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Toward institutional transformation: warming the chilly climate for women in STEM through macrostructural change

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Introduction: Although the demand for graduates with Science, Technology, Engineering, and Mathematics (STEM) credentials continues to climb, women remain underrepresented as both students and faculty in STEM higher education. Compounding social forces can hinder organizational change for gender equity in STEM, constraining institutions and individuals within them. This study advances macrostructural theory to examine the impact of gender composition (including group size and heterogeneity) of women faculty on structural change, as measured by gender desegregation of STEM degree earners. We advance this theory by incorporating faculty *rank*, rather than treating group composition as a static category.

Method: This study draws on a federal repository of data to assess institutional change in the share of STEM women faculty in the U.S. We employ quasi-experimental methods to explore the following research questions: (1) does hiring more women onto an institution's faculty roster shrink the gender gap among STEM degree earners? and (2) does segregation of faculty by gender within institutions shape the gender gap among STEM degree earners?

Findings: While institutional efforts herald their efforts of hiring more women faculty, our findings indicate that gender desegregation of STEM degree earners partially depends on the promotion of women faculty to tenure.

Discussion: Implications for theory, policy, and practice are discussed, with a focus on institutional-level change.

KEYWORDS

gender equity, academic workforce, higher education, macrostructural theory, STEM higher education, augmented inverse probability weighted

Introduction

Although the demand for graduates with Science, Technology, Engineering, and Mathematics (STEM) credentials continues to climb, women remain underrepresented in STEM higher education and among the faculty of STEM departments. This persistent gender gap in STEM writ large may seem surprising, as women have surpassed men's overall higher education degree achievement (DiPrete and Buchmann, 2013) and some STEM fields have made progress toward gender equity, especially at the undergraduate level (Perez-Felkner, 2018; National Science Board, National Science Foundation, 2021). Further, the scientific labor market has fueled United States economic growth (Maton et al., 2016), heightening the demand for graduates with STEM qualifications (Fayer et al., 2017). The STEM sector's continued expansion and purported reliance on fair, objective criteria for employment should facilitate gender integration into its myriad prestigious career tracks (Xie et al., 2015; Padavic and Prokos, 2016).

Why then do women hold a minority share of jobs in most STEM sectors in the United States economy, including less than 25% in computing and engineering roles (Beede et al., 2011; Fry et al., 2019)? Perhaps women's marginalization in STEM is an expected reflection of hegemonic male dominance in the sciences (Carter et al., 2019; Pawley, 2019) and academia (Bird, 2010; Haas, 2016). Organizational change for gender equity in academic STEM professions must counter compounding social forces affecting institutions and the individuals within them (Britton, 2017; Jensen and Deemer, 2019; Nichols, 2019). This study draws on a national repository of institutional data to analyze the impact of faculty gender equity on that of undergraduate STEM degree recipients. We aim to identify the mechanisms which effectively increase women's share of STEM degrees conferred and faculty roles.

In this study, we advance theory on *gendered organizations* (Acker, 1990, 2006; Ridgeway, 1997; Ely and Meyerson, 2000) and *social contact theory* (Blau, 1977; Fitzpatrick and Hwang, 1992). We identify mechanisms that may undo gender segregation in STEM. Research on institutional transformation programs in higher education has illuminated that successful gender transformation in STEM requires systemic approaches that support women at all organizational levels, rather than simply removing women's barriers to entry (Bilimoria et al., 2008; Griffin, 2020). Indeed, institutions across the U.S. are changing demographically (Grawe, 2018), whether institutions have formally implemented gender transformation methods. Stakeholders must understand how changes in women's enrollment, hiring, and promotion impact STEM outcomes, intentionally or otherwise. Equipped with this knowledge, colleges and universities can adapt mechanisms to improve STEM gender equity that best fit their institutional context.

We ask: does simply hiring more women onto an institution's faculty roster–regardless of tenure status–contribute to closing the gender gap in STEM degree attainment? Or should institutions seeking to reduce gender segregation in STEM specifically increase women's representation among *tenured* faculty roles? We also examine whether the degree of faculty gender segregation impacts gender exposure among STEM degree earners. Using the most recent federal data available on women's STEM degree outcomes at U.S. institutions, we investigate how changes in (1) the proportion of women faculty at each rank and (2) the degree of gender segregation among faculty at each rank between two timepoints impact the degree of gender exposure among STEM undergraduates. While institutional efforts herald their efforts of hiring more women faculty, we find that women's postsecondary STEM outcomes partially depend on the promotion of women faculty to tenure and the reduction of faculty gender segregation.

Literature review

Institutional responses to gender disparities

In recent years, higher education institutions have moved to address gender inequalities in STEM education alongside other diversity and inclusion issues on campuses (Ahmed, 2012). Recognizing gender and racial-ethnic disparities in STEM postsecondary education, federal policymakers and programs have established calls for action, and institutions have followed suit (Rincón and George-Jackson, 2016). The goal in taking these actions, including hiring more women and minorities within STEM, is to increase the presence of gender- and/or race-matched mentors, and warm potentially chilly climates within these fields. Prior studies on changing STEM climates have primarily used qualitative data, centered in single institutional contexts and point-in-time analyses (e.g., Gasman et al., 2017). While site-specific evaluations of institutional diversity and inclusion efforts offer useful insights, these studies are unable to evaluate how institutions and diversity-related outcomes are changing across the entire higher education landscape. Moreover, challenges in accessing rich higher education STEM outcomes data have limited researchers' ability to assess change over time (see Perez-Felkner, 2018).

One common institutional response to promote gender equity is to recruit more women faculty. While institutions have increasingly deployed diversity and inclusion efforts that publicly prioritize *hiring* of women and minorities, the processes of faculty *promotion and retention* are murkier (Seebruck and Savage, 2020). Although women currently earn most doctoral degrees conferred annually, they hold fewer tenured faculty positions and earn lower salaries than male academic peers (Johnson, 2017). Unequal representation of women in faculty roles may dissuade undergraduate women from lab- and research-intensive majors, notably in STEM. A dearth of representative faculty limits the opportunity for interactions that challenge stereotypes about women in STEM, contributing to the reproduction of a chilly climate (Cheryan et al., 2013; Britton, 2017). It also limits opportunities for women to have gender-matched academic role models and mentors, who may increase women's attraction to and retention in STEM (Kricorian et al., 2020; Swafford and Anderson, 2020). In contrast, receiving STEM instruction from a woman tends to improve students' beliefs about women's ability in these fields (Sansone, 2018). Accordingly, exposure to women faculty is vital for attracting and retaining women in STEM.

Previous research suggests women's faculty rank influences women's STEM degree production, as women's disproportionate presence in lower-ranked and non-tenure-earning roles may reinforce gendered stereotypes for STEM-aspiring women (Griffith, 2010; Griffith, 2014; Šaras et al., 2018). However, prior research has not examined whether gender composition of faculty by rank influences the degree of gender segregation present in STEM majors. We address this gap using quasi-experimental methodology to assess the likelihood of interaction within major disciplines, across gender (*gender exposure*). We measure the extent to which faculty gender composition by rank impacts the degree of gender exposure within STEM majors, furthering our collective understanding of its influence on women's STEM degree production.

Theoretical framework: Blau's macrostructural theory

Undergraduate women are positioned as inferior in many academic STEM environments, underrepresented in the cited literature, patents, and awards. At the interpersonal level, earlier research suggests faculty demonstrate bias in favor of men STEM students (Moss-Racusin et al., 2012); men–especially White men–tend to gain advantages from the cultural framing of science as masculine (Miller and Roksa, 2019). Prior research has identified microaggressions and discrimination toward women in STEM (Lester et al., 2017; Ong et al., 2018; Johnson et al., 2019) as well as gendered communication challenges among some faculty, staff, and students (Vitores and Gil-Juárez, 2016).

Structurally, scholars have found that women's underrepresentation in STEM faculty roles reduces the availability of gender-matched role models and mentors for undergraduate women (Sonnert et al., 2007), which is in turn associated with less connection and sense of belonging (Gaston Gayles and Ampaw, 2014). The absence or seemingly token presence of women STEM faculty can reinforce negative gender stereotypes at the departmental and institutional levels (Stoeger et al., 2013; Williams et al., 2021).

These interpersonal and structural contextual factors contribute to a negative or "chilly climate" in STEM fields, where women are less likely to become socially integrated and retained (Hall and Sandler, 1984; Šaras et al., 2018; Lee and McCabe, 2021). The degree of gender segregation between STEM and non-STEM fields is a major contributor to the chilly climate in STEM and associated the loss or "leaks" of talented scientists (see, e.g., Hinton et al., 2020). There are often limited opportunities in STEM for women to form meaningful social associations with more senior scientists, which in many STEM fields continue to be mostly men (Hall and Sandler, 1984; Simon et al., 2017). Research has documented its link to negative outcomes for STEM-aspiring women (Allan and Madden, 2006). These outcomes include reduced self-selection of women into STEM majors, increased attrition of women STEM majors, and fewer women STEM graduates entering the labor market (Glass et al., 2013). Altogether, the proportional share of women undergraduates and faculty may be strong institutional indicators of how welcoming academic environments are for women in STEM.

Macrostructural theory demonstrates that intergroup relations are dependent on the makeup of the social structure (Blau, 1977). To mitigate the chilly climate for women in STEM, the social structure must afford opportunities for positive interactions between women and men in STEM among and between students and faculty. Social structures affect intergroup associations. This hypothesis has been confirmed in studies spanning different fields, including interracial contact (Fitzpatrick and Hwang, 1992; Chakravarti et al., 2014), and intergender work relations (Randel, 2002; Kath et al., 2009; Merluzzi, 2017). We further demonstrate the utility of this theory by examining factors which foster gender segregation and chilly climates for women in STEM education. We expand Blau's theory by incorporating hierarchical rank as a factor shaping intergroup relations in this context.

Structural conditions in institutions–including faculty gender composition and faculty gender segregation across departments–may impact chilly climates by constraining or creating opportunities for both mixed-gender and gender-matched social relationships. We hypothesize that the *group size* (share of women employed at each faculty rank) impacts the likelihood of intergroup exposure between women and men in undergraduate STEM education. Interactions with tenured faculty may be key in challenging negative stereotypes about women in STEM by exposing students to women in rigorous research-centered roles. For women STEM students, interactions with tenured women faculty promote a sense of belonging, providing vital access to gender-matched mentors in academia (Sonnert et al., 2007; Gaston Gayles and Ampaw, 2014). In this study, we quantify group size as the proportion of each institution's faculty roles, at each rank, that are held by women.

Faculty are unevenly distributed across academic degree programs by gender. We hypothesize that *heterogeneity*—another structural condition referring to the degree of gender integration among faculty at each rank—influences gender segregation in STEM majors. Increasing heterogeneity in the form of decreasing segregation between women and men faculty at each rank may promote opportunities for positive interactions between women and men in STEM. We examine this structural condition as the change in gender composition in higher educational institutions' faculty population, and the impact it may have on gender desegregation in STEM.

Gendered faculty hierarchies: the focus on women faculty

Much like the gendered undergraduate STEM student experience, faculty roles on academic campuses are shaped by interactions that lead to gendered disparities in work tasks, salary, prestige, and promotion (Kelly and McCann, 2019). This is especially true for women faculty who are also Black, Indigenous, and People of Color (Kelly and McCann, 2014; Haynes et al., 2020). Bias and exclusions emerge for women in STEM during the processes of hiring and employment as faculty members (Bird, 2010). Accordingly, women are more likely to opt out of academic careers than men prior to entry into a faculty position (Armstrong and Jovanovic, 2015). Some scholars contend that women's underrepresentation among permanent, full-time STEM faculty positions results from reduced competence or interest in STEM compared to male peers (Summers, 2005). However, these perspectives fail to account for the social forces that impact the hiring and promotion of women faculty.

Underrepresentation of women faculty: group size

At the institutional level, STEM women faculty face myriad barriers to employment and promotion in a tenure-earning role. This results in smaller group size for women, and a greater degree of segregation between women and men faculty throughout departments on campus. In the U.S., federal and state laws prohibit gender discrimination in hiring and employment in higher education, yet hiring inequalities persist in this context (Simon et al., 2017). While many institutions have procedures to veto selected candidates for faculty hire, decisions about hiring faculty are typically made by faculty committees at the departmental level using subjective criteria (White-Lewis, 2020), limiting the institution's procedural ability to fully control hiring selections and ensure equity.

Additionally, women faculty experience disproportionate institutional challenges in the promotion and tenure process as compared to their male peers. Most institutions assign limited value to service work contributions in the tenure process (Bird, 2010). Traditional metrics for measuring productivity, such as publication counts, do not account for the gendered allocation of service tasks and their detraction from research productivity (Xie and Shauman, 2003). Some institutions offer policies allowing pre-tenure women who have children to *pause the tenure clock*, which extends the tenure-track timeframe without impairing candidacy (Mason et al., 2013). Women who take advantage of such institutional policies risk bias during their tenure evaluation and may experience more stigma than their male counterparts who use such policies. Moreover, *pausing the tenure clock* can postpone potential salary increases, reduce cumulative lifetime earnings, and delay the attainment of job security when tenure is achieved (Misra et al., 2012; Williams et al., 2013).

Even when accounting for differences in institutional context and candidate productivity, women achieve tenure at significantly lower rates than men (Weisshaar, 2017). This trend disproportionately affects women of color who experience compounding challenges—a double bind—at the intersection of race and gender in academia as well as specifically in STEM (Ong et al., 2011; Griffin, 2020). However, research has not yet accounted for how women's lower rates of faculty promotion and hiring correspond with gender segregation of STEM undergraduates.

Gender segregation of faculty by program: heterogeneity

Faculty and their roles are distinguished by their rank–i.e., untenured but tenure-eligible assistant professors as compared to tenured faculty at the associate and full professor levels. While rank exists for faculty off the tenure-track as well, promotion among tenure-eligible faculty often results in the attainment of tenure, and the intended "permanent" job stability and prestige associated with it (e.g., Youn and Price, 2009). Among those women who receive tenure, women in STEM remain a minority. In 2018, women comprised fewer than 30% of tenured or tenure-track faculty rolls among U.S. higher education institutions (Roy, 2019). The scarcity of women faculty in STEM reduces the potential for meaningful interactions between women faculty and students. Research on the positive effects of diversity indicates that compositional diversity is insufficient: *interaction* among individuals from diverse backgrounds drives the benefits of diversity in postsecondary educational institutions (Gurin et al., 2002). We argue that positive interactions between students and women faculty are necessary to challenge stereotypes about women in STEM and to warm the chilly climate.

Women make up a lower proportion of tenured faculty than men, however they tend to be overrepresented in non-tenure-earning roles (Kezar and Sam, 2013). This two-fold segregation may reduce opportunities for meaningful interaction among faculty, and among faculty and students. Faculty on the tenure-track have multiple publishing and service duties in addition to teaching and mentoring. Contingent faculty–as compared to "permanent faculty" with an opportunity to attain tenure–may not have the same amount of time and resources to dedicate to mentor students and engage in professional development; moreover, they tend to earn less (Childress, 2019).

The share of contingent faculty has been growing in recent decades, in part but not exclusively for budgetary reasons (McNaughtan et al., 2017). Non-tenure earning faculty appointments present status challenges for faculty within these roles, especially those with already marginalized identities (O'Meara et al., 2018; Rideau, 2019). Limited exposure to tenured and tenure-earning faculty appears to have negative consequences for student retention as well (Jaeger and Eagan, 2011). When women comprise a small minority in a STEM department, and even fewer women hold permanent, tenured faculty roles, there are limited opportunities for meaningful gender-matched association among women faculty and women students in STEM, like mentorship and advising.

The effects of such segregation have been demonstrated across contexts. Broadly, segregation diminishes intergroup contact and contributes to the production of intergroup bias and conflict (Enos and Celaya, 2018). For example, residential segregation has been shown to negatively predict interracial friendship in schools (Mouw and Entwisle, 2006). Although explorations of segregation and heterogeneity have typically focused on residential segregation by race, the flexibility of Blau's (1977) macrostructural theory allows us to expand this exploration into the university system.

Current study

Below, we present the first analysis of macrostructural theory in higher education and focus on the decade following the launch of a federally funded initiative to incentivize and support institutional-level transformation for gender equity among STEM faculty (Bilimoria et al., 2008). We seek to answer the following primary research questions. First, does an increase of at least 5% in women's proportional representation at different faculty ranks over time correspond with *increased gender exposure*–in other words, *decreased gender segregation*–of degree earners in STEM? Second, does a decrease in faculty gender segregation by rank lead to a decrease in gender segregation of STEM degree earners?

Methodology

Data source and sample

The present study uses publicly available higher education data from the National Center for Education Statistics Integrated Postsecondary Data System (IPEDS) to construct a model of change in gender exposure among STEM degree earners as impacted by changes in women's faculty composition, changes in women's enrollment, and various student and institutional factors. The dataset primarily features data from the 2000–01 and 2008–09 IPEDS reporting cycles. In each of these cycles, the IPEDS survey schedule posed an identical battery of questions about STEM degree completion by gender group. We limited our sample to include all U.S. institutions with a tenure system that offered bachelor's degrees in both 2000–01 and 2008–09. Although more recent years of data have been collected, these collection waves do not include the special, non-recurring battery of STEM-related questions needed to analyze our research questions.

Using this reported institutional data on STEM degree production, enrollment, faculty, and financial aid status reported in the 2000–01 and 2008–09 IPEDS reporting cycles, we generated variables for the degree of exposure between women and men STEM bachelor's degree earners, the change in women faculty group size by rank, the change in faculty gender heterogeneity within institutions, and the change in percentage points of students receiving federal financial aid between these two time points.

Quasi-experimental design: augmented inverse probability weighting

We selected augmented inverse probability weighting (AIPW) to conduct a quasi- experimental analysis. AIPW methodology uses doubly robust weighting techniques to control for the non-random assignment of increases in women faculty and heterogeneity by rank and by institution. The AIPW estimator is appropriate for modeling these relationships because it only requires specification of a logistic regression model for the propensity score, and specification of the regression model for the outcome variable (Glynn and Quinn, 2010). AIPW assumes that the treatment is not randomly assigned, which is appropriate for the present analysis as gender segregation of faculty is not random.

The goal is to estimate the potential outcome (gender integration) that would be observed if students were assigned the segregation treatment, then to compare the mean outcome if all students in the population were assigned either segregation or integration treatment at each faculty rank.[1] Coefficients produced from AIPW are probabilities ranging between 0 and 1 and can be interpreted as such.

To ensure the model appropriateness, we explored the assumptions of AIPW modeling, including stable unit treatment value assumption (SUTVA), consistency, exchangeability, and positivity. The primary tenet of SUTVA is to ensure that the treatment assigned to one unit has no effect on the potential outcomes of others. In our university-level analysis, each university is a distinct unit, and the treatment is applied solely within the confines of each specific university, thus having no effect on the others. The consistency assumption is met, as we explore how potential changes in structural composition of the university impact the structure of interactions within it. Thus, if gender desegregation among faculty occurs, it is plausible that gender desegregation among students would also occur. We explored the likeness of treated universities and untreated universities to consider the exchangeability assumption of AIPW. To this end, we control for university Carnegie classification, and the level of STEM exposure that existed during Time 1 of the analysis. The positivity assumption is also met, in that there is greater than zero chance that any university increases its women-faculty population by at least 5%.

To construct our model, the following variables were used to match institutions for the quasi-experimental comparison: increases in women's bachelor's degree attainment generally, increases in general enrollment and women's enrollment over time, changes in the proportion of students receiving federal aid over time, whether the institution is an Historically Black College or University (HBCU), whether a university is a Land Grant institution, whether the institution is publicly controlled, the size of the institution, whether an institution is located in a city, and highest degree awarded by the university as indicated by its Carnegie Classification. Our use of AIPW modeling techniques allows us to infer quasi-causality, that an increase of at least 5% in women faculty by rank and in heterogeneity is not only correlated with but *impacts* the degree of gender segregation between women and men STEM degree earners.

Treatment variables

Changes in women faculty group size by rank were dichotomized to a 5% or more increase in the proportion of women faculty vs. a less than 5% increase or decrease in the proportion of women faculty. We chose the benchmark of 5% because this modest increase suggests an institutional commitment to increasing the number of women faculty, while being attainable during the study window across institution types studied. We also test alternative specifications in a sensitivity analysis described later in the manuscript. It is important to calculate these variables by faculty rank, as we have posited throughout this manuscript that simply increasing the presence of women faculty is unlikely to affect student outcomes. Rather, we posit that increasing the number of *tenured* women faculty is most likely to have an effect.

Table 1 reports on our treatment, dependent, and control variables. About half of universities increased the proportion of tenured women faculty by 5% or more, while approximately 46% increased the proportion of tenure-track women faculty by the same amount. About 47% increased the proportion of non-tenure-track women faculty by 5% or more.

To construct each variable representing changes in women faculty group size by rank at each included U.S. institution, we first calculated the difference in the proportion of women faculty at each rank, between two time points. These measures were recoded such that 1 represents an increase of at least 5% in the proportion of women faculty, and 0 indicates a less than 5% increase or a decrease in the proportion of women faculty. The final dichotomous variables created by this procedure include (1) change in group size of all women faculty, (2) change in group size of tenured women faculty, and (3) change in group size of untenured or non-tenure-track women faculty. In sensitivity analyses, we treated the increased proportion of tenured women faculty at a series of levels (from 1% through 10%) to assess multiple potential interventions and contextualize the quasi-experimental analysis we focus on here.

The gender-specific faculty rank question was not a required response during the 2001–02 and 2008–09 reporting cycles. Thus, we substituted faculty data collected during the 1999–00 and 2007–08 reporting cycles. This is appropriate because we would expect some degree of lag between the hiring or promoting of women faculty and observed impacts on degree completers. To mitigate potential bias from missingness in enrollment for our first time point, we substituted 2001–02 data for the 2000–01 data on women's enrollment.

Dependent variable: gender exposure among STEM degree earners

Our dependent variable in this study is the degree of exposure between women and men STEM degree earners, derived from Massey and Denton's (1988) measures of segregation. The exposure index measures a group's exposure to other groups in the form of a weighted average depicting the gender distribution across STEM majors. It measures how likely women and men are to interact with one another within STEM majors. The index ranges from 0 to 1, where 1 indicates 100% likelihood of exposure between groups. Exposure is calculated using this formula:

$$\sum_{i=1}^{n}\left[\left(\frac{x_i}{X}\right)\left(\frac{y_i}{t_i}\right)\right],$$

where x refers to the minority population, X refers to the sum of the total minority population, y refers to the majority population, and t

1 Dichotomizing these variables is necessary to create the treatment conditions for our quasi-experimental design.

TABLE 1 Descriptive statistics.

	Mean/ Proportion	SD	Min	Max
Dependent variable: bachelor's degree outcomes				
STEM Degree Exposure 2008–09	0.39	0.13	0	0.93
STEM Degree Exposure 2000–01	0.39	0.14	0	0.97
Treatment variables: faculty indicators				
Proportion of institutions that increased tenured women faculty presence by 5% or more	50.00%		0	1
Proportion of institutions that increased tenure-track women faculty presence by 5% or more	46.16%		0	1
Proportion of institutions that increased non- tenure-track women faculty presence by 5% or more	46.80%		0	1
Women's enrollment indicators				
Increase in 12-month unduplicated enrollment of women (2001–02 to 2008–09)	116.04	219.65	−482	2,706
Federal financial aid				
% Point increase in students receiving federal grants	5.79	10.67	−53	69
Carnegie classification				
Doctoral degree granting	20.56%			
Master's degree granting	40.40%			
Bachelor's degree granting	38.72%			
Associate's degree granting	0.32%			
Institutional features				
Public institution	57.84%		0	1
Historically black college or university	42.16%		0	1
Land grant institution	5.68%		0	1
Urbanicity				
City	45.92%			
Suburb	22.24%			
Town	23.28%			
Rural	8.56%			
N	1,250			

National Center for Education Statistics Integrated Postsecondary Data System (IPEDS).

refers to the total population. In other words, the exposure measures the degree to which STEM majors have been desegregated within institutions.

The average degree of exposure in 2008–09 within STEM is 0.39, meaning that on average there is a 39% chance that women and men in STEM had the opportunity to form meaningful social relationships in the 2008–09 academic year. Our model controls for degree exposure at our first study time point in 2000–01. The average degree exposure in 2000–01 was 0.39, meaning that on average there is a 39% chance that women and men in STEM had the opportunity to form meaningful social relationships in the 2000–01 academic year.

Covariate independent variables

Change in faculty gender heterogeneity by rank

We also examine the change in faculty gender heterogeneity–via decrease in homogeneity–among faculty at each rank from 1999–2000 to 2007–08, including tenured, tenure-track, and non-tenure-track faculty. We created an isolation index (Massey and Denton, 1988) to measure changes in homogeneity (the likelihood that faculty members at each rank would interact only with members of the same gender at each time point). A decrease in homogeneity corresponds to an increase in heterogeneity. The isolation index is calculated using this formula:

$$\sum_{i=1}^{n}\left[\left(\frac{x_i}{X}\right)\left(\frac{x_i}{t_i}\right)\right]$$

where x refers to the minority population, X refers to the total sum of the minority population, and t refers to the total population.

Controls

Control variables measuring institutional context include: changes in women's bachelor's degree attainment over time, changes in general enrollment and women's enrollment over time, changes in the proportion of students receiving federal aid over time, whether the institution is an Historically Black College or

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University (HBCU), whether a university is a Land Grant institution, whether the institution is publicly controlled, the size of the institution, whether an institution is located in a city, and highest degree awarded by the university as indicated by its Carnegie Classification. We include these controls because they are the exhaustive list of potential descriptive variables in our IPEDS data and are likely to have a significant effect on STEM degree production.

Hypotheses

Group size

While institutions may champion efforts to hire more women, placing more women in teaching or specialized faculty roles that deemphasize research duties reinforces gendered stereotypes about women's research abilities. As such, we hypothesize that only increases in faculty group size at the tenured level will significantly increase gender exposure among STEM undergraduates. We hypothesize that increases in faculty group size at the non-tenure-track and tenure-track levels will not significantly impact gender exposure among STEM undergraduates. Although tenure-track women faculty serve as role models for STEM-aspiring women, their visibility, availability, and agency are limited by pressures of the tenure process and by the gendered burden of institutional service work. On the other hand, with the tenure process complete, tenured women research faculty are more secure in the stability of their role with the institution and have more time to engage in non-research tasks, such as mentorship and advising of undergraduate women.

> *H1*: Increasing the proportion of non-tenure-track women faculty will not significantly increase gender exposure among STEM undergraduates.
>
> *H2*: Increasing the proportion of tenure-track women faculty will not correspond with gender exposure among STEM undergraduates.
>
> *H3*: Increasing in the proportion of tenured women faculty will increase gender exposure among STEM degree earners.

Heterogeneity

Our second set of hypotheses addresses changes in heterogeneity by gender among faculty at each rank. We hypothesize that increasing gender heterogeneity among faculty–by decreasing gender homogeneity–will only significantly increase gender exposure among STEM undergraduates when the increase is among *tenured* faculty. Because women faculty comprise a small share of the faculty in certain disciplines, decreasing homogeneity may not equate to fully gender-integrated programs. Regardless of the degree of gender integration among faculty, those who are not on the tenure track do not have the same job security and academic freedom as their tenured and tenure-track peers. In turn, such faculty members may concentrate their efforts on the teaching and administrative responsibilities most central to their job description, with little time left for mentorship of STEM undergraduates. Conversely, prior research demonstrates that tenured faculty have greater time and resources available to provide meaningful mentorship to STEM undergraduates. Thus, an increase in heterogeneity (via a reduction in homogeneity) among tenured faculty may significantly change the culture of a program in ways that help "thaw" the chilly climate in STEM.

We measure the limited interactions between men and faculty using an isolation index (Massey and Denton, 1988) at each time point, which assesses the degree to which women and men engage in only same-gender interactions. The index ranges from 0 to 1 and is represented as a proportion. We measure the change in heterogeneity at each faculty rank from 1999 to 2007.

> *H4*: Reducing the homogeneity by gender of non-tenure-track faculty will not significantly increase gender exposure among STEM undergraduates.
>
> *H5*: Reducing the homogeneity of tenure-track faculty will not significantly increase gender exposure among STEM undergraduates.
>
> *H6*: Reducing the homogeneity of tenured faculty will significantly increase gender exposure among STEM degree earners.

Recall Table 1 shows measures for the dependent and independent variables at the two time points of this study. Table 2 shows the test results for Hypotheses 1–3, where Model 1 tests the relationship between a general increase in STEM women faculty group size and STEM degree earner gender segregation, Model 2 tests this relationship among non-tenure-track women faculty, Model 3 among tenure-track women faculty, and Model 4 among tenured women faculty. Table 3 shows test results for Hypotheses 5–8. Model 4 tests the relationship between a general increase in faculty heterogeneity and STEM degree earner gender segregation. Model 6 tests this relationship among non-tenure-track women faculty, Model 7 among tenure-track women faculty, and Model 8 among tenured women faculty.

Results

Results for all hypothesis tests are presented in Tables 2, 3. Blau's (1977) original macrostructural theory does not account for differing statuses within groups, hindering its utility. The present study advances this theory through application to a new context and offers a unique contribution through the addition of the nuance of faculty rank as a status that shapes intergroup relations. The dependent variable—degree of exposure—is a calculated probability that ranges from 0 to 1 and can be interpreted as a proportion.

Hypothesis testing: group size

H1: increasing the proportion of non-tenure-track women faculty

Table 2 Model 2 shows the results of our Hypothesis 1 test. Increasing an institution's proportion of non-tenure track women faculty by 5% or more does *not* increase gender exposure. In other words, a substantial increase in non-tenure-track faculty does not contribute to the gender desegregation of STEM degree earners. Hypothesis 1 is confirmed.

TABLE 2 AIPW regression of STEM degree exposure by increase in women faculty by 5% or more.

	[1]	[2]		[3]		[4]		
	5% Increase all ranks	5% Increase non-tenure track		5% Increase tenure-track		5% Increase tenure only		
STEM degree gender exposure (Time 2)	−0.001 [0.005]	−0.003 [0.003]		0.001 [0.003]		0.007* [0.005]		
	Control	Exp: 5% increase	Control	Exp: 5% increase	Control	Exp: 5% increase	Control	Exp: 5% increase
Women's enrollment indicators								
Increase in bachelor's degrees earned by women	−0.000* [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]
Carnegie classification								
MA degree granting	−0.022*** [0.009]	−0.050*** [0.011]	−0.018*** [0.005]	−0.024*** [0.007]	−0.019*** [0.005]	−0.018*** [0.006]	−0.022*** [0.005]	−0.018** [0.005]
BA degree granting	−0.020** [0.001]	−0.012 [0.014]	−0.018** [0.007]	−0.011 [0.008]	−0.020** [0.007]	−0.005 [0.008]	−0.021 [0.007]	−0.004 [0.008]
STEM degree exposure (Time 1)	0.808*** [0.029]	0.417*** [0.045]	0.839*** [0.030]	0.772*** [0.037]	0.822*** [0.031]	0.745*** [0.042]	0.850*** [0.024]	0.745*** [0.042]
Constant	0.091*** [0.013]	0.208*** [0.028]	0.080*** [0.013]	0.104*** [0.016]	0.084*** [0.013]	0.112*** [0.018]	0.077*** [0.011]	0.112*** [0.018]
N	1,250		1,250		1,250		1,250	

Source. National Center for Education Statistics Integrated Postsecondary Data System (IPEDS). The following variables were included in the model but not reported for space reasons: Increase in Women's Enrollment Percentage, Federal Financial Aid % Share, Public Institution, Historically Black College or University, Land Grant Institution, and Urbanicity. Robust standard errors are reported in brackets under the unstandardized slope coefficients. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

H2: increasing the proportion of tenure-track women faculty

We assess our second hypothesis as shown in Table 2, Model 3. An increase of tenure-track women faculty is not associated with increased gender exposure among STEM degree earners. Thus, Hypothesis 2 is confirmed.

H3: increasing in the proportion of tenured women faculty

Our test for hypothesis 3 is shown in Table 2, Model 4. As expected, an increase of tenured women faculty by 5% or more contributes significantly to the gender desegregation of STEM degree earners, increasing STEM degree earner exposure by 0.7%. In other words, a 5% increase in tenured women faculty increases the likelihood that women and men STEM degree earners will interact by 0.7% ($b = 0.007$, $p < 0.05$). Thus, Hypothesis 3 is confirmed.

Summary: hypotheses 1–3

Results of our first three hypotheses are confirmed. Increasing the share of non-tenured and tenure-track (but not yet tenured) women faculty is not enough to undo gender segregation in STEM degrees (via significantly increasing gender exposure). A modest increase of 5% or more of the proportion of *tenured* women faculty (treatment: increasing tenured women faculty) significantly increases gender exposure in STEM. By contrast, the same size increase in the proportion of tenure-track or non- tenure-track women faculty has a null effect.

Hypothesis testing: heterogeneity

H4: increasing non-tenure-track faculty gender heterogeneity

Model 2 in Table 3 shows that increased gender heterogeneity among non-tenure-track faculty does not significantly contribute to gender exposure among STEM degree earners. Specifically, decreasing faculty gender segregation among non-tenure-track faculty within institutions has a null effect. Hypothesis 4 is supported.

H5: increasing tenure-track faculty gender heterogeneity

Results of this test are shown in Table 3, Model 3. Supporting Hypothesis 5, a 5% or more increase in faculty gender heterogeneity at the tenure-track level does not increase gender exposure among STEM degree earners nor contribute to the gender desegregation of STEM degree earners. Hypothesis 5 is supported.

H6: increased tenured faculty gender heterogeneity

We evaluate Hypothesis 6 in Table 3, Model 4. Confirming Hypothesis 6, we find that a 5% increase in tenured faculty gender heterogeneity significantly increases gender exposure among STEM degree earners, again by 0.8% ($b = 0.008$, $p < 0.05$). Faculty gender desegregation leads to STEM degree earner

TABLE 3 AIPW regression of STEM degree exposure by increase in faculty gender heterogeneity by 5% or more.

	[1]		[2]	[3]			[4]	
	5% Increase all ranks		5% Increase non-tenure track	5% Increase tenure-track			5% Increase tenure only	
STEM degree gender exposure (Time 2)	−0.001 [0.003]		0.005 [0.003]	0.002 [0.003]			0.008* [0.003]	
	Without 5% increase	With 5% increase	Without 5% increase	With 5% increase	Without 5% increase	With 5% increase	Without 5% increase	With 5% increase
Women's enrollment indicators								
Increase in Bachelor's Degrees earned by women	−0.000* [0.000]	−0.000*** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000** [0.000]	−0.000*** [0.000]
Carnegie classification								
MA degree granting	−0.016** [0.006]	−0.011* [0.005]	−0.017** [0.005]	−0.014* [0.007]	−0.015** [0.005]	−0.014* [0.006]	−0.019*** [0.006]	−0.015** [0.005]
BA degree granting	−0.017* [0.007]	−0.006 [0.014]	−0.020** [0.010]	−0.002 [0.017]	−0.017* [0.007]	−0.007 [0.008]	−0.021** [0.007]	−0.004 [0.007]
STEM degree exposure (Time 1)	0.853*** [0.029]	0.853*** [0.032]	0.856*** [0.027]	0.842*** [0.037]	0.865*** [0.028]	0.804*** [0.038]	0.878*** [0.023]	0.774*** [0.044]
Constant	0.073*** [0.019]	0.071*** [0.014]	0.075*** [0.012]	0.072*** [0.016]	0.067*** [0.013]	0.092*** [0.016]	0.065*** [0.011]	0.106*** [0.019]
N	1,079		1,079		1,079		1,079	

Source. National Center for Education Statistics Integrated Postsecondary Data System (IPEDS). The following variables were included in the model but not reported for space reasons: Increase in Women's Enrollment Percentage, Federal Financial Aid % Share, Public Institution, Historically Black College or University, Land Grant Institution, and Urbanicity. Robust standard errors are reported in brackets under the unstandardized slope coefficients. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

gender desegregation (via increased gender exposure), but only when faculty are tenured. Accordingly, Hypothesis 6 is supported.

Summary: hypotheses 4–6

We find support for Hypotheses 4–6, confirming that increasing heterogeneity is vital for increasing gender exposure among STEM degree earners, but only when gender heterogeneity increases among *tenured* faculty members. A rise in faculty gender heterogeneity at the non-tenure-track or tenure-track level does not significantly increase the probability for interaction among STEM degree earners, across gender. However, an increase in *tenured* faculty gender heterogeneity contributes to the gender desegregation of STEM degree earners.

Additional predictive factors

We report additional significant independent variables in Tables 2, 3, these factors tend not to not meaningfully vary between the experimental and control groups in their effect on the dependent variables, and are therefore not discussed alongside the hypotheses. Not surprisingly, past STEM degree exposure positively predicts later STEM degree exposure. Yet, it bears mention that increasing undergraduate women's degree success generally (not specific to STEM fields) negatively predicts women's STEM degree success, as does being a graduate degree-granting institution. Our discussion below considers implications of our findings for equity in postsecondary institutions, with particular attention to women STEM faculty.

Sensitivity analyses

We look more closely at the requirement of institutional change in reducing gender segregation of STEM students by exploring the impact of a 1% or greater increase and a 10% or greater increase in tenured women faculty presence in additional sensitivity analyses. The 5% threshold utilized in the primary analysis indicates a deep institutional commitment to change. An increase of tenured women faculty presence by at least 1% shows, at the very least, a modest institutional commitment to increasing the presence of tenured women faculty, whereas 10% may indicate a strong institutional commitment, or a confounding high turnover rate within an institution.

In Table 4 Model 1, we test whether an increase of tenured women faculty of 1% or more leads to a reduction in gender segregation among STEM undergraduates. As expected, even a small institutional commitment to increasing tenured women faculty presence is associated with greater exposure among STEM undergraduates. An increase in tenured women faculty presence by at least 1% is associated with a 1.4% increase in gender exposure among STEM students ($b = 0.014$, $p < 0.01$).

TABLE 4 AIPW regression of STEM degree exposure by increase in tenured women faculty by greater than 0 and 10% or more.

	[1]	[2]	[3]	[4]	[5]	[6]
	1% or more increase tenure only	6% or more increase tenure only	7% or more increase tenure only	8% or more increase tenure only	9% or more increase tenure only	10% or more increase tenure only
STEM degree gender exposure (Time 2)	0.014** [0.005]	0.007 [0.003]	0.007 [0.004]	0.005 [0.004]	0.004 [0.004]	0.004 [0.005]
N	1,250	1,250	1,250	1,250	1,250	1,250

Source. National Center for Education Statistics Integrated Postsecondary Data System (IPEDS). The following variables were included in the model but not reported for space reasons: Increase in Bachelor's Degrees Earned by Women, Carnegie Classification, STEM Degree Exposure (Time 1), Increase in Women's Enrollment Percentage, Federal Financial Aid % Share, Public Institution, Historically Black College or University, Land Grant Institution, and Urbanicity. Robust standard errors are reported in brackets under the unstandardized slope coefficients. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Because between a 1 and 5% increase in tenured women faculty presence is significant enough of a structural change to reduce segregation (as were increases we tested within these margins, i.e., 2, 3, 4%), we also wanted to explore whether there is an upper threshold. In other words, is there a percentage increase of tenured women faculty that indicates structural instability rather than institutional commitment to diversifying faculty? To this end, we also tested increases of 6, 7, 8, 9, and 10% (see Table 4, models 2–6) increases in tenured women faculty. At each of these upper levels, the relationship between structural change in tenured women faculty presence and STEM degree exposure among undergraduate students is not significant. It may be because too few institutions saw increases higher than 5%; recall in Table 1, only 38% saw increases of 5% or higher of tenured women faculty.

Discussion

Here, we discuss the key findings of our study. First, we address each research question and discuss whether the findings align with our hypotheses across faculty rank. Second, we review the implications of this study for macrostructural theory in STEM education. First, we turn to women faculty's group size, the first component of Blau's (1977) macrostructural theory. We posited that only changes in the group size of *tenured* women faculty would impact gender desegregation among STEM degree earners (H1-H3). Our findings suggest that the mere presence of women faculty within institutions is not enough to desegregate undergraduate STEM degree attainment. Women faculty in non-tenure-track positions have limited job security (Kezar and Sam, 2013; Ceci et al., 2014) and may be burdened with responsibilities that limit their availability to serve as mentors to women pursuing STEM bachelor's degrees (Lubienski et al., 2018). On average, institutions sampled did not increase the share of women faculty at *any* rank by at least 5 %, illustrating that increases in faculty group size are generally modest at any rank.

To foster gender desegregation in STEM, women's representation must be considered across faculty rank. Untenured women faculty may not have enough agency, time, or resources to warm the chilly climate in STEM as role models and mentors. To potentially mitigate the insufficient numbers of tenured women faculty mentors within STEM for diverse STEM undergraduate women students, supplemental mentoring might encompass intentional mentoring (Shuler et al., 2021) and/or shadow mentoring (Davis-Reyes et al., 2022) to enhance impacts, especially within the institution. Students and other early career women scientists might also develop a mentoring network within and outside of the institution to enhance their career advancement (Montgomery, 2017) and sense of belonging in their institution and field (Perez-Felkner, 2018; Ovink et al., 2024).

Macrostructural change at institutional levels

While mentors outside of the university system are often helpful in improving student persistence and attitudes within STEM (Shuler et al., 2021; Davis-Reyes et al., 2022), tenured women faculty within the institution may be better positioned to help students foster campus relationships, advocate for students, and understand students' struggles that are unique to the institution they attend (see Baez, 2000; Perez-Felkner et al., 2022; Garrett et al., 2023). Having few tenured women faculty may result in fewer role models and less potential for skills transfer and positive socialization within the field (Whittaker et al., 2015). Stratification by rank as well as faculty type (tenure-track/tenured vs. non-tenure-track) may reproduce women's subordinate position and shape the aspirations of women—and perhaps especially women of color–undergraduate students all the way up through postdoctoral fellows pursuing STEM careers (Bilimoria et al., 2008; Lambert et al., 2020).

Undergraduate women are exposed to and influenced by the gendered norms of their faculty. Pre-tenure women faculty on the tenure-track are burdened with immense pressure to "publish or perish," which detracts from their ability to serve as mentors within their departments (Estrada et al., 2018). These responsibilities may detract from women faculty members' ability to serve as leaders in their departments and institutions, as well as in their scholarly fields (O'Meara et al., 2020). Observing that on average, women faculty have lower prestige and job security than men faculty, undergraduate women may come to understand themselves as subordinate in STEM and choose different educational and career paths accordingly (Main et al., 2020).

By contrast, tenured women faculty in STEM are better positioned to challenge stereotypes about women in their STEM discipline, and are often asked to serve as leaders and advocates for women undergraduates in their departments, to help undergraduate women bring their identity into congruence with STEM career aspirations (National Research Council, 2010; Britton, 2017). The job security that comes with the tenure status may allow women faculty to take on a stronger leadership role within their departments and allow them to be more intentional about the service tasks they accept. Indeed, these leadership positions

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may be necessary to transform department and disciplinary status quo – and contribute to transformation at the institutional level–to structure encouragement and reward for mentoring and promoting the success of underrepresented and women students in STEM fields (Lewellen-Williams et al., 2006; Ruiz et al., 2022). Such transformative leadership may benefit from increased shares of mid-career and senior women faculty, whose influence may synergistically facilitate macrostructural change within and across institutions.

However, high turnover can negatively affect institutions and organizations (Al-Suraihi et al., 2021). Large changes in faculty composition in a short timespan may indicate structural instability or a negative working environment, which research shows is associated with faculty and faculty leader attrition generally (Jo, 2008; Taylor et al., 2017) and for women in STEM fields specifically (Xu, 2008). In increasing the presence of tenured women faculty, universities must also maintain organizational stability. The average faculty turnover rate for all ranks was 9.4% in 2021, according to the CUPA-HR 2022 Higher Education Employee Retention Survey (Bichsel et al., 2022). Thus, a 6–10% increase in tenured faculty alone could be an indicator of generally high turnover within an institution—and perhaps institutional instability. Still, steady increases in tenured women faculty presence at institutions positively influences gender exposure among STEM undergraduates. Institutional commitment to improving faculty diversity is vital to warming the chilly climate among women STEM undergraduates.

Increases in women faculty group size at the tenure level is not the only contributor to gender desegregation in STEM. Instead, our study shows that desegregating faculty by gender and rank within institutions is also *necessary* to warm the chilly climate in STEM. Although these data do not allow us to evaluate women faculty's share within each department, measuring within-institution faculty segregation enables analysis of the degree of interaction among faculty across campus. Our findings isolate the importance of increasing the likelihood of interaction among women and men tenured faculty–achieved by increasing women's share of tenured roles—as this was the factor found to contribute to the gender desegregation of STEM degree earners.

Impacts of women faculty on STEM women student outcomes

Dismantling gender segregation among postsecondary faculty matters for shrinking STEM gender disparities among students. Since contingent (non-tenure-track) and otherwise untenured faculty do not have the same job stability and level of commitment from the institution (see, e.g., Zambrana et al., 2015; Rideau, 2019), it is important to undo faculty gender segregation at the tenure rank, perhaps especially for women of color faculty and the students they disproportionately mentor. Notably, future extensions of this research with regards to its implications should attend further to institutional variation and perhaps especially how STEM higher education might learn from Minority Serving Institutions like Historically Black Colleges and Universities (included in our models), whose missions focused on inclusive environments might be more favorable for women STEM faculty (see Strayhorn et al., 2013; Shuler et al., 2022). Future research may be able to investigate further as well the intersections of gender and other marginalized identities, to assess the impact of greater representation among the faculty on STEM degree attainment for women, across backgrounds, identities, and specific STEM fields.

Implications for theory and policy

This study expands upon Blau's (1977) macrostructural theory. While Blau identified both group size and heterogeneity as critical for increasing positive interaction opportunities among subgroups, he failed to account for differences in status between group members. Following the lead of later works using this theory (e.g., Fitzpatrick and Hwang, 1992), we incorporate differing statuses in our analyses. In addition, we demonstrate the utility of macrostructural theory in examining the effectiveness of institutional changes at the university level.

While institutions make public claims that hiring more women and minority faculty is a priority, the efforts institutions make regarding equality in promotion and tenure are not sufficiently transparent (see Mack et al., 2010; Ahmed, 2012; Bennett et al., 2020). If institutions hire women faculty to fill demographic quotas but fail to reduce gendered inequalities in the promotion process, institutions may fall short of their commitments to permanent, transformational change for students and faculty. Tenured faculty have more influence and agency than their untenured peers. In contrast, untenured women faculty may not have the positional leverage or job security to advocate for women students and peers, nor influence how resources are allocated (O'Meara et al., 2018; Kelly and McCann, 2019).

Implications for postsecondary institutions and practice

What does this mean for institutions? We suspect that warming the chilly climate for both undergraduate women in STEM and women faculty requires macrostructural change, specifically in the form of hiring *and tenuring* more women faculty, thus increasing gender parity at the departmental and institutional levels. As more women faculty advance to higher ranks across departments, they will have more influence over the undergraduate learning environment and will have more agency to advocate for more balanced distribution of service labor across gender. Given the positive results found in our national study, institutions' investment in tenured and tenure-track women faculty appears to demonstrate long-term commitment to gender equity, helping to thaw the chilly climate for women in STEM. These findings have potential implications for other sex-segregated fields and labor sectors beyond STEM departments and higher education institutions.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://nces.ed.gov/ipeds.

Author contributions

KE: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. ES: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. LP-F: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Acker, J. (1990). Hierarchies, jobs, bodies: a theory of gendered organizations. *Gend. Soc.* 4, 139–158. doi: 10.1177/089124390004002002

Acker, J. (2006). Inequality regimes: gender, class, and race in organizations. *Gend. Soc.* 20, 441–464. doi: 10.1177/0891243206289499

Ahmed, S. (2012). *On being included: Racism and diversity in institutional life*. Durham, NC: Duke University Press, p. 17

Allan, E. J., and Madden, M. (2006). Chilly classrooms for female undergraduate students: A question of method? *J. High. Educ.* 77, 684–711. doi: 10.1353/jhe.2006.0028

Al-Suraihi, W. A., Samikon, S. A., Al-Suraihi, A.-H. A., and Ibrahim, I. (2021). Employee turnover: causes, importance and retention strategies. *Eur. J. Bus. Manag. Res.* 6, 1–10. doi: 10.24018/ejbmr.2021.6.3.893

Armstrong, M., and Jovanovic, J. (2015). Starting at the crossroads: intersectional approaches to supporting underrepresented minority women STEM faculty. *J. Women Minorities Sci. Eng.* 21, 141–157. doi: 10.1615/JWomenMinorScienEng.2015011275

Baez, B. (2000). Race-related service and faculty of color: conceptualizing critical agency in academe. *High. Educ.* 39, 363–391. doi: 10.1023/A:1003972214943

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., and Doms, M. E. (2011). *Women in STEM: a gender gap to innovation (economics and statistics administration issue brief)*. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1964782.

Bennett, J., Lattuca, L., Redd, K., and York, T. (2020). *Strengthening pathways to faculty careers in STEM: recommendations for systemic change to support underrepresented groups. Association of Public and Land-Grant Universities (APLU)*. Available at: https://www.aplu.org/library/strengthening-pathways-to-faculty-careers-in-stem-recommendations-for-systemic-change-to-support-underrepresented-groups.

Bichsel, J., Fuesting, M., Schneider, J., and Tubbs, D. (2022). *The CUPA-HR 2022 Higher Education Employee Retention Survey: Initial Results*. CUPA-HR.

Bilimoria, D., Joy, S., and Liang, X. (2008). Breaking barriers and creating inclusiveness: lessons of organizational transformation to advance women faculty in academic science and engineering. *Hum. Resour. Manag.* 47, 423–441. doi: 10.1002/hrm.20225

Bird, S. (2010). Unsettling universities' incongruous, gendered bureaucratic structures: a case-study approach. *Gend. Work Organ.* 18, 202–230. doi: 10.1111/j.1468-0432.2009.00510.x

Blau, P. M. (1977). A macrosociological theory of social structure. *Am. J. Sociol.* 83, 26–54. doi: 10.1086/226505

Britton, D. M. (2017). Beyond the chilly climate: the salience of gender in women's academic careers. *Gend. Soc.* 31, 5–27. doi: 10.1177/0891243216681494

Carter, D. F., Razo Dueñas, J. E., and Mendoza, R. (2019). "Critical examination of the role of STEM in propagating and maintaining race and gender disparities" in *Higher education: Handbook of theory and research*. eds. M. B. Paulsen and L. W. Perna, vol. *34* (Berlin: Springer International Publishing), 39–97.

Ceci, S. J., Ginther, D. K., Kahn, S., and Williams, W. M. (2014). Women in academic science: a changing landscape. *Psychol. Sci. Public Interest* 15, 75–141. doi: 10.1177/1529100614541236

Chakravarti, A., Menon, T., and Winship, C. (2014). Contact and group structure: a natural experiment of interracial college roommate groups. *Organ. Sci.* 25, 1216–1233. doi: 10.1287/orsc.2014.0905

Cheryan, S., Drury, B. J., and Vichayapai, M. (2013). Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychol. Women Q.* 37, 72–79. doi: 10.1177/0361684312459328

Childress, H. (2019). *The adjunct underclass: How America's colleges betrayed their faculty, their students, and their mission*. Chicago: University of Chicago Press.

Davis-Reyes, B., Starbird, C., Fernandez, A. I., McCall, T., Hinton, A. O. Jr., and Termini, C. M. (2022). Shadow mentoring: a cost-benefit review for reform. *Trends Cancer* 8, 620–622. doi: 10.1016/j.trecan.2022.05.001

DiPrete, T. A., and Buchmann, C. (2013). *The rise of women: The growing gender gap in education and what it means for American schools*. New York: Russell Sage Foundation.

Ely, R. J., and Meyerson, D. E. (2000). Advancing gender equity in organizations: the challenge and importance of maintaining a gender narrative. *Organization* 7, 589–608. doi: 10.1177/135050840074005

Enos, R. D., and Celaya, C. (2018). The Effect of Segregation on Intergroup Relations. *J. Exp. Political Sci.* 5, 26–38. doi: 10.1017/XPS.2017.28

Estrada, M., Hernandez, P. R., and Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE Life Sci. Educ.* 17, 1–13. doi: 10.1187/cbe.17-04-0066

Fayer, S., Lacey, A., and Watson, A. R. (2017). *BLS spotlight on statistics: STEM occupations - past, present, and future*. Available at: https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.

Fitzpatrick, K. M., and Hwang, S.-S. (1992). The effects of community structure on opportunities for interracial contact. *Sociol. Q.* 33, 51–61. doi: 10.1111/j.1533-8525.1992.tb00363.x

Fry, R., Kennedy, B., and Funk, C. (2019). *STEM jobs see uneven progress in gender, racial, and ethnic diversity*. P. R. Center. Available at: https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/.

Garrett, S. D., Williams, M. S., and Carr, A. M. (2023). Finding their way: exploring the experiences of tenured black women faculty. *J. Divers. High. Educ.* 16, 527–538. doi: 10.1037/dhe0000213

Gasman, M., Samayoa, A. C., and Nettles, M. (2017). Investing in student success: examining the return on investment for minority-serving institutions. *ETS Res. Rep. Series* 2017, 1–66. doi: 10.1002/ets2.12187

Gaston Gayles, J., and Ampaw, F. (2014). The impact of college experiences on degree completion in STEM fields at four-year institutions: does gender matter? *J. High. Educ.* 85, 439–468. doi: 10.1080/00221546.2014.11777336

Glass, J. L., Sassler, S., Levitte, Y., and Michelmore, K. M. (2013). What's so special about STEM? A comparison of women's retention in STEM and professional occupations. *Soc. Forces* 92, 723–756. doi: 10.1093/sf/sot092

Glynn, A. N., and Quinn, K. M. (2010). An introduction to the augmented inverse propensity weighted estimator. *Polit. Anal.* 18, 36–56. doi: 10.1093/pan/mpp036

Grawe, N. D. (2018). *Demographics and the demand for higher education*. Baltimore, MD: Johns Hopkins University Press.

Griffin, K. A. (2020). "Institutional barriers, strategies, and benefits to increasing the representation of women and men of color in the professoriate" in *Higher education: Handbook of theory and research*. ed. L. W. Perna, vol. *35* (Berlin: Springer International Publishing), 1–73.

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: is it the school that matters? *Econ. Educ. Rev.* 29, 911–922. doi: 10.1016/j.econedurev.2010.06.010

Griffith, A. L. (2014). Faculty gender in the college classroom: does it matter for achievement and major choice? *South. Econ. J.* 81, 211–231. doi: 10.4284/0038-4038-2012.100

Gurin, P., Dey, E., Hurtado, S., and Gurin, G. (2002). Diversity and higher education: theory and impact on educational outcomes. *Harv. Educ. Rev.* 72, 330–367. doi: 10.17763/haer.72.3.01151786u134n051

Haas, M. (2016). Caught between restrictions and freedom: narrative biographies shed light on how gendered structures and processes affect the drop-out of females from universities. *Curr. Sociol.* 65, 1031–1049. doi: 10.1177/0011392116653173

Hall, R. M., and Sandler, B. R. (1984). *Out of the classroom: A chilly campus climate for women?* Association of American Colleges, Project on the Status and Education of Women. Available at: https://eric.ed.gov/?id=ED254125

Haynes, C., Taylor, L., Mobley, S. D., and Haywood, J. (2020). Existing and resisting: the pedagogical realities of black, critical men and women faculty. *J. High. Educ.* 91, 698–721. doi: 10.1080/00221546.2020.1731263

Hinton, A. O., Termini, C. M., Spencer, E. C., Rutaganira, F. U. N., Chery, D., Roby, R., et al. (2020). Patching the leaks: revitalizing and reimagining the STEM pipeline. *Cell* 183, 568–575. doi: 10.1016/j.cell.2020.09.029

Jaeger, A. J., and Eagan, M. K. (2011). Examining retention and contingent faculty use in a state system of public higher education. *Educ. Policy* 25, 507–537. doi: 10.1177/0895904810361723

Jensen, L. E., and Deemer, E. D. (2019). Identity, campus climate, and burnout among undergraduate women in STEM fields. *Career Dev. Q.* 67, 96–109. doi: 10.1002/cdq.12174

Jo, V. H. (2008). Voluntary turnover and women administrators in higher education. *High. Educ.* 56, 565–582. doi: 10.1007/s10734-008-9111-y

Johnson, H. (2017). *Pipelines, pathways, and institutional leadership: an update on the status of women in higher education*. American Council on Education. Available at: https://www.acenet.edu/Documents/Higher-Ed-Spotlight-Pipelines-Pathways-and-Institutional-Leadership-Status-of-Women.pdf.

Johnson, K., Johnson, W., Thomas, J., and Green, J. (2019). Mapping microaggressions on a southern university campus: where are the safe spaces for vulnerable students? *Soc. Probl.* 68, 1–18. doi: 10.1093/socpro/spz055

Kath, L. M., Swody, C. A., Magley, V. J., Bunk, J. A., and Gallus, J. A. (2009). Cross-level, three-way interactions among work-group climate, gender, and frequency of harassment on morale and withdrawal outcomes of sexual harassment. *J. Occup. Organ. Psychol.* 82, 159–182. doi: 10.1348/096317908X299764

Kelly, B. T., and McCann, K. (2014). Women faculty of color: stories behind the statistics. *Urban Rev.* 46, 681–702. doi: 10.1007/s11256-014-0275-8

Kelly, B., and McCann, K. (2019). Women faculty on the tenure track: the compounding role of being the breadwinner. *J. Prof.* 10, 73–109.

Kezar, A., and Sam, C. (2013). Institutionalizing equitable policies and practices for contingent faculty. *J. High. Educ.* 84, 56–87. doi: 10.1080/00221546.2013.11777278

Kricorian, K., Seu, M., Lopez, D., Ureta, E., and Equils, O. (2020). Factors influencing participation of underrepresented students in STEM fields: matched mentors and mindsets. *Int. J. STEM Educ.* 7:16. doi: 10.1186/s40594-020-00219-2

Lambert, W. M., Wells, M. T., Cipriano, M. F., Sneva, J. N., Morris, J. A., and Golightly, L. M. (2020). Career choices of underrepresented and female postdocs in the biomedical sciences. *eLife* 9:e48774. doi: 10.7554/eLife.48774

Lee, J. J., and McCabe, J. M. (2021). Who speaks and who listens: revisiting the chilly climate in college classrooms. *Gend. Soc.* 35, 32–60. doi: 10.1177/0891243220977141

Lester, J., Struthers, B., and Yamanaka, A. (2017). Unwelcoming classroom climates: the role of gender microaggressions in CTE: unwelcoming classroom climates. *New Dir. Community Coll.* 2017, 67–77. doi: 10.1002/cc.20254

Lewellen-Williams, C., Johnson, V. A., Deloney, L. A., Thomas, B. R., Goyol, A., and Henry-Tillman, R. (2006). The pod: a new model for mentoring underrepresented minority faculty. *Acad. Med.* 81, 275–279. doi: 10.1097/00001888-200603000-00020

Lubienski, S. T., Miller, E. K., and Saclarides, E. S. (2018). Sex differences in doctoral student publication rates. *Educ. Res.* 47, 76–81. doi: 10.3102/0013189X17738746

Mack, K., Johnson, L. R., Woodson, K. M., Henkin, A., and Dee, J. R. (2010). Empowering women faculty in STEM fields: an examination of historically black colleges and universities. *J. Women Minorities Sci. Eng.* 16, 319–341. doi: 10.1615/JWomenMinorScienEng.v16.i4.30

Main, J. B., Tan, L., Cox, M. F., McGee, E. O., and Katz, A. (2020). The correlation between undergraduate student diversity and the representation of women of color faculty in engineering. *J. Eng. Educ.* 109, 843–864. doi: 10.1002/jee.20361

Mason, M. A., Wolfinger, N. H., and Goulden, M. (2013). *Do babies matter? Gender and family in the ivory tower*. Rutgers University Press. Available at: http://www.jstor.org/stable/j.ctt5hj7tp.

Massey, D. S., and Denton, N. A. (1988). The dimensions of residential segregation. *Soc. Forces* 67, 281–315. doi: 10.2307/2579183

Maton, K., Beason, T., Godsay, S., Sto Domingo, M., Bailey, T., Sun, S., et al. (2016). Outcomes and processes in the Meyerhoff scholars program: STEM PhD completion, sense of community, perceived program benefit, science identity, and research self-efficacy. *CBE Life Sci. Educ.* 15:ar48. doi: 10.1187/cbe.16-01-0062

McNaughtan, J., García, H. A., and Nehls, K. (2017). Understanding the growth of contingent faculty. *New Dir. Inst. Res.* 2017, 9–26. doi: 10.1002/ir.20241

Merluzzi, J. (2017). Gender and negative network ties: exploring difficult work relationships within and across gender. *Organ. Sci.* 28, 636–652. doi: 10.1287/orsc.2017.1137

Miller, C., and Roksa, J. (2019). Balancing research and service in academia: gender, race, and laboratory tasks. *Gend. Soc.* 34, 131–152. doi: 10.1177/0891243219867917

Misra, J., Lundquist, J. H., and Templer, A. (2012). Gender, work time, and care responsibilities among faculty. *Sociol. Forum* 27, 300–323. doi: 10.1111/j.1573-7861.2012.01319.x

Montgomery, B. L. (2017). Mapping a mentoring roadmap and developing a supportive network for strategic career advancement. *SAGE Open* 7:215824401771028. doi: 10.1177/2158244017710288

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., and Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proc. Natl. Acad. Sci.* 109, 16474–16479. doi: 10.1073/pnas.1211286109

Mouw, T., and Entwisle, B. (2006). Residential segregation and interracial friendship in schools. *Am. J. Sociol.* 112, 394–441. doi: 10.1086/506415

National Research Council. (2010). Gender differences at critical transitions in the careers of science, engineering, and mathematics faculty. Washington, DC: The National Academies Press.

National Science Board, National Science Foundation. (2021). *The STEM labor force of today: Scientists, engineers, and skilled technical workers*. Available at: https://ncses.nsf.gov/pubs/nsb20212.

Nichols, L. (2019). Addressing exclusion in organizations: social desire paths and undocumented students attending college. *Soc. Probl.* 67, 471–487. doi: 10.1093/socpro/spz021

O'Meara, K., Sayer, L., Nyunt, G., and Lennartz, C. (2020). Stressed, interrupted, and under-estimated: experiences of women and URM faculty during one workday. *J. Prof.* 11, 106–137.

O'Meara, K., Templeton, L., and Nyunt, G. (2018). Earning professional legitimacy: challenges faced by women, underrepresented minority, and non-tenure-track faculty. *Teach. Coll. Rec.* 120, 1–38. doi: 10.1177/016146811812001203

Ong, M., Smith, J. M., and Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: marginal and central spaces for persistence and success. *J. Res. Sci. Teach.* 55, 206–245. doi: 10.1002/tea.21417

Ong, M., Wright, C., Espinosa, L., and Orfield, G. (2011). Inside the double bind: a synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harv. Educ. Rev.* 81, 172–209. doi: 10.17763/haer.81.2.t022245n7x4752v2

Ovink, S. M., Byrd, W. C., Nanney, M., and Wilson, A. (2024). "Figuring out your place at a school like this:" intersectionality and sense of belonging among STEM and non-STEM college students. *PLoS One* 19:e0296389. doi: 10.1371/journal.pone.0296389

Padavic, I., and Prokos, A. (2016). Aiming high: explaining the earnings advantage for female veterans. *Armed Forces Soc.* 43, 368–386. doi: 10.1177/0095327X16682044

Pawley, A. L. (2019). Learning from small numbers: studying ruling relations that gender and race the structure of U.S. engineering education. *J. Eng. Educ.* 108, 13–31. doi: 10.1002/jee.20247

Perez-Felkner, L. (2018). Conceptualizing the field: Higher education research on the STEM gender gap. *New Directions for Institutional Research* 11–26. doi: 10.1002/ir.20273

Perez-Felkner, L., Gast, M. J., and Ovink, S. M. (2022). Liberating our writing: critical narratives and systemic changes in education and the social sciences. *Multicult. Perspect.* 24, 162–169. doi: 10.1080/15210960.2022.2127400

Randel, A. E. (2002). Identity salience: a moderator of the relationship between group gender composition and work group conflict. *J. Organ. Behav.* 23, 749–766. doi: 10.1002/job.163

Rideau, R. (2019). "We're just not acknowledged": an examination of the identity taxation of full-time non-tenure-track women of color faculty members. *J. Divers. High. Educ.* 14, 161–173. doi: 10.1037/dhe0000139

Ridgeway, C. L. (1997). Interaction and the conservation of gender inequality: considering employment. *Am. Sociol. Rev.* 62, 218–235. doi: 10.2307/2657301

Rincón, B. E., and George-Jackson, C. E. (2016). Examining department climate for women in engineering: the role of STEM interventions. *J. Coll. Stud. Dev.* 57, 742–747. doi: 10.1353/csd.2016.0072

Roy, J. (2019). *Engineering by the numbers*. American Society for Engineering Education. Available at: https://ira.asee.org/wp-content/uploads/2019/07/2018-Engineering-by-Numbers-Engineering-Statistics-UPDATED-15-July-2019.pdf.

Ruiz, A. E., DeLong, A., and Hinton, A. (2022). Creating a positive feedback loop in leadership to accelerate cultural change. *Trends Parasitol.* 38, 1020–1022. doi: 10.1016/j.pt.2022.09.007

Sansone, D. (2018). Teacher characteristics, student beliefs, and the gender gap in STEM fields. *Educ. Eval. Policy Anal.* 41, 127–144. doi: 10.3102/0162373718819830

Šaras, E. D., Perez-Felkner, L., and Nix, S. (2018). Warming the chill: insights for institutions and researchers to keep women in STEM. *New Dir. Inst. Res.* 2018, 115–137. doi: 10.1002/ir.20278

Seebruck, R., and Savage, S. V. (2020). To promote or hire? How racial processes and organizational characteristics affect internal promotions in NCAA division I college basketball coaching. *Soc. Probl.* 67, 546–564. doi: 10.1093/socpro/spz030

Shuler, H., Cazares, V., Marshall, A., Garza-Lopez, E., Hultman, R., Francis, T., et al. (2021). Intentional mentoring: maximizing the impact of underrepresented future scientists in the 21st century. *Pathog. Dis.* 79, 1–9. doi: 10.1093/femspd/ftab038

Shuler, H. D., Spencer, E. C., Davis, J. S., Damo, S., Shakespeare, T. I., Murray, S. A., et al. (2022). Learning from HBCUs: how to produce black professionals in STEMM. *Cell* 185, 2841–2845. doi: 10.1016/j.cell.2022.06.013

Simon, R. M., Wagner, A., and Killion, B. (2017). Gender and choosing a STEM major in college: femininity, masculinity, chilly climate, and occupational values. *J. Res. Sci. Teach.* 54, 299–323. doi: 10.1002/tea.21345

Sonnert, G., Fox, M. F., and Adkins, K. (2007). Undergraduate women in science and engineering: effects of faculty, fields, and institutions over time. *Soc. Sci. Q.* 88, 1333–1356. doi: 10.1111/j.1540-6237.2007.00505.x

Stoeger, H., Duan, X., Schirner, S., Greindl, T., and Ziegler, A. (2013). The effectiveness of a one-year online mentoring program for girls in STEM. *Comput. Educ.* 69, 408–418. doi: 10.1016/j.compedu.2013.07.032

Strayhorn, T. L., Williams, M. S., Tillman-Kelly, D., and Suddeth, T. (2013). Sex differences in graduate school choice for black HBCU bachelor's degree recipients: a national analysis. *J. Afr. Am. Stud.* 17, 174–188. doi: 10.1007/s12111-012-9226-1

Summers, L. H. (2005). *Remarks at NBER conference on diversifying the science & engineering workforce*. NBER conference on diversifying the Science & Engineering Workforce, Cambridge, MA.

Swafford, M., and Anderson, R. (2020). Addressing the gender gap: Women's perceived barriers to pursuing STEM careers. *J. Res. Tech. Careers* 4:61. doi: 10.9741/2578-2118.1070

Taylor, L. L., Beck, M. I., Lahey, J. N., and Froyd, J. E. (2017). Reducing inequality in higher education: the link between faculty empowerment and climate and retention. *Innov. High. Educ.* 42, 391–405. doi: 10.1007/s10755-017-9391-1

Vitores, A., and Gil-Juárez, A. (2016). The trouble with 'women in computing': a critical examination of the deployment of research on the gender gap in computer science. *J. Gend. Stud.* 25, 666–680. doi: 10.1080/09589236.2015.1087309

Weisshaar, K. (2017). Publish and perish? An assessment of gender gaps in promotion to tenure in academia. *Soc. Forces* 96, 529–560. doi: 10.1093/sf/sox052

White-Lewis, D. K. (2020). The facade of fit in faculty search processes. *J. High. Educ.* 91, 833–857. doi: 10.1080/00221546.2020.1775058

Whittaker, J. A., Montgomery, B. L., and Martinez Acosta, V. G. (2015). Retention of Underrepresented Minority Faculty: Strategic Initiatives for Institutional Value Proposition Based on Perspectives from a Range of Academic Institutions. *J. Undergrad. Neurosci. Educ.* 13, A136–A145.

Williams, J. C., Blair-Loy, M., and Berdahl, J. L. (2013). Cultural schemas, social class, and the flexibility stigma. *J. Soc. Issues* 69, 209–234. doi: 10.1111/josi.12012

Williams, M. T., Skinta, M. D., and Martin-Willett, R. (2021). After pierce and sue: a revised racial microaggressions taxonomy. *Perspect. Psychol. Sci.* 16, 991–1007. doi: 10.1177/1745691621994247

Xie, Y., Fang, M., and Shauman, K. (2015). STEM education. *Annu. Rev. Sociol.* 41, 331–357. doi: 10.1146/annurev-soc-071312-145659

Xie, Y., and Shauman, K. A. (2003). *Women in science: Career processes and outcomes*. Cambridge, MA: Harvard University Press.

Xu, Y. J. (2008). Gender disparity in STEM disciplines: a study of faculty attrition and turnover intentions. *Res. High. Educ.* 49, 607–624. doi: 10.1007/s11162-008-9097-4

Youn, T. I. K., and Price, T. M. (2009). Learning from the experience of others: the evolution of faculty tenure and promotion rules in comprehensive institutions. *J. High. Educ.* 80, 204–237. doi: 10.1080/00221546.2009.11772139

Zambrana, R. E., Ray, R., Espino, M. M., Castro, C., Douthirt Cohen, B., and Eliason, J. (2015). "Don't leave us behind": the importance of mentoring for underrepresented minority faculty. *Am. Educ. Res. J.* 52, 40–72. doi: 10.3102/0002831214563063