Discrimination and Student-Faculty Interaction in STEM:

Exploring the Impact for Students of Different Races

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Research confirms that student-faculty interaction is linked to a wide array of benefits for the overall college student population (Crisp, 2010; DeAngelo, 2014; Kim & Conrad, 2006; Cole, 2010; Kim, Chang, & Park, 2009). However, a key puzzle in the research is the question of why some groups do not reap as many benefits from interacting with faculty as others, with notable inequities existing for racial minorities. In particular, Black students report interacting more frequently with faculty but have lower GPAs, are less likely to engage in research opportunities, and are less satisfied with faculty (Chang, 2005; Kim & Sax, 2009). These paradoxical findings for Black students extend to STEM environments. Park, Kim, Hayes, and Salazar (2017) found that Black students were more likely than other racial/ethnic groups to ask questions in class, ask faculty questions after class, and meet with faculty to discuss material that they did not understand. However, they also had the lowest rate of retention in STEM majors, were least satisfied with faculty overall, and were most likely to report experiencing discrimination from faculty. Studies suggest similar dynamics with other minorities in STEM environments, including women (see for example Cole & Espinoza, 2008).

One possibility for why minorities in STEM do not receive the full benefits of interacting with faculty is due to discrimination and negative classroom experiences. Numerous studies document the negative classroom environment encountered by underrepresented minorities and women in STEM (McGee & Martin, 2011; Ong, Wright, Espinosa, & Orfield, 2011). It may be that students are interacting with faculty, but sometimes have negative experiences that diminish the gains typically linked with engagement. Surprisingly little is known about the impact of negative experiences with faculty, and how they may lessen or disrupt the gains that result from student-faculty interaction. The underlying mechanisms among student-faculty interaction, negative experiences with faculty, and student background characteristics (e.g., race, gender) as they relate to STEM collegiate outcomes are understudied. Previous studies (e.g., Kim & Sax, 2009) utilize methods that are less suited to identify the indirect relationships between variables that may help uncover some of the dynamics behind these critical processes.

Analyzing data from the National Longitudinal Study of Freshmen, we use structural equation modeling to ask: What are the direct and indirect relationships between key background and college experience variables, student-faculty interaction, discrimination from faculty, and college GPA among undergraduate students in STEM (Science, Technology, Engineering, and Math)? Does discrimination from faculty mediate the relationship between student-faculty interaction and college GPA in STEM? Do these pathways between variables differ for students of different race/ethnicities? Clarifying the link between student-faculty interaction, discrimination, and GPA in STEM is critical in order to produce insight into the conditions potentially influencing classroom dynamics in STEM. In particular, retention is lowest for URM students and women (Park et al., 2017). Therefore, a better understanding of the relationship between student-faculty interaction, discrimination from faculty, and key outcomes will shed light into the complex dynamics occurring within STEM education.

Literature Review

In this section, we present a review of the literature focused on student-faculty interaction in STEM, and the experiences of under-represented minorities (URMs) and women in STEM environments.

Student-faculty Interactions in STEM

Higher education research confirms that student-faculty interaction is linked to a wide array of benefits for the overall college student population (Crisp, 2010; DeAngelo, 2014; Kim & Conrad, 2006; Cole, 2010; Kim et al., 2009). In particular, developing strong relationships with faculty is linked with higher retention and graduation rates, as well as attaining a higher college GPA (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). These interactions can happen in formal settings, such office hours or classrooms, or informal contexts, such as campus programs or volunteer opportunities. These individualized occasions help many students, especially those in large classes, to develop personal connections with their professors and enhance their academic aptitudes (Astin, 1993; Pascarella, 1980; Santos & Reigadas, 2000). On the contrary, when students feel intimidated by their professors or have negative student-faculty interactions, their academic results suffer and their overall dissatisfaction with the college environment grows (Chang, 2005; Pascarella & Terenzini, 1991, 2005).

Research focused on student-faculty interactions suggests that not all students gain the same benefits from their connections with professors, and that race/ethnicity and gender influence the nature of the relationships they form in college (Kim, 2010; Kim & Sax, 2009, 2011, 2014). In particular, some scholars have reported that under-represented minorities (URMs) and female students benefit the least from their interactions with faculty, and are exposed the most to negative experiences inside and outside the classroom (Lee, 2002; McGee & Martin, 2011; Ong et al., 2011; Seymour, 1995). Interestingly, in a study that examined gender differences in the effects of student-faculty interactions, Sax, Bryant, and Harper (2005) found that male students had more negative perceptions about faculty than their female counterparts, but that women who perceived that their professors did not take their comments seriously reported declines in their degree aspirations, math ability, and health.

Studies that examine student-faculty interactions in STEM are less prevalent, but scholars have found that relationships with professors affect the retention of students in STEM majors and their academic performance (Hurtado, Newman, Tran, & Chang, 2010; Park et al., 2017; Vogt, 2008). Within STEM fields, student-faculty interactions also differ notably by students' gender, race/ethnicity, and socioeconomic status (Cole & Espinoza, 2008; Hurtado et al., 2011; Park et al., 2017). For example, Park et al. (2017) found that Black students were more likely than other racial/ethnic groups to ask questions in class, ask faculty questions after class, and meet with faculty to discuss material that they did not understand. However, they also had the lowest rate of retention in STEM majors, were least satisfied with faculty overall, and were most likely to report experiencing discrimination from professors.

Studies suggest similar dynamics with URMs of other race/ethnicities in STEM environments, as well as women; and emphasize how the perceptions that students form about their professors shape their college experiences (Carlone & Johnson, 2007; Cole & Espinosa, 2008; Ong, 2005). Some studies note that when STEM students perceive that faculty are accessible and willing to support them academically, they are more likely to remain in good academic standing and complete their STEM degrees (Xu, 2016). Amelink and Creamer (2010) found that for female students in STEM, feeling like faculty cared about their learning had a significant and positive effect on their education; while for male students, being treated with respect from faculty was significantly linked with positive college outcomes. For women of color specifically, negative student-faculty interactions and experiences of racial and gender bias with STEM professors result in lower self-efficacy, and decrease their STEM professional aspirations (Carlone & Johnson, 2007; Johnson, 2007; Ong, 2002; Ong et al., 2011).

The campus context also plays a significant role on shaping the student-faculty interactions that URMs in STEM majors experience (Cromley, Perez, & Kaplan, 2016; Hurtado et al., 2011). At highly selective universities and/or predominantly white institutions (PWIs), Black students have irregular and less individualized relationships than their counterparts at Historically Black Colleges and Universities (HBCUs; Hurtado et al., 2011; Fries-Britt & Turner, 2002; Wagener & Nettles, 1998). Possibly as a result of the positive relationships with faculty, Black students attending HBCUs have higher GPAs than their counterparts at PWIs (Allen & Haniff, 1991). In addition, when URMs and female students are exposed to diverse faculty in STEM fields they have more positive student-faculty interactions, and their academic performance and overall college experiences are enhanced (Alfred et al., 2005; McGee & Martin, 2011; Seymour & Hewitt, 1997). The benefits associated with having interactions with diverse faculty have also been noted in research outside of STEM (e.g. Hurtado, Milem, Clayton-Pedersen, & Allen, 1999; Milem, 2003).

Overall, research that investigates student-faculty interactions in STEM fields is limited, and much less is known about existing variation by student characteristics, such as gender and race/ethnicity. While some research on student-faculty interactions emphasizes the positive outcomes that these connections provide to STEM students, such as increased retention and academic satisfaction (Chang, Sharkness, Hurtado, & Newman, 2014; Espinosa, 2010; Palmer, Maramba, & Dancy, 2011), it does not fully explain why URMs and women are not reaping the full benefits of their relationships with professors. One possibility may be that they are having negative classroom experiences and encountering discrimination from faculty, diminishing the gains typically linked with those connections. To better understand these dynamics, next, we present a review of the literature focused on the experiences of URMs and women in STEM.

Experiences of URMs and Women in STEM

Numerous studies have examined the experiences of URMs and women in STEM fields (Cole & Espinoza, 2008; Crisp, Nora, & Taggart, 2009; Daempfle, 2003; Seymour & Hewitt, 1997). In particular, scholars have exposed negative interactions that these students have on campus with peers and faculty, as well as the impact of the campus racial climate on their overall college experiences (Chang et al., 2011; Dortch & Patel, 2017; Johnson, 2012; Strayhorn, Long, Kitchen, Williams, Stenz; 2013). The majority of the research that examines this phenomenon of a chilly climate in STEM is qualitative in nature, reporting how URMs and women in higher education continue to experience various forms of discrimination, ranging from microaggressions to overt acts of biases, in both classroom environments and social settings on campus (Dortch & Patel, 2017; McGee, 2013; Strayhorn et al., 2013). Some quantitative studies also document negative experiences, such as the adverse effect of stereotype threat (Beasley & Fischer, 2012; Chang et al., 2011), the impact of competitive peer environments (Chang, Cerna, Han, & Saenz, 2008), and the effect of race on college persistence due to "institutional mistmatch" assumptions (Chang et al., 2008).

Inside STEM classrooms, scholars have found that URMs constantly experience being one of the few students of color and deal with tokenization, microaggressions, and stereotyping (Carlone & Johnson, 2007; Chang, Eagan, Lin, & Hurtado, 2011; Dortch & Patel, 2017; Hurtado et al., 2007; Johnson, 2007; Ong, 2002). This leads to feelings of loneliness and self-doubt about their academic competency. In addition, URMs often feel like they have to prove their intellectual capacities and fit in STEM because their actions are often generalized as if they were representing their whole racial/ethnic communities (Chang et al., 2011; McGee & Martin, 2011). In social settings, URMs often experience cultural incongruencies which impacts how they develop a general sense of belonging on campus (Cole & Espinoza, 2008; Strayhorn et al., 2013). To balance feelings of isolation, many URMs join organizations where they are able to find communities of support and people who share aspects of their backgrounds and interests (Garibay, 2018; Harper, 2005; Xu, 2016).

Among Black students in math and engineering majors, McGee and Martin (2011) found that the need to "prove others wrong" impacted how they navigated STEM environments. In particular, participants in McGee & Martin's (2011) study did not want to reinforce stereotypes about Black students that portrayed them as less intelligent than their white peers, so they felt the pressure to always "be on point" and excel in their classes. Unlike Black students, stereotype threat presents differently for Asian students in STEM contexts. For example, McGee, Thakore, and LaBlance (2016) found that Asian students experience pressure due to the "model minority myth" which depicts them as successful and naturally talented in STEM disciplines. For some students, stereotypes about Asians as high achieving STEM students serve as sources of motivation, prompting them to live up to those expectations. For others, these stereotypes affect their well-being because they feel pigeonhole when they make academic decisions, such as choosing a major (McGee et al., 2016).

Similarly, research shows that women in STEM encounter "chilly" climates and that they are treated differently than their male counterparts by their professors and peers (Amelink & Creamer, 2010; Crawford & MacLeod, 1990; Ong et al., 2011). The uneven participation of women in STEM majors is one of the factors that contributes to the challenges they encounter in STEM environments; yet, the retention and academic success of women in STEM is related to their academic experiences and satisfaction, demonstrating the complexities of this issue. In particular, research has demonstrated that the competitive and individualistic nature of STEM disciplines, impact the retention of women in STEM majors (Diekman, Weisgram, & Belanger, 2015; Lee, 2002; Reyes, 2011; Seymour, 1995). Moreover, that lack of encouragement and validation they receive in STEM settings affects how they think about their self-efficacy and influences their overall college experiences (Ong et al., 2011; Vogt et al., 2007).

While numerous studies document the negative academic experiences encountered by women and URMs in STEM contexts (McGee & Martin, 2011; Ong et al., 2011), little is known about the impact of adverse interactions with faculty, and how they may lessen or disrupt the gains that result from student-faculty interaction. In particular, the underlying mechanisms among student-faculty interaction, negative experiences with faculty, and student background characteristics (e.g., race and/or gender) as they relate to STEM outcomes, such as GPA, are understudied. In this vein, we seek to go beyond documenting the existence of negative experiences with faculty, an already unfortunate phenomena, and investigate how such experiences interplay with other interpersonal and academic dynamics (e.g., other types of engagement with faculty, academic satisfaction) in STEM environments. This knowledge can assist colleges and universities in addressing STEM inequities by clarifying the scope and impact of phenomena like discrimination in STEM settings, a critical need given that women and URMs continue to face key barriers to retention and success in STEM environments (Park et al., 2017). Given that we need to better understand the factors that impact the academic outcomes of STEM students, our study will contribute to our understanding of how these complex dynamics occur within STEM fields.

Conceptual Framework

In this study, we integrate two theoretical concepts into one conceptual framework to examine how student-faculty interactions, and in particular discrimination from professors, impact the educational outcomes of STEM students. Since we are focusing on discrimination from faculty based on student characteristics, we employ a Critical Race Theory lens in connection with the concepts of social ties and social capital to analyze this issue. Critical Race Theory (CRT) illuminates how gender, social class, and other social identities intersect with race to impact the experiences of URMs (Delgado & Stefancic, 2012). CRT can be used as an analytical tool to understand how racism is embedded in every aspect of the U.S. society including educational systems. By placing race and racism at the center of conversations, CRT scholars aim to disrupt racial oppression and promote equity and inclusion (Delgado & Stefancic, 2012; Ladson-Billings & Tate, 1995; Tate, 1997).

In education research, CRT is used to expose the persistent inequities that URMs face in K-12 and higher education settings (Zamudio, Russell, Rios & Bridgeman, 2011), such as constrained access to college due to school structures (Cabrera & La Nasa, 2000; Hurtado, Inkelas, Briggs, & Rhee, 1997; Nuñez & Crisp, 2012), and experiences of racial marginalization and tokenization (Fries-Britt & Griffin, 2007; Yosso, Smith, Ceja, & Solórzano, 2006). In this study, we use a more specific manifestation of CRT, *QuantCrit*. QuantCrit is an analytical lens that can be used to challenge deficit and incomplete representations of URMs in statistical research (Garcia, López, & Vélez, 2018), and the idea that numbers are objective (Carter & Hurtado, 2007). Through the use of QuantCrit, scholars can expose biases embedded in quantitative analyses and use numbers to promote social justice (Gillborn, Warmington, & Demack, 2018). When combined with the concepts of social ties and social capital, CRT allows us to understand how racism and discrimination influence student-faculty interactions in STEM fields, and how those connections transform into social capital in unequal ways. It allows us to specifically highlight how race, gender, and social class affect how STEM students interact with their professors, with potential implications for equity and inclusion in STEM environments.

We combine the QuantCrit perspective with research on social ties, social capital, and inequality. Social ties are the relationships, linkages, and connections that students have with others, including faculty and peers (Granovetter, 1983). Social ties can exist between two people or within broader social networks (Granovetter, 1983; Wasserman & Faust, 1994). Social capital refers to the valuable resources and/or information that are exchanged within networks of social ties. Over time, individuals can accumulate and gain social capital through their relationships with others (Bourdieu, 1986). In this study, we conceptualize student-faculty interactions as social ties that have the potential to influence student outcomes such as GPA. Over time, these relationships and associated gains may transform into social capital (e.g., internship, job placement). However, the existence of social ties does not guarantee that relationships will necessarily transform into positive outcomes or social capital because social identities (e.g., race) greatly affect the development and substance of social ties in STEM fields (Ong et al., 2011).

In education research, URMs are often portrayed as "deficient" of social capital, and their educational success is assumed to be connected to the extent of social capital they possess and/or able to accumulate (Rios-Aguilar & Deil-Amen, 2012). Yet, the social structures, such as racism, that play a role on the acquisition and/or exchange of social capital are less examined, and a QuantCrit perspective (Garcia et al., 2018; Gillborn et al., 2018) allows us to bring these issues to the forefront. For example, given the body of literature that highlights the negative and invidious influence of discrimination and racism on social relationships (Tate, 1997), discrimination is a factor that can disrupt the transmission of the benefits typically linked with student-faculty interactions (Kim et al., 2009).

Based on existing research that documents how women and URMs continue to experience discrimination from faculty (Carlone & Johnson, 2007; McGee & Martin, 2011) and that student-faculty interactions are conditional on student backgrounds (Kim, 2010; Kim & Sax, 2009), we hypothesize that the relationships that students form with their professors are also contingent on their social identities (e.g., race, gender, social class). Through a QuantCrit lens we are able to examine how racism impacts the statistical results of this investigation by focusing on students' social identities, particularly race, and the potential role of discrimination in our analysis. We posit that discrimination from faculty mediates the relationship between student-faculty interaction and student outcomes, potentially impacting the social capital of URMs and women in STEM fields over time. Accordingly, Figure 1 shows the hypothesized path model for the relationship between student-faculty interaction, discrimination from faculty, and college GPA among STEM undergraduate students.

[Insert Figure 1 about here]

Methods

In this section we provide an overview of the methods used for this study, including the data source, sample, and variables. We also provide information on how the data were analyzed and the limitations associated with this study.

Data Source and Sample

This study uses data from the National Longitudinal Study of Freshmen (NLSF). The NLSF, is a multi-wave longitudinal survey of 3,864 students from 28 selective institutions. The survey was administered to students in waves at five different time points from 2000 to 2004 and gathered an extensive information on students' backgrounds, college experiences, and college outcomes. For this study, we used data collected at the beginning of the first year of college, and end of the first, second, and fourth year of college. The sample of the study is limited to those students who declared a STEM major at the entry of college. Students from Historically Black Colleges and Universities were not included because their context for racial demography substantially differed from the rest of the sample. Data were cleaned to meet the statistical assumptions of structural equation modeling and replaced missing data with values estimated from EM (expectation maximization) algorithm. Consequently, the final sample used for the analysis of this study was composed of 778 STEM undergraduate students across 27 institutions. Gender and ethnic composition of the analytical sample are as follows: 379 (48.7%) male and 399 (51.3%) female students; 200 (25.7%) White, 196 (25.2%) Black, 176 (22.6%) Hispanic, and 206 (26.5%) Asian American students.

Variables

Ultimate endogenous variable. This study utilized one ultimate endogenous (dependent) variable, three mediating endogenous variables, and five exogenous variables. The ultimate endogenous variable in our path model was students' college GPA and this was measured by a survey item of students' self-reported GPA at the end of their fourth year of college.

Mediating endogenous variables. Besides the primary endogenous variable, we included three mediating endogenous variables in our hypothesized path model: student-faculty interaction, discrimination from faculty, and academic satisfaction. Student-faculty interaction is a four-item factor scale that assesses the extent to which students experienced various forms of faculty interaction while discrimination from faculty is another four-item factor scale that gauges the extent to which students perceived the feeling of discrimination from faculty because of their race/ethnicity (e.g., having heard derogatory remarks made by professor about students' racial or ethnic group). Academic satisfaction is a three-item factor scale that assesses the extent to which students were satisfied with courses taken, quality of instruction, and mastery of subjects. All factor scales were developed through a set of exploratory factor analysis using principal component factoring and Varimax rotation methods. Table 1 presents the factor loadings and reliability estimates of the factors; results showed that both the reliability estimates and the factor loadings were well within the acceptable range (α ranged from .65 to .87; λ ranged from .65 to .81).

[Insert Table 1 about here]

Exogenous variables. Our model includes five exogenous (independent) variables: race (Black), household income, gender (female), high school math GPA, and institutional percentage of students living on campus. Race and gender are dichotomous variables with Black and female students coded as 1 and their corresponding counterparts coded as 0, respectively. Income and high school math GPA were gauged by students' self-report on their annual household income and high school math GPA while institutional percentage of students living on campus was assessed by actual institutional data. Means, standard deviations, and correlations among all the variables used in the hypothesized path model of the study are presented in Table 2.

[Insert Table 2 about here]

Data Analysis

Utilizing structural equation modeling (SEM) with AMOS 24.0, the models proposed in this study were analyzed in three stages. The fit of our hypothesized path model (Figure 1) was evaluated using the omnibus sample (n = 778) to identify the best-fitting model that was retained as the baseline model for the analyses in stages two and three. Then we examined the comparability of the path model across four different racial groups using multiple-group analysis. Last we developed the final, partial invariance model by releasing equality constraints of five structural residuals, five structural covariates, and four structural weights (paths) one by one based on recommendations from AMOS.

Limitations

This study, like all studies, is limited by several issues. Utilizing secondary data analysis, it is limited by the items available in the NLSF dataset. While showcasing innovative features such as questions on discrimination, the NLSF has a sample that tilts towards selective institutions and thus may be limited in its generalizability towards less selective institutions.

Results

Full Sample Model

Figure 2 displays the final, full sample model, presenting standardized direct effects. Both the chi-square statistic and other fit indices indicate that the model has a good fit to the data ($\chi^2 = 22.604$, $p > .10$; CFI = .981; TLI = .960; RMSEA = .021). Most parameter estimates were significant and consistent with our hypothesized path model.

[Insert Figure 2 about here]

Direct and indirect effects. Results from the final full sample path model showed several direct and indirect effects of exogenous and mediating endogenous variables on college GPA among STEM undergraduate students (refer to Table 3 for a summary of direct and indirect effects). Academic satisfaction had a positive direct effect ($\beta = .17$, $p < .001$) on college GPA whereas experiences of discrimination from faculty had a negative direct effect ($\beta = -.08$, $p < .05$). The results suggest that STEM students who had a higher level of academic satisfaction tended to report higher college GPA at their senior year, while those who reported experiencing greater levels of discrimination from faculty because of their race/ethnicity more often tended to report lower college GPA.

Results also indicated some interesting indirect effects among variables. Student-faculty interaction had a positive indirect effect on college GPA, mediated by both academic satisfaction and experience of discrimination from faculty, acknowledging that the nature of mediation effect of the two variables was different: academic satisfaction positively mediated the relationship between student-faculty interaction and college GPA, but experience of discrimination from faculty negatively mediated the relationship. The results suggest that students who interacted more frequently with faculty tended to report greater academic satisfaction, which in turn positively affected college GPA. However, students who interacted more frequently with faculty also seemed to be more frequently exposed to experiencing discrimination from faculty because of their race/ethnicity, which hence negatively affected college GPA. In other words, experiences of discrimination from faculty tended to mitigate the positive connections between student-faculty interaction, academic satisfaction, and college GPA, reducing the positive indirect effect of student-faculty interaction on college GPA from .0306 to .0186 (39.2% reduction).

Another interesting indirect effect was the relationship between race, student-faculty interaction, and academic satisfaction. Being a Black student had a positive indirect effect on academic satisfaction, mediated by greater level of student-faculty interaction, which in turn compensated for the negative direct effect of being a Black student on academic satisfaction, a positive predictor of college GPA. Still, being a Black student had a negative indirect effect on college GPA, mediated by lower academic satisfaction and greater feelings of discrimination from faculty, which exacerbated the negative direct effect of being a Black student on college GPA.

[Insert Table 3 about here]

Multiple-group Estimation Model

Figure 3 displays the final multiple-group estimation model (i.e., partially constrained model), summarizing the standardized direct effects for White, African American, Hispanic, and Asian American students. Results showed that while most parameter estimates of the model were statistically equivalent across the four racial groups, the estimates on four direct effects of the model were significantly different across the groups. A key finding was the differential effects of student-faculty interaction on experiences of discrimination from faculty. The effect of student-faculty interaction on experiencing discrimination was significantly positive for Black STEM students ($\beta = .32$, $p < .001$) but not significant for other racial groups. This suggests that Black STEM students who interacted more frequently with faculty also seemed to be more frequently exposed to experiencing discrimination from faculty because of race/ethnicity; however, this was not the case for students of other races. Student-faculty interaction had a significant positive effect on college GPA only for White STEM students. When it comes to the effect of academic satisfaction on college GPA, greater academic satisfaction was significantly related to higher college GPA for Latinx and Asian American STEM students only. On the other hand, the positive effect of high school math GPA on academic satisfaction during college was statistically significant for Black and Latinx STEM students only.

[Insert Figure 3 about here]

Discussion

Overall findings underscore the relevance of student-faculty interaction to the key outcomes of academic satisfaction and GPA, while highlighting the role of discrimination in disrupting the positive transmission of social ties into gains linked to social capital. Overall, experiencing discrimination was linked with having a significantly lower GPA for students in STEM, a finding that echoes research on the negative effect of stereotyping and hostile classroom environments in STEM (Carlone & Johnson, 2007; Chang et al., 2011; McGee & Martin, 2011; Seymour & Hewitt, 1997). However, not only did discrimination have a direct negative link with GPA, but it tended to lessen or disrupt the otherwise positive link between student-faculty interaction, academic satisfaction, and GPA, being linked with a 39.2% reduction in the positive indirect effect of student-faculty interaction and GPA.

Unfortunately, those students who interacted more often with faculty also had greater exposure to discrimination due to race/ethnicity, which had a negative relationship with college GPA. This finding is somewhat paradoxical, given that student-faculty interaction had some benefits for Black students: For example, Black students tended to report lower levels of academic satisfaction as compared to their peers in other racial groups. However, Black students appeared to interact with faculty more frequently than did their peers, which in turn positively influenced their academic satisfaction. Consequently, the findings suggest that the negative effect of being a Black student on academic satisfaction seemed to be mitigated by the positive relationship among being a Black student, student-faculty interaction, and academic satisfaction.

However, at the same time, being a Black student had both negative direct and indirect effects on GPA, which was mediated by lower academic satisfaction and greater feelings of discrimination from faculty. Also, the relationship between student-faculty interaction and experiencing discrimination was positive for Black students in STEM ($\beta = .32$, $p < .001$) but not significant for other racial groups. This finding suggests that Black STEM students with higher interaction with faculty also were more likely to experience discrimination from faculty because of race/ethnicity; however, this was not the case for students of other races. Thus, the finding for the aggregate sample that interaction with faculty is linked with a higher likelihood of experiencing discrimination is likely being driven by the negative experiences of Black students.

Findings point to other inequities in the gains attributed to student-faculty interaction. Such engagement had a positive effect on GPA for only White students. Other experiences appeared to have a positive impact for diverse populations: Greater academic satisfaction was significantly linked with higher college GPA for only Latinx and Asian American. High school math GPA had a positive link with academic satisfaction during college for Black and Latinx STEM students only, perhaps underscoring the importance of strong high school preparation for diverse populations (Crisp et al., 2009; Chang et al., 2014; Palmer et al., 2011).

Implications

Findings indicate that encountering discrimination is linked with students in STEM having significantly lower GPAs, and that experiencing discrimination disrupts or lessens the otherwise positive link between academic satisfaction, student-faculty interaction, and GPA. Furthermore, Black students who engage more with faculty are more likely to experience racial discrimination. Altogether, our study has challenging implications for efforts to make STEM classrooms more inclusive environments that will support diverse populations. Findings point to the pernicious effect of discrimination in STEM environments, suggesting that such negative experiences have an adverse effect on academic performance and also potentially interfere with the gains typically associated with student-faculty interaction.

These findings compliment in-depth qualitative studies documenting the marginalization and hostility that URM students often experience in STEM (Dortch & Patel, 2017; Fries-Britt & Griffin, 2007), as well as quantitative studies documenting the adverse effect of discrimination and stereotype threat (Beasley & Fischer, 2012; Chang et al., 2011; Hurtado et al., 2007; Johnson, 2012). However, our study goes one step further by showing how discrimination is negatively mediating the otherwise generally positive link between student-faculty interaction and GPA, highlighting some of the processes by which discrimination has a negative impact on academic experiences. Not only did we find a direct negative relationship between discrimination and GPA, but the negative mediating effect of discrimination on student-faculty interaction and GPA helps explain why not all students benefit equally from student-faculty interaction.

The finding that discrimination is potentially and likely interfering with the ability of students to reap positive gains from student-faculty interaction is greatly troubling. In this case, discrimination appears to be a key structural force that is disrupting the translation of social ties (engagement with faculty) into social capital (benefits embedded within networks and relationships). It appears that Black students are particularly susceptible to this negative dynamic. Further, White students were the only group for which student-faculty interaction had a positive effect on GPA.

It is true that our measure of discrimination is based off of student's self-reports that they are being discriminated against by faculty versus observational data or reports from faculty that they themselves are discriminating. However, the latter source of evidence would be highly difficult to obtain. Observational data is compelling and powerful; however, gaining entry and access to such spaces is also difficult and often limited to small sample sizes. The fact remains that at minimum, students are perceiving that they are being discriminated against, and such perceptions and/or experiences are negatively linked with academic outcomes. Perceptions themselves reflect the psychological component of campus climate, which makes up an important role in the question of how well-supported students feel in an environment.

Our study opens up several potential areas for future research. Future studies could contain more detailed items on the nature of discriminatory experiences, enabling researchers to examine some of the nuance of students' experiences. Additionally, containing such items in longitudinal data collection could enable researchers to examine the effect and impact of such experiences over time. Other means of capturing student experiences such as time diaries (Frazis & Stewart, 2012) could provide more detailed logs of challenges that students are experiencing. The use of qualitative data collection—particularly repeated observations and/or interviews over time, could help shed additional light on students experiences. Finally, additional studies can examine how discrimination may play a mediating role, positive or negative, between key college experiences in STEM and other critical outcomes such as internship placement and/or long-term career retention.

With that, our findings signal that faculty in particularly need to be sensitive to the way their actions may impact students, and institutions need to provide resources, such as unconscious or implicit bias workshops, to help faculty understand how they can engage with students in healthier and more productive ways (Jackson, Hillard, Schneider, 2014). Universities could also implement measures to analyze and track which STEM majors and courses retain the least number of URMs and women. Then, university administrators, in collaboration with academic researchers, could conduct observations and/or facilitate focus groups with students to better understand the dynamics affecting their STEM attrition. From this mixed-methods analyses, higher education institutions could develop STEM retention programs and initiatives grounded on empirical data from their own college campuses. To address the potential resistance that university administrators may encounter from faculty who may not want their classes to be observed, the university could offer incentives in relation to the promotion and tenure process and/or research funding opportunities. If the university asks professors to opt-in to an "evaluation" program free of negative consequences and in exchange for incentives, faculty may be more willing to participate. It would be critical to frame these evaluation programs as STEM retention initiatives so both faculty and students could understand the direct benefits and values of participating.

For URMs and female students in STEM majors, the university could implement a bias reporting mechanism where they could safely report discrimination they experience from faculty or any incidents of perceived discrimination (Miller, Guida, Smith, Ferguson, & Medina, 2017). While some institutions have university-wide bias reporting systems and bias response teams in place (Miller et al., 2017; New, 2016; Snyder & Khalid, 2016), a STEM-focused portal could make URMs and female students feel more comfortable reporting these issues and expose unique challenges that STEM students are encountering in those fields. Tackling the subject of discrimination among students is difficult because directly highlighting inequities may ". . . inadvertently act as a social identity threat for women," and potentially other minorities (Pietri et al., 2018). One study by Pietri et al. (2018) found that interventions such as highlighting positive female scientist role models and suggesting gender bias can be overcome had a positive impact on women's sense of belonging, but did not ameliorate stereotype threat. Such research suggests that addressing challenges that women and people of color encounter in STEM settings is a complex and challenging issue and additional research is needed to investigate interventions and policies that could be beneficial in helping faculty proactively engage with students in a positive manner.

Conclusion

Altogether our findings shed new light on the relationship between discrimination, student-faculty interaction, and student outcomes in STEM, highlighting the multifaceted ways that discrimination adversely affects student experiences in STEM. Our work makes an important contribution to ongoing conversations about the need to combat a chilly climate in STEM in order to support and advance diversity. The stakes are high because key inequities related to discrimination and student-faculty interactions in STEM persist, exacerbating the disparities that exist between URMs and white students, as well as female and male students in STEM fields (Espinosa, 2010; Hurtado et al., 2007; Park et al., 2007; Seymour, 1995).

The results of this study clarified how the academic benefits associated with student-faculty relationships are interrupted by experiences of discrimination STEM students have with their professors. In particular, by illuminating that student-faculty interactions only had a positive effect on the GPA of white students, our findings demonstrate the tangible effects of discrimination on the college outcomes of URMs. Without an understanding of these relationships and complex dynamics occurring in STEM classrooms, students of color may continue to be held responsible for their "underachievement," without examining and questioning the systemic factors that create and perpetuate the inequities they experience.

Furthermore, by highlighting the negative impact of discrimination on students' experiences and the inequitable benefits that are linked with student-faculty interaction between populations, our study suggests the ongoing need for interventions that address discrimination within STEM fields; in particular, discrimination from faculty. Such interventions can hopefully provide more positive experiences for URM and female students in STEM environments, less encumbered by the forces of discrimination and structural inequality. We urge colleges and universities to take action and address these systemic and persistent inequalities so the retention and graduation of URMs and female students in STEM do not continue to be at risk.

Table 1

Factor Loadings and Internal Consistencies for Composite Measures (n = 778)

Factor/Item	Factor Loading	α
Student-faculty interaction		.78
Approached professors after class to ask a question	.82	
Asked professors questions in class	.82	
Raised hand during a lecture when I don't understand something	.76	
Met with professors in offices to ask about material I don't understand	.71	
Discrimination from faculty		.65
I felt I was discouraged by a professor from speaking out in class because of my race/ethnicity	.78	
I felt I was given a bad grade by a professor because of my race/ethnicity	.73	
I heard derogatory remarks made by professors because of my race/ethnicity	.68	
Professors made me feel uncomfortable because of my race/ethnicity	.65	
Academic satisfaction		.81
Satisfaction with courses taken	.87	
Satisfaction with quality of instruction	.86	
Satisfaction with mastery of subjects	.82	

Table 2

Means, Standard Deviations, and Correlations Among the Variables Used in the Hypothesized Path Model for the Relationship Between Student-Faculty Interaction, Discrimination from Faculty, and College GPA among STEM undergraduate students (n = 778)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. College GPA	2.93	.48	—								
2. Gender: Female	.51	.50	-.13**	—							
3. Race: Black	.25	.43	-.23**	.09*	—						
4. Household income	12.66	2.07	.13**	-.04	-.15**	—					
5. Highschool math GPA	3.74	.46	.12**	.13**	-.11**	.05	—				
6. Percent living on campus	59.12	22.81	.15**	.05	.01	.02	.06	—			
7. Academic satisfaction	7.16	1.42	.20**	.06	-.07	.05	.14**	.03	—		
8. Student-faculty interaction	3.58	2.03	-.01	.05	.22**	-.13**	-.01	.02	.16**	—	
9. Discrimination from faculty	1.14	.30	-.14**	.00	.23**	-.13**	-.01	-.06	-.01	.20**	—

*$p < .05$, **$p < .01$

Table 3

Summary of Direct and Indirect Effects of the Final Path Model for the Relationship Between Student-Faculty Interaction, Discrimination from Faculty, and College GPA among STEM undergraduate students (n = 778)

Variables	Direct Effects (β)	Indirect Effects (β)	R^2
Student-faculty interaction			.06
Income	-.10**	—	
Race: Black	.20***	—	
Discrimination from faculty			.08
Income	-.08*	-.02*	
Race: Black	.18***	.03*	
Student-faculty interaction	.15***	—	
Academic satisfaction			.05
Income	—	-.02*	
High school math GPA	.13***	—	
Race: Black	-.10***	.04*	
Student-faculty interaction	.18***	—	
College GPA			.14
Income	.07*	.01	
Gender: Female	-.14***	—	
High school math GPA	.09**	.02*	
Race: Black	-.17***	-.03*	
Institutional % living on campus	.14***	—	
Student-faculty interaction		.02*	
Discrimination from faculty	-.08*	—	
Academic satisfaction	.17***	—	

* $p < .05$, ** $p < .01$, *** $p < .001$

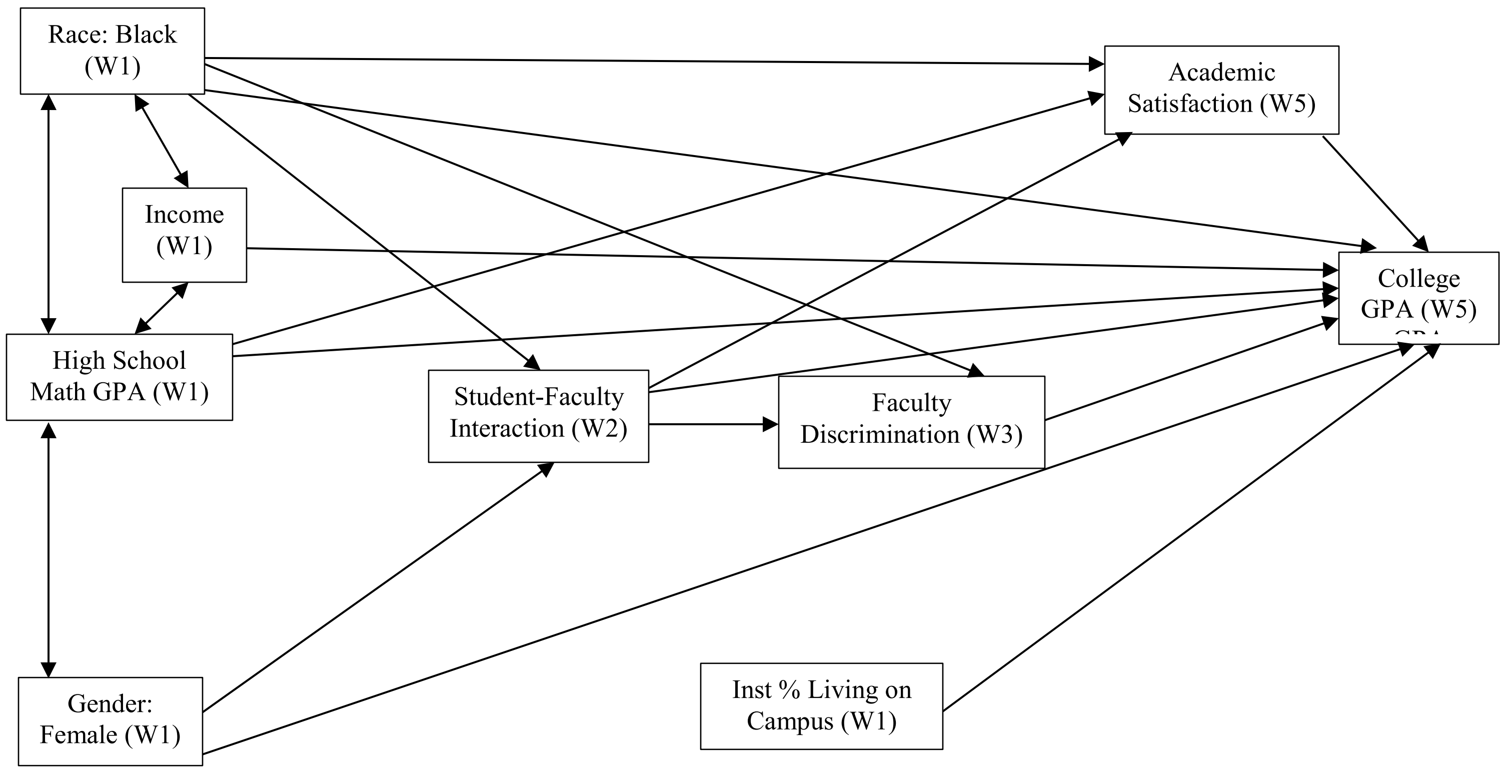

Figure 1. Conceptual model for the relationship between student-faculty interaction, discrimination from faculty, and college GPA among STEM undergraduate students. The term "W1" denotes the first wave data collection (i.e., survey administration at the beginning of the first year of college), "W2" the second wave data collection (i.e., survey administration at the end of the first year of college), "W3" the third wave data collection (i.e., survey administration at the end of the second year of college), and "W5" the fifth wave data collection (i.e., survey administration at the end of the fourth year of college).

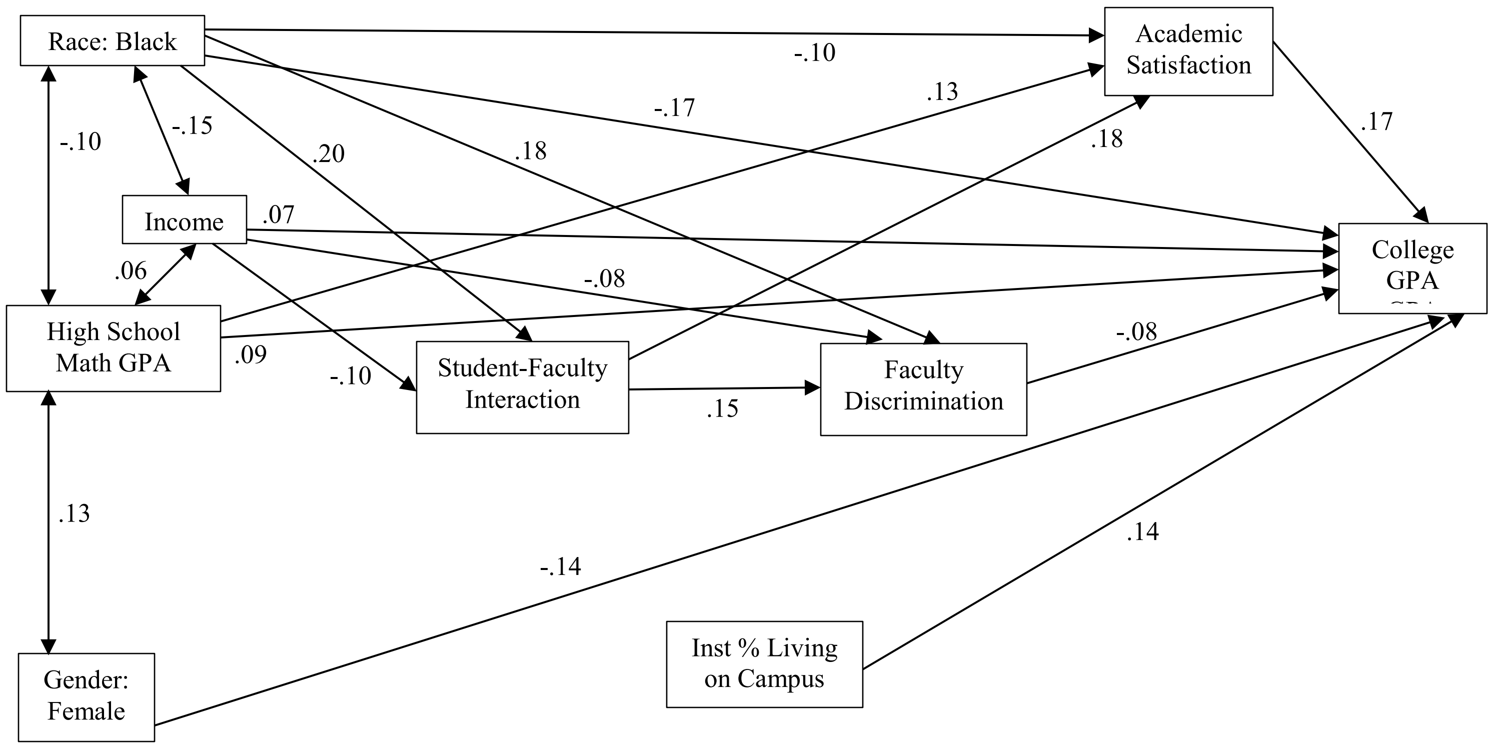

Figure 2. Final path model for the relationship between student-faculty interaction, discrimination from faculty, and college GPA among STEM undergraduate students. Path model (n = 778), χ^2/df = 1.330, CFI = .981, TLI = .960, RMSEA = .021. All structural paths and correlations were statistically significant at the .01 level except three paths (income to college GPA; income to faculty discrimination; faculty discrimination to college GPA; these paths were statistically significant at the .05 level). Disturbances for endogenous variables were omitted from the figure.

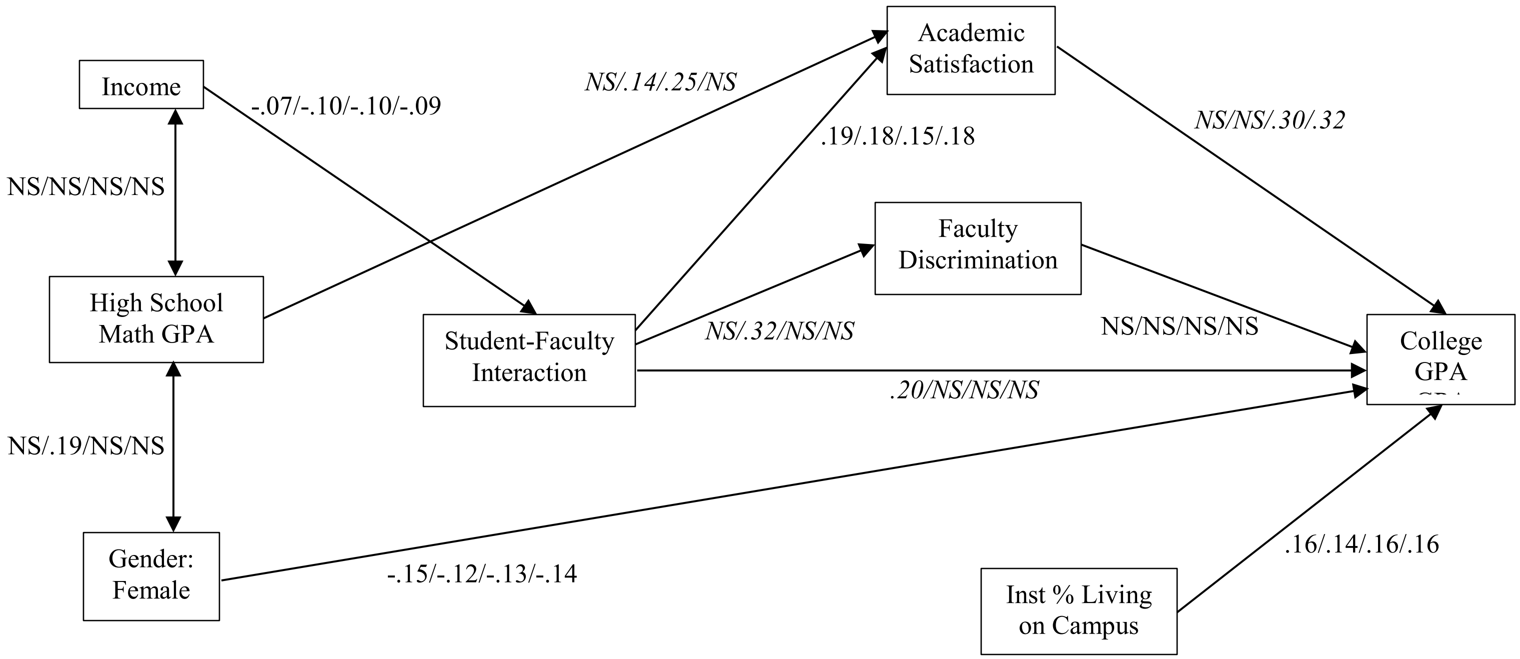

Figure 3. Multiple-group (White/Black/Hispanic/Asian American) estimation of model for the relationship between student-faculty interaction, discrimination from faculty, and college GPA among STEM undergraduate students. Variances and disturbances were omitted from the figure. Numbers presented in the figure are standardized path coefficients, all of which are significant at .05 level. Italicized numbers indicate the estimate is significantly different across groups (freely estimated paths). The term "NS" denotes the corresponding coefficients are not significant at .05 level.

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