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Student–Faculty Interaction and Discrimination from Faculty in STEM: The Link with Retention

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Abstract

Previous studies have documented student–faculty interaction in STEM, but fewer studies have specifically studied negative forms of interaction such as discrimination from faculty. Using a sample of 562 STEM undergraduates from the National Longitudinal Survey of Freshmen, we use hierarchical generalized linear modeling to investigate various types of student–faculty interaction in Science, Technology, Engineering, and Math (STEM) and in particular, the link between discrimination from faculty and retention in STEM. While Black students interacted more frequently with faculty, they were also most likely to report experiencing racial/ethnic discrimination. Overall, female, Black, and Latinx students were more likely to leave STEM by the fourth year of college than male, White, and Asian American peers. Feeling that professors made a student feel uncomfortable due to race/ethnicity was negatively linked with STEM retention. None of the traditional forms of student–faculty interaction (i.e., non-discriminatory) predicted retention. Variation in patterns by race, gender, and income are discussed, as well as implications for research, policy, and practice.

Keywords Student–faculty interaction · Retention · STEM · Discrimination from faculty · Higher education outcomes

There are major challenges to student retention[1] in STEM (Science, Technology, Engineering, and Math), with under 40% of students who plan to major in STEM actually obtaining a degree in those fields (Hurtado et al. 2012). Understanding the dynamics of STEM classrooms is critical to fostering more positive experiences. Besides the actual instruction and

[1] Retention refers to the actions institutions take to promote the return of students from semester to semester, and to enhance the likelihood of students' graduation. In contrast to retention, persistence, refers to the actions students take to continue their educational pursuits until degree completion. In this manuscript we focus on retention to place the responsibility of student success on the institution.

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curriculum, positive interactions and relationships between students and faculty are critical to student retention in STEM, influencing activities like finding letter of recommendation writers, gaining research experience, and obtaining mentorship (Dickey 1996). However, students of color often have less access to valued relationships with faculty members because of racism, discrimination, and chilly climate, within STEM disciplines (Beasley and Fischer 2012; Dortch and Patel 2017; Packard 2015), and these negative experiences can adversely affect outcomes (Chang et al. 2011).

While some studies have highlighted predictors of student–faculty interaction (see for example Eagan et al. 2011), fewer studies have explored the frequency and impact of different types of student–faculty interaction, both traditional (e.g., asking questions) and negative (e.g., discriminatory experiences). Numerous qualitative studies have brought depth and nuance to the troubling experiences with faculty often encountered by underrepresented minorities (URMs) in STEM (Dortch and Patel 2017; Ko et al. 2013; Palmer et al. 2011; Tate and Linn 2005), but with the exception of Chang et al. (2011), existing quantitative research analyzing national datasets have paid less attention the role of faculty as a source of discrimination. This gap in the literature has left questions about the pervasiveness and impact of this phenomena, as well as the relative impact of more traditional forms of student–faculty interaction in comparison to discriminatory experiences. Does the impact of more traditional forms of student–faculty interaction outweigh the effects associated with discrimination, or vice versa?

Our study seeks to address this gap in the research by analyzing a sample of 562 STEM undergraduates from the National Longitudinal Survey of Freshmen. We use hierarchical generalized linear modeling (HGLM) to ask the following four research questions: What is the rate of retention in STEM for students from different genders, races/ethnicities, and household incomes? What is the rate of traditional forms of student–faculty interaction, as well as discrimination from faculty among STEM undergraduates from these subgroups? To what extent do both traditional and discriminatory forms of interaction predict retention in STEM majors from the first to fourth year of college? How does the effect of student–faculty interaction, traditional and discriminatory, on STEM students' first-to-fourth year retention differ by gender, race/ethnicity, and income?

Literature Review

We begin with an overview of retention issues within STEM before addressing work on student–faculty interaction, both broadly and within STEM contexts.

STEM Retention

In the U.S., more than half of first-year college students who declare a STEM major at the beginning of college leave their STEM programs before their graduation (Cheng 2013). Further, more than half of those who obtain a bachelor's degree in STEM pursue a career or graduate school in non-STEM fields (Cheng 2013). The high rates of STEM attrition not only concerns universities interested in promoting equitable outcomes and experiences for students, but it also impacts the ability of the U.S. to remain competitive in the growing international labor market, which demands an increasing number of STEM professionals (Soldner et al. 2012).

Low STEM retention rates become even more alarming when focusing on specific student populations. Underrepresented minorities (URMs) including Black, Latinx, and Native American students, as well as female students, have higher rates of STEM attrition than their White and Asian American counterparts (Higher Education Research Institute 2010; Huang et al. 2000). Unfortunately, disaggregated data is unavailable to identify diversity of experiences that exist within the Asian American population, although further disparities are expected among underrepresented subgroups (Museus et al. 2011). While the number of URMs in higher education has increased during the past two decades, they are still underrepresented, obtaining fewer STEM degrees even when they enter college intending to pursue a STEM major (National Science Board 2016). Similarly, women are less likely to choose a STEM major and to graduate with a STEM degree despite initial career intentions. Reflecting this phenomena, while the proportion of women earning computer science degrees has declined during the past two decades, the proportion of first-year female students declaring computer science majors has not dropped (National Science Board 2016).

Numerous studies have indicated that the retention of STEM college students is influenced by academic preparation prior to entering higher education (Bonous-Hammarth 2000; Madigan 1997; Moore 2006; Russell and Atwater 2005; Wang 2013), as well as the experiences students have on campus including academic performance, selection of classes, and relationships with faculty and peers (Astin and Astin 1992; Cole and Espinoza 2008; Crisp et al. 2009; Daempfle 2003; Seymour and Hewitt 1997). The retention of women and URMs is affected by additional dimensions of STEM environments (Chang et al. 2011). For example, research has indicated that a lack of encouragement and validation from faculty, as well as the competitive and individualistic nature of STEM disciplines, impact the retention of women in STEM (Lee 2002; Seymour 1995).

The retention of URMs in STEM is also impacted by the campus racial climate (Hurtado et al. 2007), experiences of tokenization and stereotyping (Carlone and Johnson 2007; Chang et al. 2011), students' perceived sense of belonging and institutional support (Chang et al. 2011), opportunities for research involvement (Chang et al. 2014), and the development of students' scientific identity and self-efficacy (Byars-Winston et al. 2010; Carlone and Johnson 2007; Hurtado et al. 2009; Wang 2013). For women of color, the support they receive from their families and communities is another influential factor in their retention as STEM students (Carlone and Johnson 2007; Grandy 1998).

As a response to the high rates of student attrition in STEM majors, many colleges and universities have implemented programs and services that seek to enhance the academic and social experiences of STEM students, and provide them with tools and resources that can aid them as they pursue their degrees (Szelényi et al. 2013). For example, Soldner et al. (2012) found that STEM-focused Living-Learning programs have the potential to support retention in STEM because they foster an environment where students can discuss academic issues with their peers and build relationships with faculty outside of class. Participating in women-only STEM-focused Living-Learning programs was positively correlated with graduate school aspirations among female STEM students (Szelényi and Inkelas 2011). Similarly, Stolle-McAllister (2011) found that a summer bridge program for Black STEM students allowed students to increase levels of social and cultural capital, which fostered success in their majors. While these programs are beneficial to students, they generally serve a relatively small number of students. Thus, in this study we examine the relationships and interactions that STEM students have with faculty, given that all students potentially have the opportunity to experience some level of contact, which may facilitate student retention and other positive outcomes.

Student–Faculty Interaction and STEM

Previous research establishes that student engagement with faculty inside and outside of the classroom is linked to numerous positive academic outcomes, including higher college GPA (Cole 2011; Comeaux 2008; Kim et al. 2009; Tovar 2015; Vogt et al. 2007), retention (Barnett 2011; Crisp 2010; DeAngelo 2014; Jones et al. 2010), and degree attainment (Flynn 2014; Gayles and Ampaw 2014; Kim and Conrad 2006). However, students from diverse backgrounds may not be prepared to navigate interactions with faculty members, potentially being unfamiliar with the types of faculty interaction needed and valued in higher education settings; the lack of a diverse professoriate can also be a deterrent to student–faculty interaction for students of color (Cole and Griffin 2013; Cole and Espinoza 2008). Within STEM, students may miss critical opportunities for advancement without these interactions and relationships, facing challenges when trying to find letter of recommendation writers, valuable research experiences, and career mentorship (Dickey 1996; Ellington 2006).

The body of research addressing student–faculty interaction in STEM is surprisingly small relative to the broader body of research on STEM in higher education. In one study looking at retention in engineering programs, classroom environments had a significant relationship with students' self-assessments, learning behaviors, and academic performance (Vogt 2008), and faculty aloofness or intimidation was linked with lower self-efficacy. Chang et al. (2014) identified an initial negative relationship between faculty mentoring and persistence in STEM. Further analyses showed that faculty mentoring itself was not negatively related to persistence, but that its effectiveness is linked to whether students had other opportunities for engagement with faculty. Hurtado et al. (2011) found that Black students in STEM experienced less student–faculty interaction at predominantly White institutions than at Historically Black Colleges and Universities (HBCUs). In another study, receiving negative feedback from faculty and experiencing negative racial experiences, a measure incorporating hearing racial stereotypes from faculty, negatively predicted first-year persistence for students in STEM (Chang et al. 2011). However, the study did not isolate faculty as a distinct source of students' negative racial interactions on campus given that four of five variables in the negative racial experiences factor scale did not specify the source of the discrimination (i.e., with whom—faculty, peers, or staff—did students experience the negative racial interactions with?). Thus, questions are left regarding how experiencing discrimination from faculty specifically and uniquely shapes academic outcomes among STEM students. Additional questions remain about whether the negative effects of discrimination from faculty manifest themselves on the longer span of overall retention, given that Chang et al. (2011) studied first-year persistence.

Much of the research suggests that the effects of student–faculty interaction are "conditional" (Kim 2010; Kim and Sax 2009, 2011, 2014, 2015; Cole and Griffin 2013; Cole and Espinoza 2008). In other words, the beneficial influence of student–faculty interaction on student outcomes differ based on student characteristics such as gender and race. For example, Kim and Sax (2009) found that while both males and females benefit from interactions with faculty in course-related settings, positive relationships tend to be more pronounced among male students. This finding was supported in a similar study looking at the academic success of Latinx students in STEM fields (Cole and Espinoza 2008). Additionally, while Black students tend to interact more frequently with faculty for course-related matters than other racial groups, they are less likely to assist faculty with research (Kim and Sax 2009). This is critical given that undergraduate research opportunities with faculty provide rich venues for social capital via student–faculty interaction (Hurtado et al. 2008; Hurtado et al. 2009).

A growing body of research has begun to explore how differences in career goals and motivations for pursuing STEM majors influence the relationships and experiences of URMs and women (e.g., Diekman et al. 2015). Researchers have argued that STEM faculty, particularly at research-intensive institutions, often value science more for the advancement of research and less so for the practical application to society (Johnson 2007; Karakas 2009), an approach which may not align with the values that motivate URM students to pursue STEM degrees. For example, in a study that examined the predictors of democratic educational outcomes among STEM graduates, Garibay (2018) found that students of color and women had significantly higher social agency and values toward conducting research for social change than their white and male counterparts respectively. However, STEM settings are predominantly White spaces with White cultural norms (Ong et al. 2011), which can contradict the goals and aspirations of students of color in STEM contexts. Similarly, Diekman et al. (2015) found that for women in STEM majors, feeling that their careers were going to help others positively influenced their orientation toward STEM work. For these women, communal goals were important; when they found congruency between STEM fields and their aspirations, they were likely to stay committed to STEM (Diekman et al. 2015). This body of literature suggests that student–faculty relationships have the potential to be stronger when the values and goals of faculty are more in line with the values of underrepresented students. However, social ties between students and faculty may suffer when interests and values contradict, potentially having a more pronounced impact on women and students of color who tend to pursue STEM majors due to a sense of communal responsibility (Diekman et al. 2015; Garibay 2018).

Previous research documents that female and URM students often experience discrimination from faculty (Carlone and Johnson 2007; Justin-Johnson 2004; McGee and Martin 2011; Ong et al. 2011), and quantitative studies have documented the effect of such experiences in combination with other negative experiences (Chang et al. 2011). However, no study to date has sought to isolate the effect of faculty as a source of discrimination, leaving questions about how experiencing discrimination from faculty uniquely and specifically shapes academic outcomes among STEM students. Do more traditional forms of student–faculty interaction outweigh the negative effects of discrimination from faculty, or vice versa? Thus, our study seeks to extend both research on student–faculty interaction and discrimination from faculty in STEM education.

Theoretical Framework

This study frames student–faculty interactions as a key type of social tie that can be positive or negative for students. Social ties are the relationships and connections that students have with others, including faculty and peers; these relationships can occur within broader social networks or independently between two people (Granovetter 1973; Wasserman and Faust 1994). In this study, we conceptualize any form of student–faculty interaction, traditional or negative/discriminatory, as a type of social tie that may or may not result in valued social capital. Social capital theory describes how social mobility and social reproduction occurs through the possession of social ties and networks, reflecting how social ties can support the exchange of valuable information and assets (Coleman 1988; Putnam 2000). Via social capital, people can typically expand their access to other sources of capital, such as finances, which leads to growth of privilege and advantages over time (Bourdieu and Wacquant 1992). Conversely, a lack of positive social ties can limit or block individuals' access to resources (Bourdieu 1986).

Oftentimes research utilizing social capital frameworks portray people of color and other marginalized groups (e.g., low-income communities) as being deficient in social capital because their networks are seen as impoverished or lacking key relationships needed for social mobility (Rios-Aguilar et al. 2011; Stanton-Salazar 1997; Stanton-Salazar and Dornbusch 1995). While these stereotypes have been challenged (Rios-Aguilar et al. 2011; Yosso 2005), when individuals do not have access to forms of capital valued by dominant society (e.g., relationships with gatekeepers like faculty), access to resources is constrained, leading to further inequities in capital (Lin 2000). Further, the existence of social ties does not guarantee that the relationships will transform into valued social capital, opening the door for actual gains. For example, economic stratification and institutionalized racism influence how people develop relationships and networks that help them access and obtain social capital (Sandefur and Laumann 1998; Stanton-Salazar 1997).

For URMs and female students in STEM, social capital in the form of mentors, institutional agents, and supportive peers is critical, given their underrepresentation in most contexts (Ong et al. 2011; Packard 2015). Existing research suggests that traditionally disenfranchised students often have trouble establishing these types of relationships or that faculty may be less likely to initiate such engagement (Bonous-Hammarth 2000; Kim and Sax 2009, 2015; Seymour and Hewitt 1997). Race and gender impact how students form social ties in STEM (Ong et al. 2011), which in return may affect the transformation of social ties into social capital. Students may have limited opportunity to develop social ties and social capital to begin with. For example, in a study about Black undergraduate women in STEM, Dortch and Patel (2017) found that their participants felt excluded and isolated in STEM due to lack of faculty and peers of similar demographic backgrounds; this dynamic impacted how students navigated their education and whether they felt supported by their institutions.

Previous research has established that it is not just the existence of a social tie between student and faculty, but the quality of the social tie and whether it corresponds to benefits for students (Hurtado et al. 2011; Kim and Sax 2009; Vogt 2008). Ostensibly, a social tie characterized by negative student–faculty interaction (e.g., experiences with discrimination) will have an adverse effect on students. We are particularly interested in understanding the impact of such negative interactions on student outcomes, and the relative impact of both traditional and negative/discriminatory forms of student–faculty interaction. Altogether, we draw on these concepts to examine how different forms of student–faculty interaction vary by students' race/ethnicity, gender, and income, as well as the potential differential payoffs linked with these interactions. Conversely, we also seek to examine whether negative/discriminatory interactions with faculty have an adverse effect on the outcome of retention.

Methods

Research Questions and Hypotheses

Here we state hypotheses for each research question. Hypotheses reflect research findings on inequities in STEM, with a particular focus on the inequitable benefits and discriminatory experiences with faculty experienced by Black students in particular (Dortch and Patel 2017; McGee and Martin 2011). While Black students generally experience higher rates of student–faculty interaction (Kim and Sax 2009), they are subject to negative experiences with faculty (McGee and Martin 2011). Thus, hypotheses posit that while minorities overall will have lower retention in STEM, Black students specifically will report both the highest rates of student–faculty interaction *and* discrimination from faculty.

(1) What is the rate of retention in STEM for students from different genders, races/ethnicities, and household incomes?

Hypothesis 1a: Female, Black, Latinx, and low-income students will report lower STEM retention rates than their male, White, Asian American, and high-income peers.

(2) What is the rate of traditional student–faculty interaction (i.e., non-discriminatory experiences) and discrimination (i.e., negative interaction) from faculty among STEM undergraduates from these subgroups?

Hypothesis 2a: Black STEM students will report the highest average rates of traditional student–faculty interaction.

Hypothesis 2b: Black STEM students will report the highest average rates of experiencing discrimination from faculty than their peers, followed by Latinx and Asian American students.

(3) To what extent does student–faculty interaction and discrimination predict students' retention in STEM majors from the first to fourth year of college in the aggregate sample?

Hypothesis 3a: Traditional forms of student–faculty interaction will positively predict first-to- fourth year retention for STEM majors overall.

Hypothesis 3b: Experiences with discrimination from faculty will negatively predict first-to- fourth year retention for STEM majors overall.

(4) How does the effect of student–faculty interaction and discrimination on STEM students' first-to-fourth year retention differ by gender, race/ethnicity, and income?

Hypothesis 4a: The effect of traditional student–faculty interaction on STEM students' first-to- fourth year retention will be stronger among male, White, Asian American, and high- income peers than female, Black, Latinx, and low-income students.

Hypothesis 4b: The effect of discrimination from faculty on STEM students' first-to-fourth year retention will be stronger among female, Black, Latinx, and low-income students than male, White, Asian American, and high-income peers.

Data Source and Sample

For this study, we used data from the National Longitudinal Survey of Freshmen (NLSF). Housed at Princeton University, the NLSF is a multi-wave longitudinal survey of 3864 students from 28 institutions nationwide. The survey was administered to students in waves at five different time points (i.e., Wave 1 at the beginning of the first year and Wave 5 at the end of the fourth year) from 2000 to 2004 and gathered extensive information on students' backgrounds, college experiences, and college outcomes. Given that this study was designed to investigate the role played by student–faculty interaction (including discrimination from faculty) on STEM students' first-to-fourth year retention, the sample of the study was limited to students who (1) completed both the first wave survey and the fifth wave survey and (2) declared a STEM major[2] at college entry. We also screened and cleaned the data to meet statistical assumptions of hierarchical generalized linear modeling (HGLM) and examined the amount and patterns of missing data using Missing Values Analysis (MVA) module of SPSS 25.0. Results of the missing data analysis showed that the data were missing completely at random (Little's MCAR test $\chi^2 = 619.88$, $p > .10$); hence, all missing data for continuous variables were imputed using expectation–maximization (EM) algorithms. Then, we removed any cases with missing data for categorical variables from the data using listwise deletion. Consequently, the final analytic sample of the study consisted of 562 STEM undergraduates across 27 institutions. The demographic composition of the analytical sample is as follows: 282 (50.2%) male and 280 (49.8%) female students; 155 (27.6%) White, 138 (24.6%) Black, 129 (23.0%) Latinx, and 140 (24.9%) Asian American students. Regarding family income, 274 (48.8%) came from high-income, 187 (33.3%) from middle-income, and 101 (18.0%) from low-income families. When we grouped students based on five major academic disciplines within STEM fields, 152 (27.0%) students came from Biological Sciences, 122 (21.7%) from Computer Science, 190 (33.8%) from Engineering, 20 (3.6%) from Mathematics or Statistics, and 78 (13.9%) from Physical Sciences.

Variables

In this study, we attempted to understand whether and how the nature and frequency of student–faculty interaction—including discrimination from faculty—are linked to first-to-fourth year STEM retention and how effects differ across gender, race/ethnicity, and income, while taking into account the hierarchical nature of the NLSF data. Considering the two-level hierarchy in the data (students are nested within institutions), this study employed a multilevel modeling for data analysis; hence, we utilized both Student-level (level 1) and institution-level (level 2) variables.

Student-level variables included the dependent variable (first-to-fourth year STEM major retention), nine principal independent variables (five student–faculty interaction and four discrimination from faculty variables), and 13 student-level control variables. STEM retention was measured by a dichotomous variable that indicates whether a student who

[2] In this study, we utilized the definition of STEM used by Department of Commerce (DOC) to identify STEM majors in our data. Then, based on the categorization of STEM majors by Sax et al. (2015), we grouped the STEM majors into five major categories (disciplines) for data analysis. The five categories and specific majors included in each category are as follows: Biological Sciences (Bio-chemistry, Biological Basis of Behavior, Biology); Computer Science (Computer Science); Engineering (Bio-engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, Other Engineering); Mathematics/Statistics (Math, Actuarial Science); Physical Sciences (Chemistry, Material Science, Physics, Other Physical Science).

declared a STEM major at the entry of college stayed in a STEM major at the end of the third or fourth year.

This study used five forms of traditional student–faculty interaction measures to address the frequency of the interaction (e.g., asking professors questions in class, approaching professors after class to ask a question, meeting with professor in offices to talk about other matters). Discrimination from faculty was gauged by four survey items on students' 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, having felt students were given a bad grade by a professor because of their race or ethnicity).

Informed by the literature on STEM students' retention discussed earlier, we selected student-level control variables for the data analysis of this study. Based on Astin's I-E-O model (1991), the control variables were organized in the temporal order in which they may have affected STEM student retention: (1) students' input characteristics (e.g., gender, race, SAT Quantitative score), (2) initial academic major, and (3) academic involvement (i.e., hours spent studying, studying with other students). Refer to Table 6 in Appendix A for definitions, coding schemes, and descriptive statistics for the variables of this study.

In addition to the student-level variables, we utilized an institution-level variable to test between-group (between-institution in this case) effects in our multilevel modeling. For the study, we used the institutional proportion of URMs, the sum of percentages of Black and Latinx students, as an institution-level variable to measure campus racial diversity.

Analysis

Statistical analyses used in this study include cross-tabulations with Chi square tests and hierarchical generalized linear modeling (HGLM). To answer our research question on the differences in STEM retention by students' gender, race/ethnicity, and income, we ran a set of cross-tabulations with Chi square statistics using SPSS 25.0. We also used the same statistical methods to compare levels of student–faculty interaction and discrimination from faculty across demographic subgroups of STEM students. Lastly, we formulated and tested a series of hierarchical generalized linear models to examine the influence of student–faculty interaction and discrimination from faculty on first-to-fourth year STEM retention after controlling for relevant student- and institution-level variables. As another form of multilevel modeling, HGLM is the most appropriate statistical technique when the level-1 (or student-level) outcome is binominal (Garson 2013; Raudenbush and Bryk 2002), as is the case with STEM retention. Specifically, to answer our third research question, we tested the following three sets of HGLM models: (1) unconditional model for the aggregate STEM sample, (2) conditional model for the aggregate STEM sample, and (3) conditional models for gender, race/ethnicity, and income subgroups.

Unconditional Model for the Aggregate STEM Sample

The first HGLM model of the study was a fully unconditional model since the model included no predictor variables at any level. In this model, the outcome (log-odds of STEM retention) was predicted by the average log-odds of STEM retention across institutions and the variance between institutions in institution-average log-odds of retention. We tested this unconditional model to examine the variance between institutions in STEM retention. Results from this model showed that the estimated variance of intercept for our outcome measure was statistically significant ($u_{0j} = .28583$, $\chi^2 = 64.02$, $p < .001$), indicating that students' average STEM retention significantly varies across different institutions. Therefore, we proceeded with subsequent HGLM models, incorporating relevant student- and institution-level predictors.

Conditional Model for the Aggregate STEM Sample

In this stage of modeling, we specified and tested a conditional model for the aggregate STEM sample of the study to examine whether student–faculty interaction (including discrimination from faculty) is significantly associated with first-to-fourth year STEM retention, taking into account relevant student- and/or institution-level variables. To specify the conditional model, we expanded the unconditional model described above by incorporating 23 student-level predictors to the level-1 model and an institution-level predictor to the level-2 model, as expressed by the following equations (Eqs. 1, 2).

Level-1 or Student-Level Model

$$\begin{aligned}
Log\left[\frac{\Phi ij}{1-\Phi ij}\right] = {} & \beta_{0j} + \beta_{1j}\,(\text{Female})_{ij} + \beta_{2j}\,(\text{Asian})_{ij} + \beta_{3j}\,(\text{Black})_{ij} + \beta_{4j}\,(\text{Latinx})_{ij} \\
& + \beta_{5j}\,(\text{Low income})_{ij} + \beta_{6j}\,(\text{Middle income})_{ij} + \beta_{7j}\,(\text{SAT Quantitative})_{ij} \\
& + \beta_{8j}\,(\text{Computer science})_{ij} + \beta_{9j}\,(\text{Engineering})_{ij} + \beta_{10j}\,(\text{Math/Stats})_{ij} \\
& + \beta_{11j}\,(\text{Physical science})_{ij} + \beta_{12j}\,(\text{Hours for studying})_{ij} + \beta_{13j}\,(\text{Studying with peers})_{ij} \\
& + \beta_{14j}\,(\text{Fourth year college GPA})_{ij} + \beta_{15j}\,(\text{Asked professors question in class})_{ij} \\
& + \beta_{16j}\,(\text{Raised hand during a lecture})_{ij} + \beta_{17j}\,(\text{Approached professors after class})_{ij} \\
& + \beta_{18j}\,(\text{Met with professors in offices to ask about material I don't understand})_{ij} \\
& + \beta_{19j}\,(\text{Met with professors in offices to talk about other matters})_{ij} \\
& + \beta_{20j}\,(\text{Professors made me feel uncomfortable because of my race})_{ij} \\
& + \beta_{21j}\,(\text{Heard derogatory remarks made by professors because of my race})_{ij} \\
& + \beta_{22j}\,(\text{Felt I were given a bad grade by a professor because of my race})_{ij} \\
& + \beta_{23j}\,(\text{Felt I were discouraged by a professor from speaking out in class because of my race})_{ij}
\end{aligned} \tag{1}$$

where the outcome variable denotes the likelihood that a STEM student i in institution j stayed in STEM majors at his or her fourth year of the college. β_{0j} is an intercept, and β_{1j} through β_{23} refer to coefficients of the corresponding level-1 variables. In the level-1 model, all variables were centered on the grand mean, except for dichotomous variables, for a more meaningful interpretation of results.

Level-2 or Institution-Level Model

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\,(\text{Institutional percentage of URM}) + u_{0j} \tag{2}$$

Table 1 First-to-fourth year STEM retention and attrition rate by student gender, race/ethnicity, and household income

Student subgroup	Retained STEM	Left STEM	Significance test
Gender			
Male (n = 282)	64.2%	35.8%	p < .05, Fisher's exact test
Female (n = 280)	55.4%	44.6%	
Race/ethnicity			
Asian (n = 140)	72.1%	27.9%	$\chi^2(3) = 13.51$, p < . 01
Black (n = 138)	51.4%	48.6%	
Latinx (n = 129)	56.8%	43.2%	
White (n = 155)	58.9%	41.1%	
Household income			
Low (n = 101)	57.4%	42.6%	$\chi^2(2) = .29$, p > .10
Middle (n = 187)	60.4%	39.6%	
High (n = 274)	60.2%	39.8%	

A student's annual household income was originally measured by a fourteen-point scale, ranging 1 = under $3000 to 14 = $75,000 or more. This income variable was normalized for data analysis according to the quartile distribution of responses from the aggregate sample. Consequently, income levels were recoded into a three-point scale, including 1 = low income (lower quartile), 2 = middle income (middle two ranges), and 3 = high income (upper quartile)

In the level-2 model, the intercept, β_{0j}, was predicted by the average log-odds of STEM retention across institutions (γ_{00}), an institution-level variable (coefficient γ_{01}), and the variance between institutions in institution-average log-odds of retention (u_{0j}).

Conditional Models for Gender, Race/Ethnicity, and Income Subgroups

Lastly, using the final, full conditional model for the aggregate STEM sample (Eqs. 1 and 2) as the baseline model, we constructed conditional models for gender, race/ethnicity, and income subgroups to investigate whether the strength of the relationship between student–faculty interaction and STEM retention is different across the various student subgroups. Informed by the results of the conditional model for the aggregate STEM sample (refer to Table 4), we specified and tested reduced conditional models for demographic subgroups including only the eight level-1 variables found to be significantly related to the outcome variable for the full STEM sample, along with institutional percentage of URM students as the level-2 variable. This approach allowed us to address the sample size issues of STEM subgroups by securing a favorable model complexity (Raudenbush and Bryk 2002). Furthermore, to determine whether the observed group differences in the magnitude of regression coefficients are statistically significant, we calculated t-statistics using the following formula as suggested by Sax (2008):

$$t = \frac{b_1 - b_2}{\sqrt{S_{b1}^2 + S_{b2}^2}}$$

where b_1 denotes regression coefficient for group 1, b_2 regression coefficient for group 2, and S standard error.

Results

STEM Retention by Gender, Race/Ethnicity, and Household Income

Table 1 presents the results related to patterns of first-to-fourth year STEM retention across gender, race/ethnicity, and income subgroups of students. The results showed that male students (64.2%) were more likely to stay in STEM majors compared to female students (55.4%). Asian American students reported the highest retention rate (72.1%) and Black students reported the lowest rate (51.4%). Low-income students had a slightly lower retention rate (57.4%) than their middle-income (60.4%) and high-income (60.2%) peers.

Traditional Student–Faculty Interaction by Gender, Race/Ethnicity, and Household Income

Table 2 displays results relevant to subgroup differences in the level of traditional student–faculty interaction in STEM. The results showed that female students more frequently met with professors in offices to ask about material they did not understand. In contrast, male students more frequently met with their professors in offices to talk about other matters as compared to their female peers.

When it comes to the racial/ethnic differences, Black students approached professors after class to ask questions and met with professors to ask about material they did not understand more frequently than their peers of other racial/ethnic groups. Asian American students were less likely to be engaged in such interactions with faculty than other racial/ethnic groups.

Discrimination from Faculty by Gender, Race/Ethnicity, and Household Income

We also examined experiences of reported discrimination from faculty in Table 3. There was one significant gender difference in terms of experiencing discrimination from faculty: Female students (24.4%) were more likely than male students (13.3%) to report that "professors made me feel uncomfortable because of my race ethnicity." Black students were more likely to report agreement with this item (35.8%) than peers of other races. They also reported the highest levels of other forms of discrimination: to hear derogatory remarks made by professors due to their race/ethnicity, to feel they received a bad grade by a professor because of their race/ethnicity, and to feel discouraged by a professor from speaking out in class due to their race/ethnicity. While Black students had the highest level of feeling like professors unfairly graded them due to race (12.7%), Asian American students were not far behind, at 7.2% of respondents. The percentage of Black students who perceived that professors made them uncomfortable because of their race/ethnicity (35.8%) was over five times as high as the percentage of White students (7.1%). For family income, students from low-income families (25.9%) were more likely than their peers from middle- and high-income families (14.0% and 16.0%, respectively) to report that professors made them feel uncomfortable because of their race/ethnicity.

Predicting STEM Retention for the Aggregate STEM Sample

We formulated and tested a series of hierarchical generalized linear models to examine the influence of traditional student–faculty interaction and discrimination from

Table 2 Level of student–faculty interaction among STEM undergraduate students by gender, race/ethnicity, and household income

Percentage of students who reported high level of interaction	Gender		Race/ethnicity				Income		
	Male	Female	Asian	Black	Latinx	White	Low	Middle	High
Asked professors questions in class	22.9	20.0	15.8	23.9	22.8	23.4	24.1	23.7	19.4
Raised hand during a lecture when I don't understand something	28.3	25.5	18.7	28.4	32.3	28.6	30.4	34.2	21.3
Approached professors after class to ask a question	27.6	33.5	***20.1***	***46.3***	***30.7***	***26.0***	32.3	32.5	29.9
Met with professors in offices to ask about material I don't understand	**17.6**	**31.6**	***15.8***	***47.8***	***19.7***	***16.2***	27.8	29.8	21.3
Met with professors in offices to talk about other matters	<u>28.0</u>	<u>24.7</u>	25.2	28.4	33.1	20.1	30.4	30.7	22.8

Items on student–faculty interaction were originally measured by a ten-point Likert scale, ranging 1 = never to 10 = always. These items were normalized for data analysis according to the quartile distribution of responses from the aggregate sample. Consequently, the levels of student–faculty interaction were recoded into a three-point Likert scale, including 1 = low levels (lower quartile), 2 = moderate levels (middle two ranges), and 3 = high levels (upper quartile). Underscored, bolded, and bolded italic numbers denote that the corresponding group difference (χ^2 statistic) is significant at .05, .01, and .001 level, respectively

Table 3 Experience of discrimination from faculty among STEM undergraduate students by gender, race/ethnicity, and household income

Percentage of students who experienced discrimination from faculty	Gender		Race/ethnicity				Income		
	Male	Female	Asian	Black	Latinx	White	Low	Middle	High
Professors made me feel uncomfortable because of my race/ethnicity	**13.3**	**24.4**	***20.9***	***35.8***	***12.6***	***7.1***	25.9	14.0	16.0
I heard derogatory remarks made by professors because of my race/ethnicity	7.9	10.5	6.5	14.9	10.2	5.8	10.8	6.1	9.0
I felt I were given a bad grade by a professor because of my race/ethnicity	6.5	6.2	**7.2**	**12.7**	**3.9**	**1.9**	7.0	6.1	6.3
I felt I were discouraged by a professor from speaking out in class because of my race/ethnicity	3.6	4.7	5.8	7.5	2.4	1.3	5.7	4.4	3.4

Items on discrimination from faculty were originally measured by a five-point Likert scale, ranging from 1 = never to 5 = very often; these items were dichotomized for the data analysis. Underscored, bolded, and bolded italic numbers denote that the corresponding group difference (χ^2 statistic or Fisher's exact test statistic) is significant at .05, .01, and .001 level, respectively

Table 4 Estimation of conditional model for first-to-fourth year retention in STEM Major

Variable	Log-odds	*SE*	Delta-p (%)
Student-level			
Student input characteristics			
Gender: Female	−.53	.22	−9.38*
Race: Asian	.43	.21	7.32*
Race: Black	−.36	.32	
Race: Latinx	−.38	.30	
Low income	−.11	.23	
Middle income	.18	.22	
SAT Quantitative score	.01	.00	.19***
Initial major			
Computer science	−.62	.29	−17.13*
Engineering	.79	.28	15.79**
Mathematics/statistics	−.87	.56	
Physical sciences	.18	.32	
Academic experience			
Hours spent studying	.02	.00	.57**
Studying with other students	.03	.04	
Fourth year College GPA	−.59	.22	−14.60**
Student–faculty interaction			
Asked professors questions in class	−.05	.05	
Raised hand during a lecture when I don't understand something	.00	.05	
Approached professors after class to ask a question	.00	.06	
Met with professors in offices to ask about material I don't understand	.05	.05	
Met with professors in offices to talk about other matters	−.02	.05	
Discrimination from faculty			
Professors made me feel uncomfortable because of my race/ethnicity	−.41	.20	−9.96*
I heard derogatory remarks made by professors because of my race/ethnicity	−.10	.26	
I felt I were given a bad grade by a professor because of my race/ethnicity	.41	.37	
I felt I were discouraged by a professor from speaking out in class because of my race/ethnicity	.10	.37	
Institution-level			
Percent URM	.01	.00	

Reference group for race is White. Reference group for income level is high income. Reference group for initial major is biological science. Percent URM (underrepresented minorities) denotes institutional percentage of Black and Latinx students. Delta-p statistics were calculated only for the variables with statistically significant log-odds

$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$

faculty on STEM retention after controlling for relevant variables. Results showed that traditional forms of student–faculty interaction did not predict STEM retention once the effects of discrimination from faculty and other control variables were taken into account. However, STEM students who reported that professors made them feel uncomfortable because of their race/ethnicity had a lower probability of staying in STEM (Delta-p = −9.96) as compared to their peers who did not.

Predicting STEM Retention for the Gender, Race/Ethnicity, and Income Subgroups

We examined whether the strength of the relationship between key variables varied by students' gender, race/ethnicity, and household income. Informed by the results of the conditional model for the aggregate STEM sample in Table 4, we specified and tested the models for demographic subgroups to investigate the gender-, race-/ethnicity-, and income-based conditional effects of discrimination from faculty and other variables on STEM students' first-to-fourth year retention. Results showed that the negative effect of feeling uncomfortable by professors because of students' race/ethnicity on STEM retention was more pronounced among female, Black, and Latinx than their corresponding counterparts (see Table 5). Interestingly, the negative effect of being female was significantly more pronounced for Asian American students, and the positive effect of being Asian American was more pronounced for male students. The negative effect associated with being a Computer Science major was stronger for female and Black students; the positive effect linked with Engineering was stronger for Asian American and middle or high-income students; and hours spent studying had a stronger positive effect for low-income students.

Limitations

Like all research, the study is limited in several respects. We used a secondary dataset and thus variables of the study were restricted to the pool of measures available in our data. For instance, there are some psychological variables that might influence STEM students' retention such as students' scientific identity and self-efficacy (Byars-Winston et al. 2010; Carlone and Johnson 2007; Hurtado et al. 2009; Wang 2013) and other experiences of tokenization and stereotyping (Carlone and Johnson 2007; Chang et al. 2011); however, these variables were not available in the NLSF data. Additionally, research suggests that faculty characteristics (i.e., faculty perceptions of undergraduate research, see Webber et al. 2013) contribute to student participation in valuable activities; however, these variables were unavailable in the dataset and thus unable to be included in the analysis. We used students' fourth year college GPA to measure their academic performance since the variable of college GPA in STEM or major coursework was not available in the data. Also, some independent variables (i.e., student–faculty interaction and discrimination from faculty) and other control variables (e.g., hours spent studying) of the study are self-reported measures. Therefore, any biases derived from the use of self-reported data should be considered when interpreting findings of this study.

Another limitation is that the sample of the NLSF data primarily contains students attending selective institutions of higher education; hence, findings of this study may not be applicable to students in other types of institutions. We did not control for certain institutional characteristics such as the U.S. News & World Report doctoral ranking because previous analyses did not identify a significant effect with this variable (author omitted), possibly due to the lack of variance between NLSF institutions regarding selectivity and research activity. Also, given that Native American and multi-racial students were not available in the NLSF data, we were only able to examine patterns across only four major racial/ethnic groups (Asian American, Black, Latinx, and White). Correspondingly, we were unable to include the institutional percentage of Native Americans as part of the institutional-level underrepresented minority variable due to its omission from the dataset.

In a methodological sense, while we specified and tested a full conditional model for the aggregate STEM sample, we used reduced models for the estimation of conditional

Table 5 Estimation of conditional models for first-to-fourth year retention in STEM major by student subgroups [Log-odds, delta-p (%)]

Variable	Gender		Race/Ethnicity				Income		
	Male	Female	Asian [A]	Black [B]	Latinx [C]	White [D]	Low [E]	Middle [F]	High [G]
Student-level									
Gender: female			**−.84* (−20.51) [B,C]**	**.34 [A]**	**.09 [A]**	−.32	−.46	−.58	.04
Asian	**.86** (15.58)**	**−.06**					**−.13 [F]**	**.89* (16.06) [E,G]**	**.28 [F]**
SAT Quantitative score	.01*** (.23)	.01* (.25)	.01* (.20)	.01* (.25)	.01*** (.25)	.00	.01* (.24)	.01** (.24)	.01** (.24)
Initial major									
Computer science	**−.01**	**−1.29** (−26.97)**	**−.12 [B]**	**−1.43** (−29.36) [A,C,D]**	**−.46 [B]**	**−.60 [B]**	−.66	−.47	−.43
Engineering	1.16** (17.90)	.81* (12.90)	**1.38** (20.88) [C]**	1.33* (20.22)	**.63 [A]**	1.04* (16.22)	**.23 [F,G]**	**1.05** (16.36) [E]**	**1.23** (18.86) [E]**
Hours spent studying	.01	.02* (.49)	.01	.01	.03* (.74)	.03* (.73)	**.08*** (1.95) [F,G]**	**.01 [E]**	**.01 [E]**
Fourth year college GPA	−.53* (−12.87)	−.52* (−17.71)	**.34 [B,D]**	**−.82** (−19.57) [A,C,D]**	**−.11 [B,D]**	**−1.48** (−34.08) [A,B,C]**	−1.03* (24.88)	−.51	−.57
Discrimination from faculty									
Professors made me feel uncomfortable because of my race/ethnicity	**.08**	**−.42* (−10.45)**	**−.09 [B,C]**	**−.46** (−11.43) [A,C]**	**−.81** (−19.83) [A,B,D]**	**.53 [C]**	−.28	−.32	−.43

Table 5 continued

Variable	Gender		Race/Ethnicity				Income		
	Male	Female	Asian [A]	Black [B]	Latinx [C]	White [D]	Low [E]	Middle [F]	High [G]
Institution-level									
Percent URM	−.00	−.07	.07	.00	−.07	−.11	−.02	−.08	−.01

Delta-p statistics were calculated only for the statistically significant log-odds

Percent URM (underrepresented minorities) denotes institutional percentage of Black and Latinx students

Results of *t*-tests are presented by the bolded parameter estimates and/or the letter corresponding to the group whose effect is significantly different at the .05 level from the group compared

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

models by gender, race/ethnicity, and income subgroups. Use of the reduced models not only addressed the sample size issues of STEM subgroups but also improved the model specification of this study by securing a favorable model complexity (Raudenbush and Bryk 2002). Ideally, future research on this topic would include large enough STEM subsamples and test full conditional models on gender, race/ethnicity, and income subgroups. Lastly, we employed HGLM over survival analysis for data analysis of the study since we designed this study to examine the net effect of student–faculty interaction (including discrimination from faculty) on STEM retention, addressing the hierarchical nature of the NLSF data where students are nested within institutions. Although the use of HGLM may produce more reliable parameter estimates for the study, it should be noted that the statistical method captures only first-to-fourth year STEM retention while student attrition could occur at any given time point in the 4 years of college.

Discussion

In line with hypotheses, Black students in STEM were most likely to report experiencing racial/ethnic discrimination from faculty, and such experiences were linked with lower retention. Generally, analyses confirmed hypotheses with one key exception: Despite the wide body of research that documents the benefits of student–faculty interaction (see Kim and Sax 2017; Mayhew et al. 2016), none of the traditional forms of such interaction were linked with retention in STEM once discrimination from faculty as well as other college experiences were taken into account. However, being made uncomfortable by faculty due to race/ethnicity, a form of discrimination, was negatively linked with retention in the same situation, indicating that discrimination from faculty plays a unique and specific role in shaping retention.

Given previous research on both student–faculty interaction and retention (Barnett 2011; Crisp 2010; Kim and Sax 2017), it is puzzling that none of the traditional student–faculty interaction variables unrelated to discrimination were significant. However, few studies examine student–faculty interaction as a predictor of outcomes specifically in STEM settings, with some exceptions (see Chang et al. 2011; Chang et al. 2014), and no studies to date on student–faculty interaction included measures specifically capturing discrimination from faculty. Analyses using other methods (e.g., structural equation modeling) may be better suited to uncover if student–faculty interaction instead has more of an indirect relationship with retention, as a possible mediator of discrimination, for instance.

Previous research on student–faculty interaction documents that Black students have high rates of interaction but also have negative experiences (Kim and Sax 2009; Lundberg and Schreiner 2004). This study adds to the literature by showing that this pattern also holds within STEM fields and furthermore, has a significant link with retention that is especially pronounced for Black and Latinx students. Altogether, existing research suggests that Black students are likely not reaping the full benefits of engagement with faculty due to complex dynamics. For instance, recent research suggests that discrimination mediates (weaken in this case) the otherwise positive relationship between student–faculty interaction and GPA for Black students (author omitted). It could also be that experiences of discrimination occur in some of the spaces where Black students are more likely to interact with faculty, for instance, in asking questions about material they do not understand.

Another key finding of the study is that while the negative effect of being made uncomfortable by a professor due to race/ethnicity on retention was significant for both Black and Latinx students, this form of discrimination had the strongest negative effect for Latinx students (see Table 5) even though Black students were the most likely to experience this form of discrimination (refer to Table 3). While further research is needed, a possible explanation is that the discrimination from faculty shared its predictive power with other variables for Black students to a greater extent as compared to their Latinx peers. Particularly, fourth year college GPA was not a significant predictor for Latinx students' retention, but it was for Black students, resulting in a decreased predictive power of the discrimination for this population. Alternately, it although Black students experience higher levels of discrimination from faculty, it is possible that they have developed a certain amount of resilience that might partially buffer its negative effects. Regardless, this finding points to the need for closer attention to Latinx student experiences specifically, and affirms how discrimination experienced by URM students has an adverse effect on retention.

Additional evidence of inequality is manifest throughout the findings. Almost half of female students and Black students left STEM by the fourth year of college, while Asian Americans (as an aggregate group) and male students had the highest rates of retention. In terms of specific STEM environments, the negative effect of majoring in Computer Science on STEM retention was more pronounced for female and Black students. These findings demonstrate how STEM students' gender and racial gaps in retention interact with the disciplinary variation within STEM fields. In a practical sense, the findings suggest that the negative climate for inclusion within Silicon Valley's technology sphere (Shih 2006) seems to derive from the negative disciplinary climate for certain gender and racial subgroups at the collegiate level. Our findings lend support to initiatives such as the BRAID (Building, Recruiting, And Inclusion for Diversity) Initiative in Computer Science and others seeking to identify proactive ways of better retaining women and racial/ethnic minorities in this particular field.

Implications and Conclusion

Overall, we identified troubling findings related to the scope and impact of discrimination from faculty. In this study, having a professor who made you feel uncomfortable due to race/ethnicity was negatively linked with retention, highlighting the unique negative effect of faculty discrimination. Also troublingly, the negative effect was particularly pronounced for female, Black, and Latinx students. Our focus on faculty as a source of discrimination advances previous research that examined general stereotype threat (Beasley and Fischer 2012) or that combined discrimination from faculty with other negative experiences (Chang et al. 2011), shedding light into the distinct effect associated with discrimination from faculty.

The finding that none of the traditional student–faculty interaction variables significantly predicted retention in STEM complicates research on the widespread benefits of such interaction. While such interaction is a critical social tie, influencing access to key resources, it appears that the dynamics between student–faculty interaction, other college experiences, and STEM outcomes substantially change once experience of discrimination is added to the equation. Findings raise the possibility that that discrimination *mediates* the relationship between student–faculty interaction and STEM outcomes (retention in this case), making the relationship indirect rather than direct. Future research could help identify this relationship by examining how barriers like discrimination may be hindering or ameliorating the potential positive effect of student–faculty interaction in STEM settings. It could also be that issues such as a lack of value congruence between faculty and students stifles the presumably positive impact of social ties between students and faculty (Diekman et al. 2015; Garibay 2018).

Given the negative effect of discrimination and climate, departments and faculty need to engage in frank conversations about where and how female and URM students within STEM at their particular campuses are being pushed out, and design department and campus-specific interventions to facilitate the formation of positive social ties and social capital between marginalized student populations and faculty. Additionally, recruiting female faculty and faculty of color is critical to foster a more positive environment for diversity (Griffin et al. 2010). Educators should consider intentional outreach and support (e.g., sponsorship, funding, and collaboration) to organizations supporting female and URM students in STEM in crafting interventions and initiatives. Faculty-led initiatives that encourage students to both craft and initiate real-world applications to their work could help support values congruence between the values that often lead underrepresented minorities into STEM and their actual collegiate experience (Diekman et al. 2015).

Given the negative impact of discrimination from faculty documented in our study, faculty must engage in critical self-awareness about how discrimination may be perpetuated within STEM environments whether knowingly or not. Soliciting student feedback via climate audits and other mechanisms (e.g., partnering with student organizations) can help inform efforts to warm a chilly climate. Yeager and Walton (2011) also highlight the effectiveness of using social-psychology based interventions to buffer the effects of stereotype threat and build a sense of belonging. Finally, continued support for race-conscious admissions is essential to increasing compositional diversity in STEM, given that such policies have been used to increase the number of URM students at institutions where individual departments, including those in STEM, lack a critical mass of students of color (Brief of 823 American Social Science Researchers 2016).

Our study also opens up new questions for future research. Future qualitative research could focus on documenting more closely the nature of student–faculty interaction, both positive and negative, to see whether patterns identified in this study parallel actual student experiences. For quantitative research, the use of other methods such as structural equation modeling would shed light into whether experiences with discrimination play an indirect mediating role between forms of student–faculty interaction and various STEM outcomes including retention, GPA, or satisfaction. Additionally, data disaggregation through multiple means—e.g., within the Asian American population as well as examining trends that exist along both race and gender, race and class, and the like—could also contribute to a more nuanced understanding of inequality within STEM. Altogether major inequities persist in STEM, and the United States is potentially missing out on future contributors to STEM given the negative climate and experiences that permeate many students' experiences. Demographic factors—race/ethnicity and sex/gender—cannot and should not continue to be major factors influencing who is most likely to persist in STEM versus not. Our research highlights the urgency of curbing the pervasiveness of discrimination so that all students can have a better chance at experiencing a high quality education.

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Appendix

See Table 6.

Table 6 Variable definitions, coding schemes, and descriptive statistics

Variable	Coding scheme	M	SD	Min	Max
Student-level variables					
Dependent variable					
First-to-fourth year STEM retention	Dichotomous: 0 = no, 1 = yes	.67	.47	0	1
Independent variables					
Student–faculty interaction					
Asked professors questions in class	Three-point scale: 1 = low level to 3 = high level	2.01	.66	1	3
Raised hand during a lecture when I don't understand something	Three-point scale: 1 = low level to 3 = high level	2.04	.70	1	3
Approached professors after class to ask a question	Three-point scale: 1 = low level to 3 = high level	1.99	.75	1	3
Met with professors in offices to ask about material I don't understand	Three-point scale: 1 = low level to 3 = high level	1.88	.69	1	3
Met with professors in offices to talk about other matters	Three-point scale: 1 = low level to 3 = high level	1.77	.82	1	3
Discrimination from faculty					
Professors made me feel uncomfortable because of my race/ethnicity	Dichotomous: 0 = no, 1 = yes	.15	.35	0	1
I heard derogatory remarks made by professors because of my race/ethnicity	Dichotomous: 0 = no, 1 = yes	.09	.28	0	1
I felt I were given a bad grade by a professor because of my race/ethnicity	Dichotomous: 0 = no, 1 = yes	.06	.24	0	1
I felt I were discouraged by a professor from speaking out in class because of my race/ethnicity	Dichotomous: 0 = no, 1 = yes	.05	.22	0	1
Control variables					
Student input characteristics					
Gender: female	Dichotomous: 0 = no, 1 = yes	.38	.48	0	1
Race (Reference: White)					
Asian	Dichotomous: 0 = no, 1 = yes	.11	.31	0	1
Black	Dichotomous: 0 = no, 1 = yes	.15	.36	0	1
Latinx	Dichotomous: 0 = no, 1 = yes	.13	.39	0	1

Table 6 (continued)

Variable	Coding scheme	M	SD	Min	Max
Income (Reference: High)					
Low	Dichotomous: 0 = no, 1 = yes	.14	.35	0	1
Middle	Dichotomous: 0 = no, 1 = yes	.30	.46	0	1
SAT quantitative score	Continuous	681.79	82.29	0	800
Initial major					
Biological science (reference)					
Computer science	Dichotomous: 0 = no, 1 = yes	.26	.43	0	1
Engineering	Dichotomous: 0 = no, 1 = yes	.32	.47	0	1
Mathematics/statistics	Dichotomous: 0 = no, 1 = yes	.05	.21	0	1
Physical science	Dichotomous: 0 = no, 1 = yes	.15	.36	0	1
College experience					
Hours spent studying	Continuous: total number of hours that a student spent in studying on a week (both weekdays and weekend)	25.29	14.93	0	120
Studying with other students	Three-point scale: 1 = low level to 3 = high level	2.06	.71	1	3
Institution-level variables					
Percentage of URM	Continuous: institutional percentage of underrepresented minority students	26.25	12.63	8	54

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