Transforming Student-Faculty Relationships into Social Capital in STEM: The Influence of Race and Gender

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Abstract

This qualitative study examines how race/ethnicity and gender influence the transformation of student-faculty relationships into valued forms of social capital that students could leverage for career opportunities within Science, Technology, Mathematics, and Engineering (STEM) contexts. Through retrospective interviews with 40 STEM graduates, the data revealed: (1) that experiences of racism and sexism among women of color affected their ability to attend office hours and build strong relationships with professors; (2) that while white females experienced sexism from faculty, their white privilege lessened the negative effects associated with their gender; (3) that being exposed to diverse faculty facilitated conversations between female students and students of color and their professors about their career pathways; and (4) that the negative influence of race/ethnicity and gender on student-faculty relationships was alleviated, but not eliminated, through research engagement.

Keywords

Under-represented minorities, women, social capital, social ties, student-faculty interactions, STEM, post-graduation, career outcomes

The interactions that students have in college with their professors play a key role in their college experiences and consequently on their career-related opportunities. These student-faculty relationships are forms of social ties and can happen independently or within broader social networks (Granovetter, 1973), such as classroom settings and student organizations. Establishing close and positive relationships with faculty is linked with key academic outcomes such as developing cognitive skills, increasing academic competence, enhancing interpersonal skills, and defining career aspirations (Campbell & Campbell, 1997; Kim & Lundberg, 2016; Komarraju, Musulkin, & Bhattacharya, 2010; Kuh & Hu, 2001; Pascarella, 1980). In contrast, when students have distant relationships and negative experiences with professors, their academic self-efficacy and performance are negatively impacted, hurting their overall college experiences (Cole, 2007, 2010; Cotten & Wilson, 2006). In some cases, negative student-faculty interactions can even deter students from pursuing their originally intended majors, also altering their post-graduation plans (Hearn, 1987; Vogt, 2008).

While in theory every student has access to professors, research shows that student-faculty interaction is influenced by race/ethnicity and gender (Cole, 2004; Hurtado, Eagan, Tran, Newman, Chang, & Velasco, 2011; Kim, 2006; Lundberg & Schreiner, 2004; Sax, Bryant, & Harper, 2005); and that under-represented minorities (URMs) and women do not obtain the same benefits from their relationships with professors as their white and male peers (Carlone & Johnson, 2007; Kezar & Moriarty, 2000; Sax, Bryant, & Harper, 2005). Within Science, Technology, Mathematics, and Engineering (STEM) contexts, research demonstrates that URMs and women encounter marginalization in the classroom and are subject to discrimination from faculty, impacting their general academic experiences and career pathways (Chang, Eagan, Lin, & Hurtado, 2011; Creamer, Burger, Meszaros, 2008; Espinosa, 2001; Park, Kim, Hayes, &

Salazar, 2017; Rosser, 2004; Seymour, 1995). This research implies that as a result of negative interactions that URMs and women have with professors in STEM settings, they are not benefiting as much as they could from those relationships, such as obtaining recommendations for career opportunities and access to professional contacts. These relationships are usually considered valued forms of social capital because they can lead to social gains and opportunities overtime (Bourdieu, 1986). Therefore, when URMs and women in STEM contexts do not have access to these positive relationships due to systemic issues, such as encountering discrimination from faculty (Park et al., 2017), they are at a disadvantage in comparison to their white and male counterparts. Furthermore, the inequities that URMs and women encounter within higher education have the potential to also influence their career-related opportunities post-graduation.

While research on STEM education has been growing for the past 15 years (Chang et al., 2011; Cole & Espinoza, 2008; Hurtado, Eagan, Cabrera, Lin, Park, & Lopez, 2008; Ong, 2002; Starobin, Smith, & Santos Laanan, 2016), no studies have examined how race/ethnicity and gender influence the transformation of student-faculty relationships into capital-related gains that extend beyond the college years. This gap leaves questions about inequities that transcend educational settings and affect the professional opportunities of women and URMs even after they graduate with STEM college degrees. It also highlights the need to investigate how the career-related opportunities of STEM graduates are influenced by their relationships with faculty.

Thus, the purpose of this study is to understand how race/ethnicity and gender influence the transformation of student-faculty relationships into career-related opportunities in STEM. We seek to understand the processes behind how social ties transform into social capital, and the influence of race/ethnicity and gender in that process. Specifically, through retrospective

interviews with 40 STEM graduates, this study seeks to answer the following research questions: (1) To what extent do race/ethnicity and gender influence the relationships STEM students are able to develop with faculty? and (2) In what ways do racial/ethnic and gender differences influence how STEM students gain career-related opportunities through their relationships with faculty? We begin this paper with an overview of relevant literature and follow with the conceptual framework guiding the analysis in this study.

Literature Review

In this section, we provide an overview of the literature focusing on the experiences of URMs and women in STEM settings, and on the role that race/ethnicity and gender play in student-faculty interactions within STEM contexts.

Experiences of Under-represented Minorities and Female Students in STEM

Research centering the experiences of STEM students has grown for the past 15 years, uncovering how students navigate various STEM environments and the factors that impact academic outcomes such as retention and graduation. Within this body of literature, several studies have focused on women and URMs, documenting their distinct educational pathways and the unique challenges that they face based on their race/ethnicity and/or gender (e.g., Carlone & Johnson, 2007; Dortch & Patel, 2017; McGee, 2013). While the metaphor of a "leaky pipeline" is vastly used in STEM contexts to indicate that there are many leaks throughout K-12, higher education, and the workforce affecting the number of STEM college graduates and professionals (Packard, 2016; Preston, 2004), scholars have found that URMs and women in STEM are not just "leaking out" ad hoc, but that they are in a way being pushed out due to systemic issues such as racism and sexism (Dortch & Patel, 2017; Park et al., 2017; Xu, 2017). Unlike their male and white counterparts, women and URMs in STEM, often encounter "chilly climates" and are

subject to marginalization from peers and professors (Dortch & Patel, 2017; McGee, 2013; Strayhorn, Long, Kitchen, Williams, Stenz, 2013). This not only affects their academic outcomes but their overall career trajectories because they are more likely than white and male students to change their majors early on their college years and leave STEM fields altogether (Seymour & Hewitt, 1997; Xie & Shauman, 2003).

Research has demonstrated that among STEM students, women are less likely to be academically satisfied than their male peers, and that their academic dissatisfaction is often associated to the STEM classroom environment and unwelcoming climate that they typically have to navigate (Amelink & Creamer, 2010; Gayles & Ampaw, 2014; Ong, Wright, Espinosa, & Orfield, 2011). Seymour (1995) found that women in STEM classes often felt excluded by their professors from class activities, which negatively impacted their academic experiences. In addition, the students in Seymour's (1995) study felt that male faculty disapproved of their presence in STEM classrooms, which led many of them to switch out of STEM majors despite their career aspirations. In a more recent study, similarly to Seymour's (1995) findings, Amelink and Creamer (2010) found that the academic satisfaction of female students in STEM was correlated with how they developed relationships and connected with peers, as well as the respect they perceived to receive from faculty.

Additionally, among the factors contributing to the negative experiences of women in STEM are the competitive, individualistic, and male-dominated nature of STEM contexts (Cheryan, Ziegler, Montoya, & Jian, 2016; Diekman, Weisgram, & Belanger, 2015; Lee, 2002; Reyes, 2011; Seymour, 1995; Seymour & Hewitt, 1997). This not only affects how female students think about their academic and professional aspirations, but how they develop a science identity and persist in STEM (Carlone & Johnson, 2007). For example, in a study that examined

the gender gaps in participation among several STEM majors, Cheryan et al. (2016) found that women had lower participation in computer science, physics, and engineering disciplines. This was in part correlated with the "masculine cultures" (p. 6) associated with those majors, making it more difficult for women to develop a sense of belonging and seeing themselves "fit" in such fields (Cheryan et al., 2016, p. 6).

Negative stereotypes about women in STEM fields such as them having lower academic abilities than men, and the phenomena of stereotype threat (being afraid of reinforcing negative stereotypes) also influence the experiences of female STEM students (Beasley & Fischer, 2012; Smith, Sansone, & White, 2007). This is particularly true among Black women who are often described as facing a "double threat" due to their membership to multiple marginalized groups (Brown, 2000). Likewise, in their foundational piece that synthesizes empirical research focused on the experiences of women of color (WOC) in STEM, Ong et al. (2011) demonstrate that the intersections of racism and sexism continue to present significant and unique challenges to these women. Some of these hurdles include finding peer study groups (Justin-Johnson, 2004) and establishing a sense of belonging within and outside STEM settings (Dortch & Patel, 2017).

Moreover, various scholars have found that URMs in STEM settings experience feelings of isolation and lack of sense of belonging regardless of their gender identification (Cole & Espinoza, 2008; Strayhorn et al., 2013). This is related to being one of the few students of color in their majors, and encountering tokenization, stereotyping, microaggressions, discrimination, and cultural incongruity in STEM contexts (Carlone & Johnson, 2007; Chang, Eagan, Lin, & Hurtado, 2011; Cole & Espinoza, 2008; Hurtado, Han, Sáenz, Espinosa, Cabrera, & Cerna, 2007; Johnson, 2007; Ong, 2002). For example, Dortch and Patel (2017) found that Black women

pursuing STEM majors experienced microaggressions on a regular basis due to their race. This can result in feelings of self-doubt about their academic aptitude.

Moreover, due to their under-representation in STEM classrooms, URMs often feel pressured to prove that they are intelligent and competent because their academic performance and actions can be generalized and used to reinforce negative stereotypes about students of color (Chang et al., 2011; McGee & Martin, 2011). For example, McGee and Martin (2011) found that Black students in engineering and math majors felt the need to prove people wrong by excelling academically in their classes. In another study McGee, Thakore, and LaBlance (2016) found that stereotypes that portray Asian/Asian American students as high achieving and as model minorities, added stress to students as they made decisions related to their STEM majors. A large number of students in this study spoke about how they were encouraged to pursue STEM majors because there is a dominant perception of Asian/Asian American students being good at science and math (McGee et al., 2016). While Asian/Asian Americans are generally not underrepresented in STEM writ-large (although Asian American women may be), their work speaks to the pressure imposed on a student population due to racialization.

A large number of the studies that have investigated the experiences of women and URMs in STEM contexts are qualitative in nature and have emphasized how race/ethnicity distinctly influence students' educational pathways (e.g., Carlone & Johnson, 2007; McGee et al., 2016). Quantitative studies have also demonstrated how race/ethnicity and gender are factors associated with college outcomes such as the retention and graduation of URMs and women in STEM (e.g., Beasley & Fischer, 2012; Cole & Espinoza, 2008). This body of research explains how women and URMs navigate STEM environments while in college, but it does not clarify the extent to which undergraduate experiences, and the relationships students form through higher

education, affect their career opportunities after graduation. Understanding this process and the conditions that influence whether or not the connections students form in college transform into professional gains can help to address the persistent inequalities encountered by URMs and women in STEM contexts. To further understand how the relationships of URMs and female students in STEM are connected to their career-related opportunities, we focus the next section of this literature review on student-faculty interactions.

Student-Faculty Interactions in STEM

The positive outcomes associated with close student-faculty interactions are well established in higher education literature (Crisp, 2010; DeAngelo, 2014; Kim & Conrad, 2006; Cole, 2010; Kim, Chang, & Park, 2009). Specifically, positive and close relationships developed between college students and faculty strengthens retention and graduation rates; college GPA is also positively linked to student-faculty interactions (Barnett, 2011; Cole, 2010; Comeaux, 2008; Crisp, 2010; DeAngelo, 2014; Flynn, 2014; Gayles & Ampaw 2014; Jones, Barlow, & Villarejo, 2010; Kim et al., 2009; Tovar, 2015; Vogt, Hocevar, & Hagedorn, 2007). Students and faculty are able to interact in different settings and capacities, from formal to informal contexts. For example, some formal settings include the classroom, office hour visits, or a professor's laboratory if a student is employed or conducting research there. Informal contexts may include campus programs through co-curricular student involvement or community service opportunities. While favorable individual interactions between students and faculty can support the academic achievement of students and allow them to build meaningful connections (Astin, 1993; Pascarella, 1980; Santos & Reigadas, 2000), some students have negative encounters with faculty and/or may feel intimidated by their professors. Such interactions may be detrimental to

students academically and students' overall satisfaction with their college experience may decline (Chang, 2005; Pascarella & Terenzini, 1991, 2005).

Research shows that not all students experience the benefits typically associated with student-faculty interaction and that students' race/ethnicity and gender may influence whether they have positive or negative relationships with professors (Kim, 2010; Kim & Sax, 2009, 2011, 2014). Women and URMs are likely to receive the least positive interactions with faculty in both formal and informal settings (Lee, 2002; McGee & Martin, 2011; Ong et al., 2011; Seymour, 1995). For example, Hurtado et al. (2011) found that URMs enrolled at predominantly white institutions (PWI) perceived STEM faculty as uncaring, distant, and inaccessible. Furthermore, women in STEM repeatedly describe their interactions with professors as cold and unreceptive, which discourages them from fully participating in classroom discussions (Amelink & Creamer, 2010; Chang et al., 2011; Crawford & MacLeod, 1990; Dortch & Patel, 2017; Johnson, 2012; Ong et al., 2011). Some women even report a decline in their health from encountering and navigating conversations with condescending or unsupportive faculty (Sax, Bryant, & Harper, 2005). These structural issues may push women out of STEM disciplines and impact their overall academic and professional achievements. On the other hand, receiving faculty support and perceiving professors as accessible has the potential to strengthen the experiences of women in STEM (Xu, 2016).

Recent literature focused on student-faculty interactions within STEM contexts illuminates some of the inequities that URMs continue to face during their college years. In a quantitative study, Park et al. (2017) found that Black students have the lowest retention rates within STEM majors even though they are more likely to ask questions regarding course materials during and after class, as well as during office hours (Park et al., 2017). In addition,

compared to students of other racial/ethnic backgrounds, Park et al. (2017) found that Black students were most likely to report encountering discrimination from faculty members. These findings imply that as a result of more interactions with professors, Black students are increasingly exposed to negative interactions with faculty, which consequently impacts their retention and academic success in STEM.

This body of research demonstrates how positive and negative student-faculty interactions can affect the academic outcomes and experiences of women and URMs within STEM contexts (Hurtado et al., 2011; McGee & Martin, 2011; Ong et al., 2011). However, little is known about how the relationships that STEM students develop with their professors impact their post-graduation outcomes, and if race/ethnicity and gender influence the way that student-faculty interactions are able to transform into capital-related gains overtime. Only a few studies have uncovered how engaging in undergraduate research with a faculty member can shape the graduate school aspirations and pathways of STEM students (e.g., Posselt, Porter, Kamimura, 2018; Strayhorn, 2010). Since the relationships that STEM students form in college with professors have the potential to meaningfully impact their post-graduation plans, it is critical to understand the complexities and the conditions that influence whether or not students transform their faculty connections into valued forms of social capital beyond college. This aspect of the STEM student experience is still unclear and in need of greater study in order to address persistent inequalities in STEM contexts.

Theoretical Foundations

In this paper, we use the concepts of social ties—the connections that people have among each other (Granovetter, 1973) and social capital—the valuable resources and information that are exchanged within networks of social ties (Dika & Singh, 2002) in combination with Critical

Race Theory to examine the process of transforming student-faculty relationships into valuable resources that promote career-related opportunities within STEM contexts. In this section, we provide a brief overview of both theories and explain how they have been integrated into a conceptual framework to analyze the data in this study.

Social Ties and Social Capital

The connections that people have among each other—social ties can occur individually or within larger networks (Granovetter, 1973; Waserman & Faust, 1994). When these social relationships lead to professional and economic advancement opportunities through the exchange of information and resources, they are often referred to as social capital (Bordieu, 1985; Dika & Singh, 200). Social capital in the form of mentors, institutional agents, and supportive peers are critical to the academic and professional success of women and URMs in STEM, given their underrepresentation in most contexts (Chang, Sharkness, Hurtado, & Newman, 2014; Ellington, 2006; Johnson, 2007; Ong et al., 2011).

In STEM education settings, social capital networks contain important resources that students need to successfully navigate higher education and professional settings, from the support of study groups to the connections needed to land a job (Espinosa, 2009; Grandy, 1998). Faculty, pre-professional associations, lab partners, friendship groups, and colleagues and mentors from internships or co-ops are important sources of social capital (Chang et al., 2014); however, not everyone has the same access to those forms of capital because the formation of social ties is influenced by race/ethnicity and gender (Carlone & Johnson, 2007; Feeney & Bernal, 2010; Hurtado et al., 2011; Ong, 2002). Knowing that racial/ethnic and gender student characteristics play a role on how STEM students develop relationships with faculty in unequal

ways (Cole & Espinoza, 2008; Ong et al., 2011; Vogt, 2008), we incorporate a Critical Race Theory lens to our conceptual framework.

Critical Race Theory

Critical Race Theory (CRT) is a theoretical framework that emerged in legal scholarship during the 1970s to challenge racial oppression and as a tool to achieve racial justice (Crenshaw, 1995; Delgado & Stefancic, 2012). In education research, CRT began to be used as a theoretical lens in the mid 1990s when Gloria Ladson-Billings and William F. Tate called-in education scholars to address the problem of racial inequality in schools, and to examine how race and racial dynamics lead to educational disparities (Zamudio, Russell, Rios & Bridgeman, 2011). Since then, numerous education scholars have used this theoretical lens to examine the experiences of students of color within K-12 and higher education settings (e.g., Anyon et al., 2017; Solórzano, Ceja, & Yosso, 2000; Teranishi, 2002).

Through the years, the principles of CRT have been defined and expanded by critical scholars and they now primarily center on: (1) the recognition of the prevalence and centrality of racism in the U.S. society—racism as ordinary, (2) the acknowledgement that racial progress is achieved when white interests are served—interest convergence, (3) the understanding that people experience intersecting systems of oppression based on their multiple social identities—intersectionality, and (4) the use of narratives that challenge dominant ideologies and deficit perspectives about URMs—counterstorytelling (Delgado & Stefancic, 2012). In this study, we adopt these tenets and acknowledge that racism is prevalent within STEM educational contexts, and that it manifests through the interactions that URMs have with their professors consequently affecting student outcomes (Park et al., 2017). In addition, we recognize that the WOC in STEM

encounter racism and sexism due to their intersecting social identities (Ong et al., 2011) and that their experiences differ from white women who may experience sexism but not racism.

Conceptual Framework

We use the concepts of social ties and social capital in combination with CRT to critically examine the process of transforming student-faculty relationships into valuable resources that promote career-related opportunities in STEM contexts. Since CRT illuminates how gender, social class, and other social identities intersect with race to impact the experiences of URMs in educational contexts (Delgado & Stefancic, 2012; Zamudio et al., 2011), we use this lens to specifically understand how race/ethnicity and gender played a role on the way STEM college graduates interacted with their professors while they were in college. When combined with the concepts of social ties (Granovetter, 1973) and social capital (Bordieu, 1985), CRT allows us to investigate how racism, and other forms of systemic oppression such as sexism, influence the relationships that STEM students develop with faculty; and how those relationships may transform into valued forms of social capital in unequal ways among women and URMs beyond higher education settings. By applying a CRT lens to this study, we also seek to challenge master narratives that portray URMs and women in STEM as underachieving and less successful in their careers than their white and male counterparts; and expose how systemic oppression that manifests through student-faculty interactions leads to inequitable experiences and outcomes in STEM contexts. Figure 1 represents the theoretical foundations guiding this study.

[*Insert Figure 1 here*]

Methodology

We employed a multiple case study research design (Yin, 2014) to understand how race/ethnicity and gender influenced the transformation of student-faculty relationships into capital-related gains among 40 STEM graduates. In this investigation, each participant is a case (Stake, 1995), experiencing and representing the phenomena under study—the transformation of student-faculty interactions into career-related opportunities. We employed a purposeful sampling method to obtain cases that were rich in information and related to the purpose of the investigation (Merriam, 2001). Since we were interested in understanding the process of transforming relationships with professors into professional opportunities, we decided to recruit working professionals because they were able to comment on both their college experiences and career outcomes retrospectively.

Sample

We interviewed 40 STEM graduates living the DC, Maryland, and Virginia (DMV) metropolitan area, who had been working in STEM fields for at least 5 years. Our sample was racially diverse, consisting of Black/African American (n=12), Latina/o/x (n=9), Asian/Asian American (n=9), and white (n=10) participants. Out of the 40 participants, 57.5% were women (n=23) and 42.5% were men (n=17). In each of the racial groups, we had a minimum of 5 women. Fifty percent (n=20) of our participants had degrees in various engineering disciplines, 25% (n=10) had degrees in the sciences, such as Biology and Physics; 10% (n=4) had technology degrees; and 7.5% (n=3) had graduated with mathematics degrees. The other three participants had college degrees outside of traditional STEM majors but were working in STEM-related careers. For example, one of our participants was working as an Environmental Engineer and had graduated with a Construction Management degree granted by the School of

Engineering at his institution. Appendix A contains a table with detailed information on the participants' backgrounds.

Data Collection and Data Analysis

All 40 interviews were conducted in-person by the first author from October 2017 to April 2018 in a location chosen by participants. Most interviews were conducted in public places, such as coffee shops and restaurants, and a small number of them were conducted in the participants' office spaces. In average, interviews lasted 60 minutes. All but one of the interviews were audio recorded since the participant did not grant us consent to audio record the interview. All interviews were transcribed verbatim by an independent service provider and we verified all transcriptions for accuracy (Poland, 1995).

We engaged in inductive and deductive coding techniques to analyze all data. Inductive techniques allowed us as researchers to gather emergent or in vivo codes through the data analysis process and find patterns among the entire corpus of data (Creswell, 2013). Deductive coding techniques allowed us to include a priori codes, derived from the conceptual framework and/or literature, throughout the coding process (Creswell, 2013). We began by coding each case independently and developing individual codes. Then, we analyzed and compare the codes across cases to come up categories and themes related to the phenomenon under investigation (Merriam, 2001; Yin, 2014).

Findings

The data revealed four important themes about how race/ethnicity and gender influenced the relationships that STEM graduates developed with their professors, as well as whether and how those social ties transformed into valued forms of social capital that they could leverage for career opportunities. First, the experiences of racism and sexism among women of color affected

their ability to attend office hours and build strong relationships with STEM professors. Second, while white females experienced sexism from STEM faculty, their white privilege lessened the negative effects associated with their gender. Third, being exposed to diverse faculty facilitated conversations between women and URMs and their professors about their career pathways in STEM contexts. And fourth, the negative influence of race/ethnicity and gender on student-faculty relationships was alleviated, but not eliminated, through research engagement. In this section, we present each of these four findings.

Experiences of Racism and Sexism Among Female Students of Color

In discussing how racial/ethnic and gender identities influenced how STEM graduates associated with faculty when they were pursuing their degrees, we found that women of color (WOC) experienced significant challenges in building relationships with professors in STEM settings due to instances of overt and subtle discrimination. Several WOC in our study recalled occurrences of racism and sexism that they experienced from faculty and/or teaching assistants (TAs). In particular, the data revealed that WOC were subject to discrimination that manifested on the way faculty evaluated their academic work and classroom performance. Felicia[1], a Black/African American woman who pursued a degree in Mechanical Engineering, talked about more than one negative experience she encountered with faculty; she said:

> I remember we had an exam and I had the same exact work, the same exact answer as one of my colleagues [white peer] and my professor's assistant wrote on my paper "so, you don't know what you're doing." And I was like, you could have just said it was wrong, you didn't have to express how you felt. And I took it to the professor and I was thinking, this is not good for you [herself] to do. You [herself] could get a worst grade. But said [to the professor] look at his work [white peer] and look at mine. It is the exact same thing. It looks like we may have cheated. How is it that his overall score is an 84 and mine is a 52?

[1] All participants' names have been changed for privacy.

After that conversation, the professor changed Felicia's grade to an 80, but she continued to face similar issues in other classes. During her undergraduate years, Felicia continued to advocate for herself and even filed official complaints against her professors with the Office of Diversity and Inclusion and other departments on her campus. Felicia shared that in one occasion she had to go through a grade change process that took over a year a half because she received a failing grade in a class when she had gotten an A in her final exam and had turned in all her work on time. After the long process, the professor changed her grade to a B, but those experiences took a toll on Felicia and made her question if persisting in college and in STEM "was worth it."

Another participant, Reyna, a Latinx female who majored in Computer Telecommunications Engineering, also talked about her academic work being graded unfairly; she said:

> So, it's me and this kid. He [white professor] partnered me up with this kid who was an international student. He was from China. He was an exchange student for a year. And so, it was me and him [Chinese student]. He did computer science. He did the same project for computer science, the same exact project, and I did the same exact project for electrical engineering. We submitted the same exact report. We both co-wrote this report, it was like 30 or 40 pages at the end, my report was double what his was. He got an A. I got a D. And I was like so mad. I even went to the dean and I was like "What – how is this fair?"

In this case, Reyna's grade was not altered, even after she filed an official complaint against the professor with the Dean. Reyna spoke about two more instances when she felt that that she was given worst grades than her peers and she believed that it was based on her racial and gender identities. Reyna expressed her frustrations and shared how she was still affected by those negative interactions with her professors; she said that she has not remained in touch with any of the faculty at her school because she had "terrible" experiences with most of them.

Similarly, Ebony, a Black/African American woman who graduated with a degree in Computer Information Systems mentioned that there were instances during her undergraduate

years where she had to “defend [her] grades or defend [her] work.” Ebony shared that when she started college, she quickly realized that there “was not as much help [from faculty], or not as much grooming or nurture, as there was for other [white] students.” These negative experiences led Ebony to maintain distant relationships with her professors and mostly communicate with them via online platforms.

In addition, other WOC participants recounted moments of overt and public discrimination from faculty during their undergraduate years that negatively influenced their relationships. Natalia, a Latinx female who graduated with an Electrical Engineering degree, spoke about one of her white male professors making biased jokes about her; she said:

> There was this particular professor that was very outspoken. He thought he was just making jokes, but he would pick a lot on me. He would say, "Natalia, it's okay. In case this [engineering degree] doesn't work for you, you can marry anyone from this classroom."

Natalia also recalled another instance when the same professor told an entire classroom that she was very smart because she was surrounding herself with engineers, and that she could marry one of them if she did not become an engineer herself. Natalia added: “I didn’t feel comfortable to even go to his [professor] office and ask him a question, because in my head I was like, oh, he’s going to think I’m dumb.” So instead of seeking support from her professor, Natalia would go to a close family member that had an engineering background. While several WOC recalled negative experiences with faculty, it is important to note that not all WOC in the study articulated that they encountered discriminatory experiences with their professors. For example, Lynn an Asian/Asian American woman who graduated with a degree in Civil Engineering did not develop close connections with faculty members but did not recall any negative experiences.

White Privilege Among White Female Students

In discussing how gender affected the relationships that white women were able to develop with their professors, we found that, to an extent, being white (or having white privilege) lessened some of the negative experiences of female participants in STEM contexts. Our data shows that in contrast to the large number of WOC who experienced both sexism and racism from faculty, many white female participants felt supported and comfortable with their professors in formal and informal settings. When speaking about her experiences with faculty during her undergraduate years, Cathy, a white female participant who graduated with an Architectural Engineering degree said:

> It was really nice because the faculty was more hands-on, and they knew all the students. So, it was easy to feel comfortable to ask them questions and then also go to them during their office hours because since it was a smaller college, all the classes were near each other. All the faculty offices were close by. So, it was very easy to talk to them.

Cathy attributed her close relationships with faculty to the size of her program. She mentioned that although she attended a large public university, her major had about 100 students per year and that about 20% were female, so being part of a smaller community made a difference in her college experiences. Cathy went on to share that most her faculty were white men and that every student was assigned a faculty mentor for their required capstone project. When speaking about that particular experience, she said:

> He [assigned faculty mentor] happened to be one that traveled a lot and did a lot of research, so he wasn't always around, so I tended to go to some other professors too, to ask some questions. But from my classes previously, I was at least comfortable enough to approach him.

Similar to Cathy, other white female participants talked about feeling supported academically by their professors and being comfortable going to office hours when they faced challenges in their courses. Emily, who graduated with a Math degree described her professors, most who were also white men, as "amazing at helping" and "very encouraging." She recalled

her professors going out of their way to help her understand concepts during office hours, and spending time with her talking about the next steps in her career. Kristen, who graduated with an Engineering Science and Mechanics degree mentioned that she formed "friendships" with some of her professors who were willing to support her through her academic struggles. To this day, Kristen has remained in contact with a few of her undergraduate professors and has met with them when she has visited her campus as an alumni. Like Kristen, Cathy also talked about remaining connected with her undergraduate professors after graduation and even speaking with them about best practices and innovations within her professional field.

While several white female participants spoke positively about their relationships with professors, a few others talked about experiences of sexism from faculty. For example, Amanda, a white female who studied Civil Engineering said: "I'll be honest, there were a few [professors] at the time who were outright hostile to having women in the class so that didn't help the relationship." When asked to expand on her comment about the hostility perpetuated by faculty, Amanda mentioned that some male professors advised women and URMs in STEM to leave the fields altogether. She recalled a male faculty member telling her that "[she] would never succeed." At the time, Amanda did not know if the professor's comment was related to her gender identity or another reason. These negative experiences deterred Amanda from establishing close relationships with faculty, even when she knew those could be beneficial because she saw some of her peers becoming exposed to good opportunities, such as serving as a TA for an undergraduate STEM course. Although a few white female participants spoke about experiences of sexism, which are deeply troubling, none of them mentioned that their academic work was actually judged poorly because of their gender identity.

The Impact of Diverse Faculty on Underrepresented Minorities and Female Students

In speaking with participants about the racial/ethnic and gender identities of their professors, a large number of them spoke about the lack of diversity among STEM faculty. For example, Amanda said: "I don't think I ever had a female professor in the engineering school… Overall it was fine. I just was never close with any of them [faculty]." Similarly, Emma, a white female participant who completed a Geology degree said: "I don't recall any female professors in any STEM class I took in college." Emma also spoke about having negative interactions with male professors who did not think she could be a Geologist and work in the field as a woman. In addition, Cathy said: "I think there was one woman and one other minority [among the entire engineering faculty]. The rest were all white men."

However, when URMs and women participants were exposed to faculty of diverse racial/ethnic and gender backgrounds, their experiences were significantly different, allowing them to obtain valuable resources that positively impacted their academic and career trajectories. Kim, an Asian/Asian American woman who graduated with a Chemical Engineering degree talked about a close relationship that she developed with a female faculty member in STEM:

> I did [develop a strong relationship] with one other professor [besides her faculty advisor] who would come in and teach one of the classes that I was really interested in, it was a bio technology class. And it was a female and she was great, she was really approachable so like even after class I would go and talk to her when I was interested in graduate school. I chatted with her about what are good programs, where are good places to apply or look into for research if I was interested in x, y, z, research. So, she was really helpful at that point.

As noted by Kim, being exposed to a female faculty member in her field allowed her to seek guidance regarding her post-graduation plans. A few years after Kim graduated from college, she pursued a doctorate in STEM and has had a very fruitful career working in biochemical research.

Sonya, an Asian/Asian American female who pursued a degree in Environmental Science, spoke very clearly about the positive impact of having a faculty member with whom she

could relate based on social identities. When speaking about her STEM undergraduate experiences, she said:

> It was hard, but I was very lucky that I had a mentor, in a way. And she was only during my undergrad, but that was when I needed it, looking back. So, during my second year of undergrad, I had to take statistics and I had a female professor who was of [Asian ethnicity] descent and that's what I am, [Asian ethnicity] descent. And she was a phenomenal statistics professor. She was the one who told me that, as a female, I didn't need to be intimidated by statistics or math. And in fact, it was because of her that I ended up loving statistics.

Sonya mentioned how her father was a STEM professor himself who held very strong gendered stereotypes, so she had internalized some of those messages about women not being good in STEM. However, her female faculty mentor would challenge her and say: "Sonya, why do you believe that you're bad at math? I mean, girls can be good at statistics." Sonya went on to share that because her mentor had a Ph.D. in Statistics, she became "a living example" and showed her that women could "be good at physics and at math and at the quantitative side of things."

Similar to Kim's experience, Courtney, a Black/African American woman who graduated with a Biochemistry degree, spoke about developing a strong relationship with a Black female professor who talked to her about feeling like an outsider in academia due to her background. Courtney said that her professor taught her:

> To not be afraid to be Black and present and to say this is what our experiences are and it's okay. And this is what my preferences are culturally and as a collective body here in the United States, and it's okay. Especially within the context of a campus where you feel misunderstood most of the time.

After college, Courtney remained in touch with her professor, and even saw her a few times when she was pursuing her medical degree. Now as a medical doctor, Courtney tries to connect with that faculty member for mentorship and to touch base because she was "definitely someone that was pivotal" during her college years. Another participant, Midori, an Asian/Asian American woman who graduated with a Biomedical Engineering degree also spoke about the

value of connecting with a female faculty member on campus, she said: “I was pretty close with her [female faculty member]… she was great, and it was nice to see how she kind of balanced her life and things like that.” Though Midori did not take any classes with the female professor, she was able to develop a close relationship with through an on-campus student organization.

In talking to participants about their relationships with faculty, we also found that those who attended Historically Black Colleges and Universities (HBCU) and all-women’s colleges felt very supported by their professors. Malik, a Black/African American man who switched from Computer Science to Elementary Education and was teaching Math at the time of the study, attended an HBCU and shared that he developed a very close relationship with his statistics professor, who was also a Black man. Malik recalled how this faculty member wrote a letter of recommendation for his first job after college, and how they talked about his career even after he switched out of his STEM major. Similarly, Gloria, a Latinx female who graduated with a Neuroscience degree from an all-women’s college spoke about being “mentored by female faculty” early on her college years and finding a strong support network as a STEM female student. Gloria shared that she was part of a group that helped WOC in the sciences, and through that opportunity she was able to connect with a WOC STEM faculty member who could relate to her unique experiences.

Although not a large number, a few WOC and URMs spoke about building close relationships with faculty despite their racial/ethnic differences. For example, Kenji, an Asian/Asian American male who graduated with a degree in Electrical Engineering and moved to the United States for college said, “all the faculty were very nice.” During his undergraduate years, Kenji received several invitations from the Assistant Dean of the Engineering School to have dinner with him and his family. Janae, a Black/African American woman who graduated

with a Science degree described her faculty, most of whom were white males, as "phenomenal" and shared that they wrote letters of recommendation for her when she was applying to medical school. Also, it is important to note, that not all white men participants developed strong relationships with faculty. Mark, a white male who graduated with a Fire Protection Engineering degree said:

> I didn't have much relationship with the professors. Again, because we were a smaller class; we had smaller class sizes in fire protection; a lot of them knew us by name. So, even if we weren't all that active in the classroom, they knew who we were. There weren't a whole lot that I really had a relationship with while I was there. But there were a couple that if you stayed late and you had extra questions, you could get them answered. But that was about the extent of it; I didn't maintain much of a relationship with them outside of the classes.

It is important to illuminate experiences such as Kenji's, Janae's, and Mark's because it shows the complexities of student-faculty relationships in relation to race/ethnicity and gender.

Alleviating the Negative Effects of Race/Ethnicity and Gender on Student-Faculty Interactions Through Research Engagement

In analyzing how and whether participants transformed their relationships with faculty into career-related gains during and after college, we found that when participants across all racial/ethnic groups and genders were able to engage in research with faculty, they were able to gain career advancement opportunities. However, not all participants were able to participate in research projects as undergraduate students. In the cases when participants were able to do research, they spoke about how conducting research with professors was key during their undergraduate years, allowing them to expand their social networks and knowledge about professional pathways. Midori started conducting research in her sophomore year of college with the faculty member, a white male, who had been assigned as her advisor in the engineering school, she said:

> But, the main point for me that made me interested in grad school is that I started doing research my sophomore year. I did research in the lab, and I had a really good experience. I had a great advisor. I had a great graduate mentor. They gave us independent projects to work on, so something that's my own but kinda linked up with the other projects in the lab… I was able to attend conferences when I was an undergrad, present the research, and just see the PhD students that I was working with talk to these other people from other institutions and give oral presentations. It was very cool.

Midori sought out research opportunities early on her college years because her parents told her that those opportunities were good for her career. Upon her graduation, Midori entered the Ph.D. program at her undergraduate institution and stayed working with the same advisor because she had developed a strong relationship with him. The graduate mentor who worked with Midori in the lab when she was in undergrad was also an Asian woman; Midori described her as "great" and "very helpful." In addition to mentoring Midori in the lab, the graduate mentor helped her find a professional job after she had been applying to opportunities without success upon the completion of her doctorate.

Another participant, Jamal, a Black/African American man who graduated with a Physics degree form an HBCU, talked about how "helpful" it was for him to get involved in research throughout his undergraduate years. In particular, engaging in research allowed Jamal to develop strong relationships with a community of researchers and develop networks within and outside his campus. During his first year in college, Jamal conducted research with a professor who managed a lab outside of campus, so he would travel with his professor to the research site and spend a significant amount of time with him in informal and formal settings. In addition, with the support of a white female professor who wrote letters of recommendations, Jamal was able to get two more research internships as an undergraduate student; one of those opportunities was in Europe. Jamal shared that these experiences were valuable for him because they exposed him to

different aspects of the field, but that there were other factors that influenced his decision to not pursue a research-focused career upon his graduation, he said:

> And it was actually one of the things that, a little bit, turned me off to the STEM field. I was always the youngest. I was always the only minority. And it just, it didn't feel – it wasn't the exciting part of science that I had loved so much as a kid. Right? I loved being in the laboratory setting, but the laboratory setting wasn't as fun as I remembered. Like when I went to do these internships, it was a lot of time in front of a computer, or waiting for something to happen, and not doing science, and that's really important to me, to be actively doing science. Which I think is one of the things that I think I really enjoy about teaching.

At the time of the study, Jamal worked in physics education, and shared that he was very satisfied with his career as a high school STEM educator.

Similarly, Malcolm, a Black/African American man who also attended an HBCU and graduated with a Biology degree, shared that through his summer bridge program and undergraduate research exposure he was able to think more critically about his career plans. When speaking about the summer bridge program prior to his first year in college, he said:

> They'd expose us to different research opportunities. They took us to [national science organization]. Around the campus, to the different labs, and just kind of exposed us to what research was, as an enterprise, as a future career, because that – I mean, I knew – like I said, I knew what a science was. I didn't know what graduate school was at that time.

During his sophomore year, Malcolm found an unpaid research opportunity off campus through a peer; that engagement turned into a publication opportunity and allowed him to gain valuable skills that he could leverage when seeking admission to graduate school. In addition, when Malcolm was approaching his senior year, he reached out to a professor who taught some of the more advanced science classes because he was considering pursuing a master's degree. He asked the professor if he could work at his lab to learn more about his research focus, but the professor asked Malcolm to draft up an independent research project proposal instead. Malcolm drafted the proposal and at the same time he applied to graduate school, so he ended up working

on his own research project under the supervision of the professor while he was pursuing his graduate degree. Malcolm now works for a national organization focused on STEM research and plans to go back to school to pursue a doctorate degree.

While engaging in research alleviated some of the negative effects of race/ethnicity and gender on student-faculty relationships, it did not eliminate occurrences of discrimination from faculty in STEM contexts among URMs and female students. For example, Courtney, who conducted research in a biology lab for two summers during her undergraduate years, and generally described her experiences with professors as positive, said:

> There was, I would say, maybe one or two professors within the Chemistry department who definitely made students of color feel quite uncomfortable. He would just make very off-centered remarks. It was always hard to know whether or not they were intentionally malignant or not. But it was definitely a shared feeling of discomfort among people of color.

Courtney's experiences reflect the pervasive nature of discrimination within STEM settings and demonstrates how engaging in research may help some students develop strong relationships with a few professors, but it does not eliminate the negative influence of race/ethnicity and gender on student-faculty relationships.

Discussion and Implications

Our data suggests that race/ethnicity and gender significantly influenced the transformation of student-faculty relationships into valued forms of social capital in STEM contexts. With the exception of a small number of WOC in our study, such as Courtney and Midori, the majority of WOC participants were unable to transform their connections with professors into career advancement opportunities due to adverse experiences. As a result of negative interactions with faculty, whether they were explicit or subtle forms of discrimination, many WOC participants did not develop strong connections with their professors and limited

their exchanges to classroom settings. This impacted the opportunities they obtained during their undergraduate years and also affected how they started their STEM careers. For example, Felicia, Reyna, and Natalia, graduated college without a job offer and struggled to find their first professional position despite high demands for STEM professionals. Although they all worked in STEM fields at the time of the study, they talked about feeling insecure and stressed about their STEM pathways after college. This can be, in part, because they did not have faculty mentors and/or networks of people that could offer professional guidance early on their careers. This finding is significant and raises questions about equity that extends beyond higher education settings because it implies that even when WOC graduate with STEM degrees, they are still placed at a disadvantage and unable to reap the benefits associated with their education. Future studies could further examine the longitudinal effects of student-faculty relationships in the career pathways of STEM graduates and use additional sources of data, such as observations, to better understand the nature of these interactions.

The stories that WOC shared about how their academic performance was evaluated worse than their peers demonstrated the detrimental effects that those interactions had on them, impacting their undergraduate and career pathways. Interestingly, neither white women, white men, nor men of color talked about their academic work being graded unfairly, bringing attention to a unique form of discrimination that WOC in STEM encounter on college campuses. In addition, the narratives that WOC shared about advocating for themselves and filing official complaints when their academic work was graded unfairly, illuminated the additional emotional and psychological burden placed on these women as a result of this form of discrimination. On top of facing racism and sexism, which takes a toll on the wellbeing of WOC in STEM (Ong et al., 2011; Seymour & Hewitt, 1997), the WOC in our study were forced to either accept the

lower grades or to courageously advocate for themselves, which involved risking relationships with professors. This finding adds to the literature in a unique way by exposing a less overt but very damaging form of academic discrimination encountered by WOC in STEM, which can ultimately lead to lower retention and graduation rates. Scholars interested in further examining this phenomenon could conduct case study research within specific STEM contexts, such as engineering classrooms at research universities, to critically examine whether there are significant differences by race/ethnicity and gender on the way the academic performance of students is evaluated.

Our findings also confirm key differences that exist among the experiences of white students and students of color noted on existing STEM literature, such facing racial/ethnic microaggressions (Carlone & Johnson, 2007; Chang et al., 2011; Cole & Espinoza, 2008; Hurtado et al., 2007; Johnson, 2007; Ong, 2002). However, our study goes one step further by highlighting how white privilege manifests among white female students in STEM contexts. While a few white female participants spoke about having negative interactions with their professors, their grades did not suffer as a result of those interactions. In a way, their whiteness acted as a shield that protected them from further forms of discrimination and served as a conduit for social capital. For white female participants, race/ethnicity had a stronger influence than gender on the relationships that they were able to develop with faculty. As a result, many white women in our study spoke highly about their professors and talked about remaining in contact with them even after graduation. By comparing the experiences of WOC and white women in relation to student-faculty interactions within this study, we were able to further examine the effects of systemic inequities that extend beyond college. Future research can continue to

examine the ways in which white privilege manifests within STEM contexts and may protect students despite having other marginalized social identities.

Additionally, our findings illuminate the significance of having diverse STEM faculty with whom students can relate based on race/ethnicity and/or gender. This finding complements current quantitative STEM literature that documents the significant and positive seffects of having diverse professors in student outcomes (Chang et al., 2014; Hurtado et al., 2011). From participants' narratives, it was evident that having access to female professors and faculty of color made a difference on the undergraduate experiences of STEM students. Even if participants did not remain in touch with faculty after graduation, they were able to foster close connections with diverse faculty, who extended their support beyond the classroom environment, while they were in college. In some cases, through these informal connections, some URMs and female participants in our study were even able to discuss their post-graduation plans and receive career mentorship from professors with whom they could relate based on social identities. While URMs and female participants in our study did not speak about negative experiences with diverse faculty, it is important to not assume that URMs and female STEM students only have positive interactions with diverse faculty members. Future research could further examine the dynamics of student-faculty interactions by race/ethnicity and gender and look into the additional expectations placed on diverse faculty within STEM contexts. If professors of color and female faculty are disproportionately mentoring and serving URMs and female students in STEM fields, they may be more likely to burn out or "suffer" professionally by not dedicating more of their time to activities typically related to tenure and promotion, such as research.

Lastly, our findings also add to the very limited body of literature that explores the benefits of participating in research projects during college (e.g., Hathaway, Nagda, Gregerman,

2002; Posselt et al., 2018; Strayhorn, 2010). Our data emphasizes how URMs and women in STEM may be able to alleviate, but not eliminate, the otherwise negative effects of race/ethnicity on student-faculty interactions through research engagement. Through research opportunities some of the URMs and female participants in our study were able to develop positive and strong connections with a few faculty members who helped them professionally and academically. Being able to conduct research with professors as undergraduate students not only helped participants to gain valuable knowledge and skills and connect with faculty, but also exposed them to graduate students who in many cases became mentors and valuable sources of social capital. This finding is important because it also shows the extent to which positive relationships with professors and graduate student mentors can shape the undergraduate and post-graduation experiences of STEM students. However, undergraduate research opportunities are still limited and underfunded on college campuses. Future studies should further explore the relationships between undergraduate research engagement and academic and professional outcomes within STEM settings. In particular, it would be important to understand more about the factors that deter URMs and women from engaging in research during their undergraduate years (e.g., finances, access) and what research experiences could yield the most benefits in STEM settings in order to implement programs and strategies that promote their engagement.

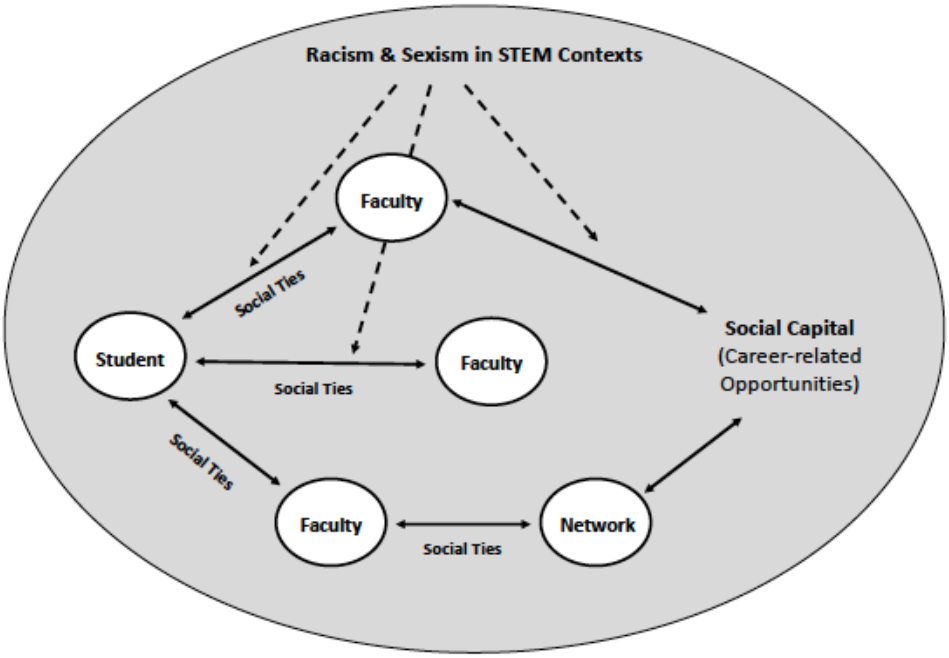
Conclusion

Overall, our data reveals the degree to which race/ethnicity and gender continue to influence the nature of student-faculty interactions within STEM environments and illuminates how the inequities encountered by URMs and women as undergraduate STEM students extend beyond educational contexts. In particular, our findings show the tangible effects of intersecting systems of oppression (racism and sexism), which disproportionally affected the WOC in our

study, such as disrupting the transformation of student-faculty relationships into career-related opportunities and social gains overtime. Additionally, our study brings to the forefront a unique, but very harmful, form of discrimination encountered by WOC—their academic performance being evaluated unfairly. This less overt manifestation of discrimination raises questions about ethics and equity within STEM educational environments. It also elevates the need for accountability measures within STEM classrooms and demands further examination of professors' grading practices.

Our research also adds to the critical conversations about equal opportunities and the equalizing effect of attaining a higher education within the broader U.S. society. As demonstrated by our findings, even after successfully completing their undergraduate degrees, women and URMs in STEM contexts may still be unable to reap the full benefits associated with their undergraduate education. Structural issues, such as racism and sexism, continue to limit the ability of minoritized groups to acquire social gains and block their access to valuable relationships and resources that they could leverage for professional and societal advancement. Higher education institutions, as the hubs for knowledge and development, must take the lead in addressing systemic injustices, and set the example by first addressing the racism, sexism, and others forms of discrimination manifested within various academic environments.

Figure 1: Conceptual Framework



Appendix A: Participants' Race/Ethnicity, Gender, and STEM Field

Race (n=40)	
Black or African American	12
Asian or Asian American	9
Latina/o/x or Hispanic	9
White	10

Gender (n=40)	
Female	23
Male	17

STEM Fields (n=40)	
Science	10
Technology	4
Engineering	20
Mathematics	3
Other	3

Race, Gender & STEM Field (n=40)								
	Black or African American		Asian or Asian American		Latina/o/x or Hispanic		White	
	Female	Male	Female	Male	Female	Male	Female	Male
Science	3	2	1	0	1	0	1	2
Technology	1	0	0	1	1	0	1	0
Engineering	1	3	4	2	3	2	3	2
Mathematics	0	0	0	1	1	0	1	0
Other	1	1	0	0	0	1	0	0