagan, Lin, and Hurtado, in press) and how supportive, collaborative, and structurally diverse environments are able to develop students' science identity without neglecting their racial identity (Hurtado, Cabrera, Lin, Arellano, and Espinosa, 2009). These studies, however, examine STEM persistence by treating social identities as static variables using race and gender only as filters to select research subjects.

Few studies have intentionally explored this link between science identity and social identities while simultaneously viewing identity as dynamic – something that is not intrinsic within oneself but instead demonstrated or achieved through social interactions and relationships (Bohan, 1993). In other words, thinking of identity as dynamic makes it something one is, as well as something one does (Carlone & Johnson, 2007). For example, a scientist who is also woman of color may perform her science identity by communicating relevant scientific knowledge in different ways, depending on whether she is speaking to her family, friends, or a classroom full of White male scientists. Not only is identity performed by individuals through

their actions and behaviors, but it also affects how individuals are perceived and treated by others. For instance, how a student's identity is understood and perceived by faculty in science can influence whether the student is recognized, rewarded, ignored, or even sanctioned (O'Connor, 2001). In Tate and Linn's (2005) study of female engineering students of color, the researchers utilized a multiple identities framework that included and emphasized the importance of examining the intersections of three types of identities: an academic identity associated with earning good grades, an intellectual identity tied to aspirations of being engineer, and the social identities of race and gender. They found that women and ethnic minorities pursuing STEM fields frequently deal with differences in ethnic cultural values and socialization as well as stereotypes, isolation, and perceptions of racism. Further, in Johnson's (2007) qualitative study of 16 Black, Latina, and American Indian undergraduate women at a large, predominantly White research university, she identified several dominant cultural values in science departments that served to discourage women of color in the sciences. She found that the culture of the science classroom portrayed science as meritocratic and neutral to individual characteristics and social identities. While professors may have had good intentions behind their focus on individual talent over social identities, the silence surrounding race, ethnicity, and gender gave students the impression that these issues had no place in science and that bringing them up would call into question their credibility as objective scientists.

Perhaps the most extensive research study of the relationship between science identity and social identity to-date was conducted by Carlone and Johnson (2007), who interviewed 15 women of color in STEM fields during several different time points in their undergraduate careers at a large, predominantly White, public university. Findings concentrated primarily on the recognition of science identities both within oneself and by external constituents, such as

faculty and classmates. Many of these women experienced significant gender and racial stigmatization, as well as a lack of external recognition of their identities as scientists by departmental faculty and peers. Despite this external disapproval, the participants were able to culturally reconstruct what it meant to be a woman of color in science through their love of science research and their belief in science as a vehicle for altruistic aims. Although Carlone and Johnson examined the women's' relationships with fellow students and science faculty, they did not explore relationships with non-science peers, families, and communities.

Additionally, previous research has seldom addressed the relationship between science identity and the intersections of more than two social identities, let alone combinations of three or more social identities. In reality, individuals are members of several social groups at once. The combinations of these social identities creates a unique set of issues based on the multiple oppressions an individual can experience from being a member of two or more oppressed groups (Reynolds & Pope, 1991). In addition, in all of the aforementioned studies, the single institutional context and small sample sizes-ranging from two to fifteen students, limited both the depth and breadth of the findings. In studies that examine the intersections of multiple social identities, it is ideal to have a large and diverse sample of institutions and individual participants in order to capture the multitude of perspectives and experiences of students with various combinations of social identities, including racial/ethnic, gender, socioeconomic, and spiritual/religious identities.

More research is also needed to identify aspects of supportive environments and the strategies that departments and institutions have effectively employed to validate and recognize the science identities of students from diverse backgrounds. For instance, Hurtado, Cabrera, Lin, Arellano, and Espinosa (2009) found that historically Black colleges and universities provide

academically supportive environments for science identity development. Therefore it is not surprising that HBCUs are known for their high production of minority scientists and engineers. This study will also attempt to document how successful students developed their science identity without neglecting their multiple social identities, which will inform institutional practice

Theoretical Framework

This paper will draw from several theoretical and conceptual frameworks. First, the model of science identity provides a framework to interpret the experiences of graduate students in their development as scientists (Carlone and Johnson, 2007). This model will be used to illuminate how social identities interact with the internal and external recognition of science identities. In addition, we will examine the dimension of science identity performance, or how students present and communicate relevant scientific knowledge and practices. Using the construct of science identity acknowledges both student agency and the social structures that impede persistence. Nasir and Saxe (2003) suggest that frameworks for examining conflict and tension between ethnic identities and academic identities must also consider the ways students manage and negotiate these tensions. In this study, we will explore student agency, or the capacity of individuals to make choices and act on their own behalf and highlight the negotiation strategies that have been influential amongst graduate students.

While the model of science identity was based on the experiences of women of color and hinges on the assumption that students' multiple social identities are linked with their science identity, this aspect remains underexplored. Therefore, we draw from Jones and McEwen's (2000) conceptual model of multiple dimensions of identity, which underscores the importance

of acknowledging an individual's multiple social identities, the intersections of these identities, and how the development of these identity dimensions are invariably influenced by contextual factors such as educational and career decisions. Acknowledging that there are multiple contexts within which identity is developed and enacted, we are able to more fully explore the socialization process of becoming a scientist. We will examine how student attempt to shift, balance, and merge their multiple identities as they move between STEM contexts and broader socio-cultural contexts.

While studies are often limited to one or perhaps two dimensions of identity (Shields, 2008), our research will examine the multiple dimensions of identity and utilize an intersectional approached to examining the various combinations of these identity dimensions. 'Intersectionality', initially coined by critical race theor (1989), has been adopted across several other disciplines to reference the "interaction between gender, race, and other categories of difference in individual lives, social practices, institutional arrangements, and cultural ideologies" (Davis, 2008, p. 68). The central tenet of intersectionality theory posits that identities are defined in relation to one another, and as such the intersections of multiple identities can have unique and transformative effects on science identity conflict and convergence. According to this perspective, the intersection of two or more identities cannot be viewed simply as a location, like a street corner where two streets cross, but rather as a transformative process that produces an entirely new set of circumstances (Crenshaw, 1991). In reality, individuals are members of several social groups at once. Since a woman can be a person of color, a lesbian, and have physical disabilities all at the same time, the intersections and combinations of these social identities create a unique set of issues (Reynolds & Pope, 1991). To

disassociate people into singular identity categories is to ignore the complexity of individuals and present an incomplete picture of who a person really is.

Use of this theory has often focused on the outcomes of these interactions in terms of power dynamics with intersectionality as an analytic tool for understanding structural oppression and multiple inequalities (Choo & Ferree, 2010). Drawing from Crenshaw's (1989) definition of political intersectionality, we can see how inequalities are both imbedded in, and act to transform structures at all levels and in all institutional contexts (Davis, 2008). By employing a qualitative approach in examining the intersectionality of identity within an individual's experience we thereby acknowledge the power and social structures inherent in STEM disciplines and how they influence students' negotiation of STEM academic programs. Rather than simply giving voice to marginalized groups we include examination of the dominant paradigms that these students must operated within in order to achieve in theses STEM disciplines in order critically examining the active processes (Cole, 2008) across individual experiences and recognizing how power continually operates within societal and institutional contexts. Therefore, we seek to identify and compare dynamic processes, rather than individuals that simply sit at the crossroads of intersecting categories (Davis, 2008).

Methods

From December 2009 through May 2010, focus group interviews were conducted with STEM graduate students (N=132) during site visits to seven campuses across the United States. The sample included 29% African Americans, 28% Latina/os, 24% Whites, 12% Asian Americans, 6% American Indians, and 1% who marked other. Approximately 8% of the participants were multi-racial, and 46% were women. The average age was 27.5 with a range of 21-53 years old. The campus sites included three Hispanic serving institutions (HSI), one

historically Black college/university (HBCU), and three predominantly White institutions (PWI). These institutions were selected based on their high rates of STEM degree completion among URMs. Students at the graduate level were selected as they could offer insights regarding the key experiences that influenced their successful journey from early education, to college, and then to graduate school. To ensure racial diversity in the sample, we purposefully recruited a portion of the participants through structured programs specifically targeted at URMs in STEM. Purposeful sampling was utilized in order to capture "information-rich cases that elicit an in-depth understanding of a particular phenomenon" (Jones, Torres, & Arminio, 2006, p. 65),

Focus groups interviews, ranging from 60 to 90 minutes, were conducted with 4 to 6 participants per session. We utilized a semi-structured interview technique which allowed us to respond "to the situation at hand, to the emerging worldview of the respondent, and to new ideas on the topic" (Merriam, 1998). Maxwell (2005) suggests that this technique increases the "internal validity and contextual understanding and is particularly useful in revealing the processes that led to specific outcomes" (p. 80). Prior to the interviews, participants were asked to complete a brief biographical questionnaire, which gathered data on a range of relevant background characteristics (e.g., demographic information, educational attainment, and research experience). All interviews were digitally recorded, transcribed verbatim by a professional transcription company, checked for accuracy, and loaded into NVivo8 qualitative software.

In order to develop the coding architecture, each transcript was open coded by examining the raw data and coding for salient categories supported by the text. Our team of six researchers each read transcripts from two institutions, gathering and comparing themes across focus groups and institutions. Creswell (1998) describes this process: "using the constant comparative approach, the researcher attempts to 'saturate' the categories—to look for instances that

represent the category and to continue looking until the new information does not provide further insight into the category" (pp. 150-151). Once we felt that we had reached saturation in generating codes, we developed several iterations of coding schemes, wherein codes were created, expanded, defined, and refined. This data analysis strategy followed an inductive process of narrowing from particular (text segments) to larger themes (Creswell, 2002). These categories/themes in the raw data were then labeled as "nodes." Six researchers thematically coded three randomly-selected sections of text and inter-coder reliability ratings consistently ranged from between 8085 percent (Miles & Huberman, 1994). Following inter-coder reliability exercises, the coding was re-validated and we were able to add new codes and sub-codes where necessary. Once the coding structure was finalized, we utilized 24 primary nodes, 111 secondary nodes, and 86 tertiary nodes in NVivo8 to code the data by selecting relevant text segments representing each node, and dragging and dropping these selections into the free node section of the program. The data selected were stored there under the node and the link to the full record was maintained. Frequencies of occurrence were calculated for each theme, and queries were run linking participant attributes with coding references.

FINDINGS

The overall purpose of this study is to examine the complex interactions between science identity and other social identities amongst graduate students in STEM as they progress along their trajectory towards becoming scientists. Chloe, an African American engineer at a PWI elucidated the issue under examination beautifully when she stated:

> So, it [my field] is really dominated by older, white men. So, that was probably the most difficult in terms of my age, my race, my gender, all of those things kind of made life a

> little bit difficult. – Chloe (African American Female, Chemical Engineering Major, PWI)

We explore and describe identity interactions from the vantage point of successful STEM students like Chloe as it allows critical insight into how they are able to develop their science identity while maintaining a unique and complex array of social identities. In undertaking this intersection between social identities and science identity, we present detailed data in two main areas: convergence and conflict between science and social identities, and the resultant negotiation strategies students employ.

As describing in detail the educational experiences and multiple intersecting identities that embody each of the 132 students in our study is neither practical nor necessary, we have chosen to feature three typical students whose identity intersections and educational trajectories we relate here in-depth. The narratives of these three students' identities and experiences are being utilized as the foundation for our examination of interactions between science and social identities. Not only are each of their stories representative of the various identities and STEM graduate student experience across our sample, but they are particularly illustrative of the key themes of identity convergence, conflict, and negotiation. These students were also able to articulate their identity interactions in tremendous detail and express themselves with great candor and eloquence.

Kaelyn

Kaelyn is 31 year-old African American woman in her second year as a Ph.D. student in biology at a historically black college/university (HBCU) on the East Coast. Both of Kaelyn's parents are college educated. Despite having a certain advantages due to her family's level of

education and SES, she acknowledged being unsure in high school of whether to pursue her interest in science in part because she saw very few scientists who were women of color like herself. While a summer internship in a chemistry lab eventually alleviated her insecurities and solidified her interest in science, she still emphasized the need for more female faculty and faculty of color to serve as role models. She also admitted that the role of male faculty and non-URMs is equally important to creating a more inclusive culture of science. She received a bachelor's degree in biology from an HBCU in the Southern United States, where she recounted numerous non-minority faculty who taught science from culturally conscious and socially just perspectives.

Kaelyn subsequently completed her master's degree in genetics at a large, predominantly White (PWI), public institution in the Midwest. She cited an influential professor, who she worked with during an internship in a genetics lab, as the catalyst for her interest in science research and her decision to pursue enter graduate school. She also credited the institutional culture at the HBCU she attended during her undergraduate years for teaching her to expect and demand more inclusive conceptions of science education. Between earning her master's and enrolling in her doctoral program, she also worked for three years as a science assistant at the National Science Foundation.

Carson

Carson is a 32 year-old American Indian man in his fourth year of a Ph.D. program in bioinformatics. As a child, he learn math with ease, but also characterized himself as having a very reserved personality that sometimes made it difficult for him to perform and demonstrate his math capabilities in school. His parents encouraged him academically by buying science toys

and workbooks. His father, who possessed a graduate degree, would urge him in attend a local Indian American community center in order to receive guidance from community elders and to focus on further developing his academic abilities. He described the community center as a key source of support and inspiration to pursue math, as he was often reminded of the important role he could play in improving the representation of Indian Americans in STEM fields.

Carson encountered challenges in his early experiences with higher education due to being underprepared and feeling a lack of academic and social support. He attended three different universities before completing his bachelor's degree in computer science. He claimed to have barely graduated and was motivated primarily by the increasingly large debt he had accumulated during college. He worked in a lab for three years after graduation, conducting malaria research, where his mentor eventually persuaded him to go to graduate school to follow his passion in science. Before this he had never once considered pursuing a Ph.D. Carson completed some graduate coursework at the local university in Seattle to improve his grades before he was actively recruited by the large public research university in the Midwest which he now attends.

Noah

Noah is a 24 year-old Latino man in his third year as a Ph.D. student in organic chemistry. He currently attends a large public research university on the West Coast that is highly selective and predominantly White. After earning his undergraduate degree in chemistry, he interned at a pharmaceutical company for a summer before going straight into his doctoral program. His undergraduate institution was a local Hispanic serving institution in California's

Central Valley, where he was born and spent most of his life. He described the community where he grew up as predominantly working class and Latina/o.

In the third grade Noah recalled having a deep curiosity about the moon which prompted him to learn more about the sciences. As a young child, he performed poorly in school largely because of his inability to remain attentive towards the didactic teaching methods that mostly emphasized recitation highly abstract scientific information. Unbeknownst to many of his teachers, he would quietly flip through the pages of scientific books during class, captivated by captivated images of space and the moon. While his family tried very hard to encourage his scientific interest, they did not have access to all the tools or resources needed to further his academic development. His family could not afford a computer, and neither of his parents possess beyond a high school education. Despite their limited understanding of science, they still made numerous attempts to provide him with science related books and equipment throughout his childhood. He credited an influential elementary school teacher for helping him enter a science and engineering magnet program in middle school. This teacher both recognized and cultivated his interest in science through hand-on teaching and learning methods.

Through his participation in structured research programs for URMs in college, he learned about the opportunities that graduate school could offer to further his scientific aspirations. Coming from a less selective undergraduate institution, he initially felt unprepared for the rigor of his graduate degree program, but eventually he earned grades that put him at the top of his class. His transition was also aided by an internship opportunity offered by his department, which allowed him to arrive early during the summer before his first year of graduate school.

Convergence between Science and Social Identities

While we are largely interested in how students negotiate identity conflict, there were a few exceptional instances when students described feeling little to no conflict between their social identities and science identity. Referring back to the narratives above – despite some initial adversity in school, all three students received academic encouragement from their parents and teachers. They also enjoyed a certain level of success in math and science prior to college. In addition, two of the students had well-educated parents who possessed graduate degrees. These are prototypical examples of identity convergence. In discussing convergence between students' science and social identities, we describe instances where students could easily merge their social identities with their science identity without needing to actively exercise agency to negotiate identity conflicts. Here Carson related how that convergence encouraged him and shaped his trajectory.

> Math just always made sense to me. My parents would buy me math workbooks, and I just loved to do them, and so I was pretty good at math early on, so I got a lot of extra learning outside of school. And also my family always encouraged me to just follow whatever made me happy. That happened to be science and math. – Carson

In Carson's case, math felt very logical and natural to him. His parents not only supported him emotionally but were also relatively informed as to the precise supplemental activities and books to buy him in order to foster his fascination with the sciences. Chloe, an African American engineer at a PWI had a similar experience. Coming from a family of engineers, she had both the intimate knowledge of relevant educational trajectories, and role models of successful engineers of color, which served as a source of support for her emerging identity.

> Well, my family is very supportive and interested in all of those things. My brother is an electrical engineer...my uncle is an engineer. So, it's kind of like it wasn't anything new for me to become an engineer. And I don't think we talk about – my brother does talk about his research and things with the family, and I used to as well, but not so over their heads or whatever. – Chloe (African American Female, Chemical Engineering Major, PWI)

Like Chloe, Amelia had a role model in a close family member-her mother, who had attended college and was able to expose her to the medical field at a young age. As a result, Amelia was able to more easily see herself as an American Indian microbiologist, and experienced no conflict in that regard, as she stated:

> My mother was an EMT. She was always talking about medical related subjects, and so that kind of got me interested in like the medical field in general. Once I started taking science and microbiology classes, I just fell in love with it, and that's what made me realize that's what I want to do. I want to move on with my career and eventually one day have my own research lab and try to come up with a cure for something, but it was more, I think, like family influences that kind of pushed me in this direction. – Amelia (American Indian Female, Microbiology and Immunology Major, PWI)

Beyond early dispositions toward science and parental influences, institutional context can also create an environment that promotes identity convergence. For John, a Latino Wildlife Science major, and Brianna, a Latina Industrial Engineering major, the racial and ethnic diversity of their institutions and departments made for an environment where they felt that they fit in.

> My biology and ecology and wildlife sciences in general are just filled with all kind of people. So I don't feel like I'm either set apart or actually I feel I'm part of the flock. So yeah, I don't see any difference. – John (Latino, Wildlife Science Major, HSI)

> So now it's starting to creep in a little bit more. I'm starting to maybe see myself that way or see myself being seen, especially now that I'm applying for jobs…'Ethnicity' – Hispanic. I never felt – especially here because there's so many of us. I've never felt

> like different or minority. But if I'm looking to get a job not here, but somewhere else, then that does become a factor. – Brianna (Latina, Industrial Engineering Major, HSI)

Although Brianna felt her graduate environment to be inclusive, she noted that she was amongst a heavily Latino population, attending an HSI. There she was able to take her Latina identity for granted, but realized that once she went elsewhere looking for a job, her racial identity would become more salient.

Like Brianna and John, Paige and Kaylee also found their environments to be inclusive and cooperative, where they were not forced to parse apart their gender and science identities, but where their identities could converge.

> And in terms of being like a female biologist…I don't look at myself as like, "Oh, I'm different then other people – the guys in my lab." It's like, "No. We're in all the lab together. We're all working together." We're all scientists and we're all working on different projects. – Paige (White Female, Biology Major, HSI)

> I don't really feel any different being a woman in science. It was also kind of weird because my graduating class, my chemistry graduating class, was the majority female. Both the labs I've worked in here so far have been – they've had like one male in each of them. – Kaylee (White Female, Cell and Molecular Biology Major, PWI)

For the aforementioned students these instances of identity convergence made elements of their STEM trajectory easier to navigate. Their institutional contexts, family background, and/or early learning experiences enabled them to establish a strong science identity along with their existent social identities, where they came to see themselves as complex individuals who possessed the capability of being themselves and being scientists. Unfortunately, those students who experienced such convergence were rare in our sample. More often, students described

conflict between their science and social identities, which caused them many struggles along the STEM pathway.

Conflict between Science and Social Identities

As is evident from Kaelyn, Carson, and Noah's educational narratives, students experienced substantial internal and external conflicts between their identity as scientists and their social identities, where one identity was forced to diverge from another. This conflict originated from a wide range of causes, such as underrepresentation in science, overt discrimination, and science disciplines that lacked cultural inclusiveness and relevance. Underrepresentation in science leads to a lack of role models amongst marginalized groups, which makes it difficult for students to see how they might fit into STEM fields. Carson describes how he was often reminded of this underrepresentation even at an early age:

> So we'd go to the community center, and we'd work on our schoolwork and talk to elders and learn different teachings and that kind of thing. That was helpful to keep me focused, I think, and encourage me, and I was always reminded by people that there just aren't a lot of Indians in science and math, so it's important to follow that. – Carson

For Kaelyn, this conflict was evident when she entered the classroom as a TA for the very first time and her students' perspective clearly communicated that as an African American female she was an unexpected figure in her position as a STEM instructor.

> When you walk into the classroom, you don't fit that mold. Because I remember my first time ever teaching experience, and it was in Iowa. In Iowa. I mean, two percent Black. I walked in, and my students – I already knew I was going to get this – and then I go to the board, and I will never forget the look in their eyes. They were like, "Are you serious? Are you the TA?" And I said, "Yes, I am," and I just started teaching. So you can actually have an impact not just for minority students, but on non-minority students

> because they're like “Wow! They've never seen a Black woman teach at the collegiate level because there were not a lot of black professors even there. – Kaelyn

Kaelyn felt that students were shocked to see an African American woman TAing their STEM course and her identities became particularly salient. Not only were there very few African Americans in Iowa, but even fewer African American female STEM graduate students period. When reflecting on her own science trajectory, Kaelyn stated that she did not initially fully recognize science an option she could pursue due to her minority status as a woman of color, her lack of role models, and the stereotypical notion that only White men fit the mold of a scientist. Due to her own difficulties in finding other women of color to serve as mentors, she understood the value of interacting with role models who share similar characteristics and backgrounds and also felt she was able to expand her students' notions of what a STEM graduate student could look like.

The impact of these external perceptions are notable as they further marginalize students and may call into question the student's science identity at a critical point where recognition is fundamental part of their development process as “scientists”. This lack of recognition is seen Sydney's experience as she encountered this issue based on gender.

> It always surprises people when you tell them you're an engineer. It was funny, when I came down here for the tour, I came with my boyfriend at the time. We went through the department, and the department head addressed him. [My boyfriend] was like, “Not me. I'm going into journalism.” So there's still stereotypes. – Sydney (White Female, Industrial Engineering Major, HSI)

Like Sydney, many students felt that their racial and/or gender identifiers caused them to be dismissed by science faculty and peers. This phenomenon demonstrates how these students,

along their science identity pathway, experience signals in their everyday lives that constantly communicate a sense that their minority status doesn't fit the mold of a scientist. In other cases, students are not just made aware of their underrepresentation, but have endured overt discrimination as others question whether they even belong in science. Cooper and Sean, for example, each felt that their position as successful STEM graduate students was questioned because of their racial identity and felt that they had to justify their roles or prove themselves.

> I mean, people always say, "Well, you got this scholarship because you're black." So you just always have to be prepared to answer those types of questions. – Cooper (African American Chemistry Major, PWI)

> But like race is a big one just because you just don't see a lot of African Americans in engineering or anything like the STEM fields. And it's kind of a conflict because, you know there's, you know even within the academy itself, you know there's people who kind of question, you know your ability. I always feel the need to kind of work harder and outperform, you know other people because like I'm aware of the fact that there are some people who question am I supposed to be here, can I really measure up. – Sean (African American Male, Engineering Major, PWI)

Noah was faced with a bolder clash of identities brought on by his peers, who questioned his abilities and qualifications outright.

> It was just hard to interact, because like he was saying, like the fear of the affirmative action type thing. 'Cause some students actually voiced that opinion, you know. Like, I mean, just blatantly that, oh, maybe, you got in through that or something. And so, one of my friends who came from Fresno State with me, another Latino student, and so, me and him, kind of like, we always worked together. So me and him relied on each other a lot to transition, but even he kind of a made a complaint that it was hard to adjust to that coming from Fresno. When I talked to my friend, who is the only other Hispanic student in the class, I told him like I was really afraid that if we did bad in the class or something, compared to everybody, that we could kind of be like looked down upon. I felt like I had to do really well, like twice as well. And so, I ended up doing well during that quarter because I also had that kind of pressure to show that I just didn't get thrown in here

> because I had maybe minority money attached to me or something. And so, even when I went into my second quarter here, I ended up as a number one student on one of the cumulative exams. For me, it was like satisfying, because the students that were kind of accusatory of that, some of them weren't afraid to say it. But I just told them, "I TAed with you guys and I took the same classes. And I still got into a top spot anyway." So, I had to explain to them that, yeah, that didn't matter. – Noah

By Noah's peers accusing him of getting into his graduate program through Affirmative Action, they forced his racial and ethnic identity up against his identity as a scientist, calling his abilities and skills into question. He felt that if he were to do poorly, his fellow students would look down upon him, and this would bolster their claim that he didn't belong. The pressure of having to prove that he did indeed belong in the program drove Noah to succeed. Nevertheless, the combination of a racial minority identity and an identity of a budding scientist created tremendous conflict for Noah, and also for many other students we interviewed.

Beyond external pressures that students encounter in their interactions with others, these students must operated within a disconnected disciplinary culture. Due to the historical underrepresentation, discussions of social identities such as race or gender, are often absent from science classrooms, which can isolate women and URMs. As students developed their interest and identity in science, many experienced internal conflicts related to the nature of their disciplinary culture, as science education often lacks cultural inclusiveness and relevance, as Brody's statement illustrates.

> The reason I sometimes resist the label of a scientist is because I recognize with that label comes a certain perspective, and that world view is often very much associated with if I can't observe it, or if my interpretation of the data leads me to realize that something doesn't exist then it doesn't exist. Let me give you an example. With regards to the physics community, I think the data are something like African American and Hispanic physicists constitute about less than two percent of physicists currently out there. If a physicist who isn't concerned with racial issues in America looks at the data, they might

> easily interpret "Oh, well African Americans and Hispanics can't cut it. They're not physicists because they just can't do it." And because their interpretation of the data is limited to their world view, then that leads them to the interpretation of course the smart people will become physicists. And so the problem with science, to me, always is that it's only as good as the amount of information that you're taking in, which is always limited. Because there's so few people in the discipline who are black, Hispanic, Native American, I guess, that it just makes a presumption of ignorance until proven that you're competent. – Brody (African American Male, Physics Major, HBCU)

Similarly for Kaelyn, during her master's training at a PWI, she felt that science faculty often omitted the contributions of women and people of color. Here, she discusses how this silence surrounding race, ethnicity, and gender can give students the impression that these issues have no place in science.

> When I went to Iowa, you know, I would tell the professors, "Do you know why those are called HeLa cells? You know, Henrietta Lacks?" If you just read the *Immortal Life of Henrietta Lacks*, she had like cervical cancer, and so they took her cells back in like the fifties or whatever. And a researcher wanted some cells that they could keep and culture over and over again, that they could just keep replicating. And so her cells are the ones that are HeLa cells, and some researcher just transcribed HeLa because they didn't know how to spell her name, Henrietta Lacks. So they're still using her cells, you know, in research. I would talk to my professors about these things, you know, things like Black history. Like "Don't skip over that page about Ernest Everett Just in the book. Like, I mean, that's in the book. Let's read about this, you know." I'm really serious about that. I want to know. Why can't other students know about what he did? It's so amazing how it is an institutional type thing, you know, but it can be on an individual basis too though. I know they didn't because, I mean, for the students at Iowa that doesn't necessarily intrigue them like it intrigues me. – Kaelyn

She courageously challenged these faculty members by inserting the topics of race and gender into class discussions; yet, the reality is that most students are in situations where similar concerns often go unheard. The dominant disciplinary culture generally dictates scientific teaching, learning, and practice and therefore has the ability to promote dominant groups while

marginalizing minority identities. Students describe the distancing of social identities as being promoted in variety of ways within their program, (i.e. the absence of culturally relevant materials and discussions), which was often rationalized within the discipline as maintaining objectivity within science. These experiences of marginalization can cause a student's gender, race, or ethnicity to be seen by the student herself as a cultural deficit and leads to "forced choices," where students believe they must choose between a positive ethnic or gender identity and a strong science identity. The following perspective exemplifies this "forced choice" to separate social identity from science.

> I think inside you're either a good scientist or you're not. You're not a female scientist. You're not a male scientist. You're either a good scientist or you're not. – Landon (American Indian and African American Male, Molecular Biology, HSI)

Landon seems to have divorced social identities from science identity, yet many students were unable or unwilling to make such a choice, which created unseen barriers for them in the STM trajectories. This conflict was pervasive as it extended beyond the classroom and directly restricted them from merging their scientific pursuits with their interests and motivations based on their own cultural worldviews. Carson elaborates on this dynamic.

> My first advisor actually was pretty awful and wouldn't let me… we fought about whether I should engage in extra-curricular activities. I was recruited by a minority recruitment person here, so when I got here the woman said it would be nice if you could help recruit more students. My advisor wouldn't let me, so I told her I can't do that. So the recruiter went to the director of my program and said, "What's going on? Carson's not helping out. We helped him get here." So that sort of put this tension between me and my program. And then my advisor, we just never worked out and eventually she cut my funding and told someone else to cut my funding. It was a really ugly thing. – Carson

His transition into the doctoral program was initially impeded by his first faculty advisor who failed to recognize the importance of his cultural identity. He felt an obligation to his community to actively assist the outreach and recruitment of more Indian American students into his institution and department. This conflicted with his advisor's mandate to discontinue his extracurricular activities in order to devote the bulk of his time to lab research.

While students face "forced choices" within the science context, as in the aforementioned examples, there may also be a disconnect when student's science identity interacts within non-science environments, such a student's family and community life. Values and conceptions stemming from their affiliation with science may not directly align with their cultural values, traditions, and ideologies, which can require a "balancing act" among multiple belief systems that are equally valid in the eyes of the student. For instance, students' spiritual and cultural beliefs may conflict with dominant conceptions of biology and medicine.

> I talk about my experiments with my parents and my little brothers. In a way I'm kind of educating them. They like to hear what I learned and its relevance. Maybe because there's stuff that they didn't know could go on in your body. 'Cause I mainly talk to them about our immune system, how it's activated and what happens when something goes wrong. They're just amazed by it 'cause I'm Navajo so we have stories of how we became us, but then there's a science part to that, too. So they're like, 'Oh really' when I tell them about it. They're like 'Okay, I don't know if I believe you, but okay.' – Avery (American Indian Female, Biology, HSI)

Avery's scientific research does not align with the traditional creation stories of her people. As demonstrated through her words, her interactions with family and within a communal context provide reminders of the conflict she must negotiated. Therefore, she is faced with the dilemma that many of the students in our sample encountered, trying to reconcile two worlds that are both valid and central to their lives. Their personal accounts revealed that they utilized

numerous negotiation strategies in order to maintain their complex array of identities. We detail these negotiation strategies below, including: "wearing different hats", simplifying science, and redefining science.

Negotiation of Science and Social Identity Conflict

Many females, URMs, and first generation college students who felt that their identities were not congruent with the prototypical conception of a scientist continuously renegotiated their identities in order to navigate their multiple environments. The following student experiences begin to uncover how students engaged in this constant negotiation process in order to reconcile and merge these identities to achieve and persist in STEM fields. These students actively exercised their agency in order to find convergence between their identities.

Wearing different hats

Some students negotiated their social identities in relation to their science identity by varying the emphasis of each identity within multiple contexts. Students prioritized and integrated their positionality depending on the setting and their relationships within groups, as Benjamin described below.

> He asked me "How does your being in science…, does that conflict with your religious beliefs?" I can see the perceptions that you hear all the time, and I do feel it 'cause I am a religious person first, then everything else. So I do think they interact all the time, but I think being in science and even as a student with an identity, I think they just blend. I think sometimes putting on your hat at this certain place is okay. Okay, now I have to [put on another hat because] now I'm with this group. I'm a Christian first. So wherever I'm at that's going to be my focus first, and then I blend in if I'm science. – Benjamin (Latino, Industrial Engineering, HSI)

Benjamin stated that his religious identity is his predominant identity, although his identities interacted all the time, he "puts on another hat" depending on the setting. Many students echoed Benjamin's sentiment, including Julia, an African American women from an HBCU, who discussed navigating her racial and other social identities depending on the situation.

> I feel like my identity is also, I guess, fluid. It's not really static. So I do find myself at times, I guess, limiting the conversations that I have with my family members or other people from my hometown just because I know they won't necessarily understand. And I don't want to make them feel uncomfortable or make them feel as though I'm being condescending or anything. And a lot of times I just bite my tongue or I withdraw from the conversation just because I don't want to cause any type of conflict in the house. I just don't want to engage in conversations that they may not completely understand, so I guess in a sense, I feel like I'm two different people when I'm at home and when I'm here at graduate school. – Julia (African American Female, Genetics Major, HBCU)

As these students' words reveal, this strategy allowed them to navigate through society while filling different roles at different times. While this strategy may be temporarily effective, other students went beyond this to begin to find ways to make connections between these interacting identities and contexts, wherein they simplified their science to make it more accessible, as we discuss below.

Simplifying Science

When students returned home and interacted with non-science peers or family members they described feeling like "two different people" or that they had to distinguish between their personal identity and their science or academic identities. To do this many would minimize their educational accomplishments and often this was based on the desire to maintain humility, while acknowledging the value of their community's cultural wealth and the experiences of others.

This speaks to their inclination to retain a sense of self within their communities and maintain relationships amongst their non-science networks.

> I identify myself with being an engineer/scientist, but I also find myself having to downplay that on a pretty regular basis. A lot of my friends and peers are either not college educated or college educated but not in a STEM background. And so in a lot of ways I find myself even sometimes making excuses for myself as far as what I do, how I identify myself in these particular – as a scientist and an engineer. Because some people then treat me differently if I automatically put that out there. And in some ways they either discount what I say or they put me on too high of a pedestal, which I don't deserve. – Brady (African American Male, Electrical Engineering Major, PWI)

Because many of Brady's friends were not college educated or involved in STEM, he felt that he needed to minimize his accomplishments to acknowledge their experiences as equally valid. Likewise, Logan and Abby found themselves in a similar position, where they struggled with the best ways to convey elements of their STEM education in order to make themselves and the work that is important to them more relatable to those with non-science backgrounds.

> It just makes people more comfortable talking to you and interacting with you. If you don't say exactly what you're doing or what your position is or anything like this, because you may not think it does, but I realize that they feel a little bit belittled if you say, oh, for example, I'm gonna be a doctor. I'm doing my Ph.D. But if I just say, oh, I'm doing research at a hospital. They're like, oh, okay. They're kind of curious. So, there's different ways of saying it that I noticed help sort of interactions with people. – Logan (Latino, Molecular Biology Major, PWI)

> So we go to high school and do demonstrations, but you don't really talk about your research 'cause it gets kind of complicated. They find it boring. So we just try to show them, like, "Oh, there's this thing that – it's fluorescent," or, "You can get DNA." We try to teach some of the simple things just to get them excited because they can do cool things. And sometimes if I'm speaking to people in other field, you have to really put it in simplistic ways, but I don't like doing that sometimes because I feel like people might think I'm being condescending. – Abby (Latina, Pharmacology Major, PWI)

Students also formulated more culturally specific ways to present the benefits of their scientific work. By communicating the relevance of science to their communities, they were able to preserve relationships and garner support from non-science friends and family members while providing relevant, useful knowledge. Refer again back to Carson, he prided himself on finding ways to simplify scientific concepts in order to increase scientific literacy and make science more applicable to the general population. For example, he and his wife serve on the board of directors for their local American Indian community center, and they also aspire to develop non-profit organizations that will use technology for the advancement of the American Indian community. He discussed his strategy of simplifying and culturally tailoring his science discussions below.

> One of my goals in getting a PhD is to develop a language to talk to people that don't understand science – I want science to be more accessible so that people aren't afraid of it. If I'm in the American Indian community, I always say diabetes because it's one of the biggest things. So that'll catch somebody's ear and maybe they'll be interested a little bit more. I have this story that I've made up where instead of talking about proteins I talk about zombies and that the misfolded proteins are zombies and they're affecting people that are coming into the city. That's a fun way for me to talk about what I do and people's eyes don't glaze over. – Carson

Like Carson, Julia and Cooper placed great importance on sharing their knowledge with their respective community in accessible ways.

> I'd like to use my PhD just to make sure that I'm educating in particular the minority population about the genetic resources that are available. So I know that genetics information is not something that people talk about on a daily basis. It's something that some communities never talk about just because they're not informed. So I really like to use my PhD to, I guess, provide them with the information that's available and let them

> know about some of the life-saving technologies that are coming out, to which they may not be aware. – Julia (African American Female, Genetics Major, HBCU)

> When it comes to explaining things to my family, I kind of just find they're just so proud that I'm doing my Ph.D. I think all the tellers at the bank that my grandma and my mom go to know that I'm getting a PhD in chemistry. To them the fact that I'm getting my degree – and specifically for them as African Americans being able to tell people who are not African American in the South, which is still to some points very segregated, is a lot. It's not very often where people in your family have done things that are good and people feel like they can really talk about it. I think there's a lot of great things happening in my family, don't get me wrong, but anything like from like my nephews and nieces getting A's on their report cards to someone getting a job is always broadcast because there's always negative things that come out, and there's also negative social implications. So I mean, I've gone back home recently and my mom will always say, "Oh yeah, this is my son Cooper, he's getting his PhD." And depending on who she tells, she gets a very different reaction. So a lot of African American people be like, "Oh that's so cool. That's really nice." Then when you talk to some of the White counterparts you don't quite get the same reaction. They're like, "Oh, that's nice." It's kind of like a "Who do you think you are" kind of thing. But for my parents it doesn't really matter that much. So I don't want to gloss over the fact that I do talk to my parents about what I do, and I do practice and make sure that every year I try to get more clear and more succinct about what I'm doing so they have a better context. – Cooper (African American Male, Chemistry Major, PWI)

By making their science knowledge more widely available to others within their non-science circles, these students were able to preserve their identities as both members of their home communities and as scientists, while maintaining relationships and acknowledging the value in both experiences. Other students similarly aimed to establish a culturally relevant path for their STEM knowledge in order to negotiate their identities by actually redefining and re-structuring their scientific endeavors. For these students, their social identities drove the direction of their science and their STEM trajectories.

Redefining

Many of the participants said they were able to remain and persist in STEM by adopting a strategy to redefine, or merge their science identities with their social identities. Perhaps the most frequently cited way to redefine their science identities was for students to find a match between science and their altruistic and socially just aims. Here are just some of the comments offered by participants who express this desire to merge social concerns with science.

> I did research at the School of Public Health. I worked with a Latina physician, who opened my eyes to sort of a population-based approach to health as opposed to a one-on-one individual commission approach. I enjoyed her approach to problems that I sort of grew up with on the border, in terms of environmental health conditions. That's what inspired me in graduate school." - Jackson (Latino, Public Health Major, PWI)

> I also see myself kind of going into like genetics, the ethical side of genetics, just to make sure that we don't have a repeat of like Tuskegee experiments or other unethical experiments that went on with individuals. For me, history plays a significant part in my career decisions too just because I am aware of unethical experiments that have been performed with minority populations. So I want to make sure I do what I can to ensure that those same situations don't occur again. – Julia (African American Female, Genetics, HBCU)

> And I think it's quite interesting that I identify myself as a scientist or someone who has a science background and I have an opportunity now to do something that I actually work with people and look at poverty reduction and issues of electricity when it comes to poverty reduction. So I get to actually do something I feel that's meaningful in everyday. – Brandon (African American Male, Applied Physics Major, PWI)

> The reason I'm interested in global health is mostly 'cause it pulls on my heartstrings, and I really feel like we need to bridge the gap between scientists and people that are like the public health officials who are trained in a very different way than we are, and so there's a big gap in communication. Maybe somewhere along the line, I would like to be one of the people that can understand science and can understand the research in a very critical way and can inform people that, you know, are making these decisions or maybe

> become one of those people that make decisions. – Elizabeth (Latina, Cellular Molecular Biology, PWI)

For many participants, like Jackson, if scientific endeavors could reflect the social issues of the working class and ethnic minority communities from which they came, then these students could utilize their social identities as strengths to contribute unique perspectives to advance science in new and ever more socially conscious ways. Many of participants said their strength simply rested in the fact that they just care more about social concerns than most of the other scientists and engineers they came across. Others said their knowledge and awareness of the ways science had historically affected different cultural groups was a unique strength. Julia in particular believed that scientists who were well versed in the histories of racism, sexisms, and classism in America could monitor scientific policies to avoid repeating ethical mistakes in the future. Many students, like Brandon, also felt their identity as scientists intensified when their research became aligned with real world applications that addressed social concerns, such as poverty reduction. Perhaps the most important strength students said they could offer was their interdisciplinary perspective. Participants, like Elizabeth, believed that they had prepared themselves to be more than just researchers or technicians, but rather they had developed an interdisciplinary perspective that could transcend barriers between scientists and policymakers. These students believed their backgrounds had uniquely qualified them to communicate and interact with policymakers in order to inform policy change.

Once again, refer back to all three of our student narratives. Kaelyn, Noah and Carson were each driven by the desire to improve the representation of women and URM scientists. Amongst our sample this was the most frequently cited way to transform science in order to

match students' altruistic and socially just aims. These students planned not only to become scientists themselves to increase the numbers of women and URM among faculty, but also to make the culture of science more inclusive from within and encourage future generations to become scientists. Thus these students negotiated the disconnect between science culture and their social identities by making intentional efforts to redefine scientific endeavors toward altruistic and socially just aims, and utilized their racial backgrounds as strengths that contributed a unique perspective aimed at advancing science in new ways. Kaelyn was motivated to take on a faculty role by the visibility she could bring to women of color in STEM and by the chance to serve as a role model. Noah felt that he could bring a level of understanding of Latino students' needs and relate the potential impact of science to them that outsiders often could not. Carson described wanting to teach at the undergraduate level science to generate students' early interest in the field and make science more accessible to American Indian students. They describe these motivations and desires below.

> I've thought about going into academics, maybe, going back to the Central Valley, 'cause where I'm from – it's kind of one reason why I even considered academics, just 'cause I was comfortable around that area. I kinda knew the mindset of the people around the area. I saw the professors come in, but they came in from a bigger university. They just kinda had no idea how to deal with that level of student. So, for me, it was kind of hard to see them go in there and they have lots that they want to do, but they can't do it 'cause they just don't understand why people are even going to that school, you know? And so, I thought about doing academics. – Noah

> One aspect of my identity is to help those other young girls, Black girls just like me, that didn't know maybe what they want to do. You know, when we talk to – when we see these undergraduates out here, I say, have you ever thought about graduate school? If you've never done research, you might not even know that you were interested in something that you never knew about. So that's where the identity comes in, is exactly, standing there as a Black woman for those who might not even know about a career path that they didn't hear about. – Kaelyn

> And I have a good advisor that's invested in my – in the things that are important to me like teaching Indian students and going to these conferences to meet other Indian people and network so I can get a job teaching and working in science with Indians. – Carson

This sentiment was echoed by many other students, including Lillian and David, who were also quite direct in defining their goals as increasing minority representation in the sciences.

> I was never good at math, so it never would have occurred to me to do anything related to science or technology. I think if you're not good in those subjects you kind of do get shifted to another path. So it took me having to wait until I was older and just saying, "I like it, and I'm going to do it". One of my goals now is to work with minority students to try to lift them up at a teaching capacity so they don't have to feel like I did, like, "Wow, I don't belong here." You know, so I really am committed to that. - Lillian (Latina, Biomedical Science Major, HSI)

> So what I want – the ultimate goal is to increase under-represented populations to increase their presence in organismal biology, like ecology-related fields. Particularly herpetology if I can, just because it's near and dear to my heart and I'd like to do that by introducing high school aged students to research, to field research, throughout high school. – David (African American Male, Animal Behavior and Ecology Major, HBCU)

The above participants were very clear in specifying their goals of increasing minority representation in the sciences. Their desire to teach or participate in outreach was not just motivated simply out of pure altruism, but rather as a way to advance social justice by responding to barriers that impede URMs in STEM, such as discouragement from stereotypes or lack of exposure to science pathways. By becoming STEM faculty and instructors these participants felt empowered by the possibility of reconstructing and changing science contexts to reflect the structural diversity of U.S. society among the faculty, while also generating greater interest in STEM to increase the diversity of students who enter and persist in the field.

Whether redefining, communicating science in culturally relevant and accessible ways, or shifting their science identities, these students engaged in complex negotiation strategies in order to be scientists while maintaining their social identities. Many met conflict along the way, while others experienced significant areas of convergence. As Kaelyn, Noah, and Carson's narratives reveal, these identity interactions are significant elements along STEM students' educational trajectories towards becoming scientists. Through this examination of the ways in which successful students navigate such elements in their pathways, we have been able to generate findings with wide applicability on the programmatic and policy level.

DISCUSSION

This study presented a myriad of factors rooted in contexts and culture of STEM whereby students experienced conflict between their science and social identities. Additionally, we also presented some rare instances during students' lives when their social identities and science identity converged without having to negotiate identity conflicts. For example, students often felt little or no conflict entering STEM fields when they enjoyed early success in math and science, received academic encouragement from adults, or had highly educated family members who were scientists. We also found that having structural diversity at institutions and in STEM departments permitted a certain level of identity convergence, though the impact was limited. These feelings of convergence were often short-lived because students would eventually experience identity conflicts as the level of structural diversity diminished once they left their institutions to enter the workforce or broader science contexts. Furthermore, since topics of racial and gender diversity were seldom discussed or even acknowledged in science contexts, many of the institutions failed to capitalize on the structural diversity by promoting cross-cultural engagement in the classroom.

Instances of identity convergence were the exception, as students for the most part described instances of conflict between their social identities and science identity. Sources of conflict include underrepresentation in science, overt discrimination, science disciplines that lacked cultural inclusiveness and relevance, and misalignment between student's social identities and science identity. Underrepresentation, being a core issue, results in a lack of role models, which makes students feel they don't fit in as scientists. Additionally stereotyping and overt discrimination places external pressure on students and limits their opportunities to receive the type of recognition that is critical during science identity development. Distancing of social identities from the science context is promoted and perpetuated through s lack of inclusiveness and relevance in science disciplines, which leads to forced choices where students must choose between a positive ethnic or gender identity and a strong science identity. Divergence between identities manifests as interacting identities and contexts are misalign and tension is present among multiple belief systems. Successful students must demonstrate agency in finding ways to reconcile these conflicts in order to persist in these discipline, which initially may be incongruent with their social identities.

The results of this study indicated that students adopt specific strategies to manage and negotiate tensions between their social identities and science identities. Among these strategies, we found that students who experience identity conflicts with science were able to redefine or reconstruct their own meanings of what it meant to be a scientist and a person of color. While these findings generally confirmed those of Carlone and Johnson (2007), we distinctly found that students redefined science not only for altruistic aims, but specifically toward socially just aims, such as improving conditions for communities of color. By redefining science, students were able to include their social identities as the impetus for their scientific work, but also transform

science into a vehicle for social change. As such, redefining science was considered an ideal strategy to successfully merge their science and social identities. An additional strategy students commonly utilized was wearing multiple hats or managing different identities for each given context or situation. By shifting the emphasis or salience of their science identity between science and non-science contexts, students were able to delicately balance seemingly oppositional identity frameworks. While this strategy of avoiding conflict allowed students to persist in STEM, it did not permit them to merge their science and social identities.

The research findings also support Rendon's assertion that students find additional sources of encouragement, support, and validation from friends, family members, and home communities. In such case, students made deliberate efforts to preserve these relationships by simplifying science in order to make it more relevant and accessible to non-science friends and family members. In order to persist, it was especially important for students to rely on these out-of-class sources of support, especially when they felt as if they their science identities were not fully recognized or validated in class and in the lab.

Conclusion

This study contributes to a better understanding of the science identity development process, specifically how STEM students experience conflict between their social identities and science identities. Whether students can negotiate this tension in order to maintain a sufficient sense of identification with the sciences has a significant influence on whether they ultimately persist or leave the STEM education pipeline. By identifying the strategies that students have found to successfully negotiate identity conflicts, we can potentially inform mentoring, pedagogy, programmatic support systems, and institutional culture that assist students from

diverse racial, gender, socioeconomic (SES), sexuality, ability, and religious backgrounds to continue along their trajectories as scientists.

When developing these support programs and initiatives, the conventional approach has been to focus on the disadvantages these students face in order to address barriers to persistence. However, student agency is an under-examined area in studies of STEM students, with limited consideration given to how they actively position themselves to succeed. So while it is important to understand the structures or cultures that cause students to withdraw from academic identities, the overwhelming research focus on barriers alone can contribute to the cultural reproduction of the perception of URMs as leavers of science based on deficits (Bensimon, 2005). The disproportionate focus on the underachievement of URMs in the STEM literature not only distorts the image of URMs, but it can unintentionally create a lower set of expectations for URMs (Fries-Britt, 1998). By approaching the issue of STEM persistence informed by an orientation of "achievement" rather than a focus on disadvantages and barriers, we have identified several negotiation strategies that students employ to help themselves successfully navigate the STEM education pipeline. Nevertheless, there is a critical need for more studies to further attempt to understand the experiences of students who have successful persisted in the STEM disciplines.

It is clearly important for future studies to examine how faculty and peers in science departments, as well as institutions, can recognize, validate, and support the capabilities and unique perspectives that diverse students contribute to graduate STEM programs. Students in our sample provided us with some keen examples of what this type of individual and institutional support can and should look like. Refer back once again to Carson – despite the conflict with his first advisor, he was able to connect with another faculty member who not only recognized the

importance of his cultural identity, but who was a staunch advocate of his success, especially in raising awareness of the unique needs and interests of URM students in STEM.

> I have a good advisor that's invested in the things that are important to me like teaching American Indian students and going to conferences to meet other Indian people and network so I can get a job teaching and working in science with Indians. He's a member of SACNAS, which I'm a member of which is Society for the Advancement of Chicanos, Hispanics and Native Americans in Science. He has lobbied for me in my program. Now my program is really supportive of me and is always looking for new opportunities and encouraging me to apply for fellowships and honor societies and that kind of thing. So now I think through my experience, they're much more aware of things that are maybe important to some minority students. – Carson (American Indian Male, Bioinformatics Major, PWI)

While Carson provides an insightful example of the power of individual support, other students benefitted from institutional initiatives and intentional programming stemming from institutional context and culture. Several structured programs that represented institutions' intentional efforts were noted by students as providing multiple venues of support (i.e. financial support, research exposure, mentorship) that assisted them in negotiating barriers and championed their success. Here Isaac describes his institution's curricular focus on promoting socially relevant ways of teaching, learning, and conducting scientific research.

> What going to an HBCU does for you is that you're allowed to do research that has social responsibility, like research on prostate cancer, the number one killer of Black men. I wouldn't necessarily have that opportunity at a predominantly White institution. That may not be their focus. I think that coming here avails that opportunity for you to have research that deals with social responsibility. – Isaac (African American Male, Chemistry)

For Isaac, Carson, and many other students in our sample, STEM faculty members, departments, peers and even institutions as a whole were instrumental in permitting them to remain fully engaged in STEM by thoughtfully guiding and supporting their interests and motivations, by allowing them to be themselves and be scientists. By documenting the

educational experiences of more successful STEM students like those in our sample, we can learn what students, faculty, departments, and institutions are doing that works and learn from their success as we move forward in diversifying the STEM pipeline.

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