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**A “Chillier” Climate for Multiply Marginalized STEM Faculty Impedes Research
Collaboration**

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Abstract

Research collaboration is key to faculty career success in science, technology, engineering, and mathematics (STEM). Yet little research has considered how faculty from multiple marginalized identity groups experience collaboration compared to colleagues from majority groups. The present study fills that gap by examining similarities and differences in collaboration experiences of faculty across multiple marginalized groups, and the role of department climate in those experiences. A survey of STEM faculty at a large public research university found that faculty from underrepresented groups – in terms of gender, race, and sexual orientation – had more negative experiences with department-level research collaborations. Moreover, faculty with multiply marginalized identities had worse collaboration experiences than others with a single marginalized identity or none. They also perceived their department climate to be less inclusive, equitable, and transparent; and felt their opinion was less valued in the department than colleagues from majority groups. Negative department climate, in turn, mediated and predicted less hospitable experiences with department-level research collaboration. These data suggest that multiply marginalized faculty, across different identity groups, share some common experiences of a “chilly” department climate relative to their peers from majority groups, which impedes opportunities for scientific collaboration, a key ingredient for faculty success. These findings have policy implications for retention of diverse faculty in university STEM departments.

Keywords: STEM faculty; higher education; collaboration; climate; gender; race; sexual orientation

A “Chillier” Climate for Multiply Marginalized STEM Faculty Impedes Research Collaboration

Research collaboration is a key component of academic work, particularly in science, technology, engineering, and mathematics (STEM), where team science is responsible for some of the most impactful discoveries (Leahey, 2016) and major funders are increasingly dedicating resources to multidisciplinary team research. Scientists, engineers, and technologists are collaborating in growing numbers, as demonstrated by an upward trend in the number of coauthored papers (Bozeman & Youtie, 2017). Research collaboration also benefits careers of individual scientists through increased productivity and impact (Abramo et al., 2013; Lee & Bozeman, 2005). Policies and initiatives aimed at developing and supporting research collaborations are growing in both university and industry settings.

However, not all scientists and engineers have equal access to research collaboration: women faculty and faculty from other underrepresented groups in STEM experience unique challenges in their collaborations (Abramo et al., 2019; Gaughan et al., 2018; Kyvik & Teigen, 1996; McDowell & Smith, 1992). Previous studies on research collaboration have examined how gender or race shape faculty collaboration experiences, typically focusing on singular marginalized identity groups (for an exception see Gaughan et al., 2018). There is a scarcity of research examining how faculty from intersecting identity groups that are marginalized in academia experience collaborative research, and whether multiple marginalization creates added barriers to collaboration in academic science and engineering. This is especially surprising given the vast intersectional literature illustrating how overlapping systems of oppression shape faculty careers (e.g., Cech & Waidzun, 2011; Ong et al., 2011; Turner et al., 2011; Zambrana, 2018). Most of the existing work shows that academics with “multiple marginality” (Turner, 2002)

experience a “chilly climate” (Hall & Sandler, 1982), especially women of color working in STEM fields that privilege heterosexual, white men as ideal scientists (Collins, 1990; Ridgeway, 2011; Zambrana, 2018). But this work has not examined how intersecting marginalized identities relate to faculty experiences of research collaboration. Understanding the relationship between faculty’s identities, their experiences of institutional climate, and research collaboration opportunities is important to faculty productivity and retention in science and engineering, but this linkage has yet to be examined.

Because departments are crucial sites of faculty life, providing faculty with professional relationships and research networks (Evans et al., 2011; Fleming et al., 2016; Fox & Mohapatra, 2007; Larivière et al., 2006), we propose that the culture and climate of academic departments is likely to shape faculty’s access to within-department collaborators and their subsequent satisfaction with such research collaborations. Surprisingly little research has examined whether and how department cultures promote or impede STEM faculty’s collaborative research, despite research demonstrating that most collaborations occur within institutions (but see Pinheiro & Melkers, 2011; Smith-Doerr & Croissant, 2016). Our research aims to fill this gap by considering whether STEM faculty who are marginalized on the basis of one or more social identities share commonalities in everyday, lived experiences in their home departments. Faculty perceptions of departmental climate include the quality of interpersonal relationships among colleagues in the department, perceived equity in the treatment of all faculty across identity groups, and voice in department governance. Given most research collaborations are intra-university (Bozeman & Corley, 2004; Lee & Bozeman, 2005) and occur within departments, we focus on faculty experiences of collaboration within the university. We examine which of these aspects of department climate most influences scientific collaboration experiences of faculty

from multiply marginalized groups. Identifying interpersonal processes that facilitate versus impede collaboration and investigating whether these processes differ for diverse groups of faculties, is a necessary precursor to designing institutional solutions to remove career barriers and advance equity.

We conducted a survey of STEM faculty at a large public research university to examine the professional experiences of faculty from underrepresented groups as compared to their majority colleagues. Three underrepresented identity groups are at the focus of this investigation—women, underrepresented racial and ethnic minorities (URMs), and sexual minorities—groups that remain demographically underrepresented and systemically marginalized in STEM. We examine how the experiences of faculty from one marginalized identity group (e.g., white heterosexual women, white gay men, etc.) compare to their colleagues from multiple underrepresented identity groups (e.g., Black heterosexual women, Latino gay men, etc.). (Note: URM is defined in terms of NSF standards of underrepresentation. See Rivers (2017) for an example.)

Three questions guide the current research. First, to what extent do the identities of faculty – in terms of gender, race, and sexual orientation – shape their research collaboration experiences? Second, how do the collaboration experiences of faculty who identify with multiple underrepresented identities compare to those of their colleagues who have fewer or no marginalized identities? While there are important unique experiences of being marginalized in terms of race or gender or sexuality, with each identity group having its own histories and positionalities, we propose there may be some shared experiences across marginalized identity groups as faculty navigate white, masculine, and heteronormative institutions of higher education. Third, to what extent are differential collaboration patterns explained by three aspects

of department climate: (1) quality of interpersonal relations among faculty (e.g., cooperative or competitive, respectful or disrespectful, etc.), (2) perceived equity in the treatment of majority vs. minority identity groups, and (3) faculty voice in departmental decision-making.

Importance of Research Collaboration in Faculty Careers in STEM

Collaboration is central to knowledge production, scientific discovery, and innovation in academia, especially in STEM fields, which often rely on interdisciplinary research teams funded through collaborative grants. Collaboration provides faculty means to ideas, skills, expertise, and equipment that enhances career success (Bozeman & Youtie, 2017; Fox & Mohapatra, 2007; Hall et al., 2018). There is a growing scholarly interest in research collaboration in academic settings, focusing on the impacts of collaboration on faculty careers, evaluating the effectiveness of various kinds of collaborations (for a review see Bozeman et al., 2013), and the impacts on higher education institutions (Torres-Olave et al., 2020).

Studies consistently show that research collaboration is associated with greater productivity, a key metric of success in academia and a feature of tenure and promotion evaluations, particularly in research-intensive universities. Scientists who collaborate tend to publish more peer-reviewed publications of higher quality, including publications that land in higher impact journals (Fox & Mohapatra, 2007; Freeman & Huang, 2015; Lee & Bozeman, 2005; Liao, 2011). Coauthored academic papers are more likely to be accepted for publication and have higher citation counts than single-authored papers (Wuchty et al., 2007; He et al., 2009). In sum, successful researchers exhibit similar collaborative behaviors: they collaborate with a larger number of colleagues, seek out innovative ideas by brokering information across diverse groups in their networks, and engage in repetitive collaborations (Jadidi et al., 2018).

Much of the research on collaboration and productivity conceptualizes research collaboration through output measures, using bibliometric techniques to count coauthored publications and examine their impact factors (Bozeman et al., 2013). Bibliometric studies are appealing, convenient, and verifiable as they quantify collaboration – but they only count collaborations that result in formal outputs (Sacco, 2020). Analyses capturing the end products of collaboration do little to illuminate the relational processes that lead to fruitful research collaborations. The success or failure of a collaboration in terms of resulting in a knowledge product depends on interpersonal factors like cooperation, support, and respect (Bozeman et al., 2013; Powell et al., 2011). Collaborations also benefit researchers in ways that go beyond research products by providing them with professional and social connections, mentoring, institutional knowledge, new skills, and even friendship (Beaver, 2001; Bozeman & Corley, 2004; D’Este & Perkmann, 2011). The actual interpersonal experiences of collaboration remain elusive in the research literature, including faculty reports of satisfaction with research collaboration (Belle et al., 2014), feeling respected and valued by their collaborators, or perhaps disrespected and exploited. Examining interpersonal processes underlying collaboration, and how these processes vary for different groups of faculties, is necessary to explain whether or not a collaboration will endure, whether faculty will pursue a collaboration again, and, further, whether faculty are drawn to remain at their institution because they value those collaborative relationships (Etzkowitz et al., 2000).

Given that most researchers opt to collaborate within their institutions (Bozeman & Corley, 2004; Lee & Bozeman, 2005), we propose that faculty perceptions of the local climate may be a key antecedent to collaboration, shaping opportunities to collaborate, willingness to seek out collaboration, and satisfaction with collaborations. No published research has directly

examined the role of climate in shaping researchers' collaboration motives and choices. That said, allied research has examined the relation between department climate and professional satisfaction (Griffith & Dasgupta, 2018) or academic productivity (Fox, 1991; Fox & Mohapatra, 2007; Sheridan et al., 2017). Other research mapped out the collaboration networks of scientists who are women or racial ethnic minorities and found that both groups collaborate more with colleagues outside their home universities compared to White and Asian male faculty (Pinheiro & Melkers, 2011). But this study did not examine faculty members' self-reported experiences with research collaboration at their home institutions, the culture and climate in their institutions, or the relation between the two. Another qualitative study found that access to resources, recognition, and relationships created the ideal conditions under which collaboration yielded gender equitable outcomes for women and men faculty in STEM (Misra et al. 2017). Given this was a qualitative study with a small sample size, it was not able to assess whether faculty experiences of research collaborations were related to the culture and climate in their departments.

Bozeman et al. (2013) argue that there is a need for a deeper understanding of the "psychological antecedents to research collaboration choice" (pp. 37-38). Faculty often have complex, perhaps competing motives when choosing to pursue collaborative relationships; understanding the organizational contexts within which they make those decisions is essential to understanding collaboration as an interpersonal process. Thus, we propose to examine faculty perceptions of the organizational context and assess the degree to which it is associated with positive experiences of research collaboration, including time spent collaborating and satisfaction with collaboration opportunities within the university. This allows us to examine the

psychological antecedents of research collaboration in a way that has not been investigated in past research.

Relation between Social Identities and Research Collaboration in STEM

Faculty from underrepresented groups in STEM experience what has been described as a “chilly climate” in their departments and institutions (Britton, 2017; Hall & Sandler, 1982). Gender, race, and sexuality shape STEM norms and values, procedures, interactions, relationships, and evaluations to privilege the experiences of straight, white men as “ideal scientists,” while placing women faculty, faculty of color, and sexual minority faculty as outsiders to that culture (Bilimoria & Stewart, 2009; Cech and Waidzun, 2011; Ridgeway, 2011; Ong et al. 2011; Turner et al., 2011; Zambrana, 2018). Intersectionality theory draws attention to the fact that sexism, racism, and other interlocking systems of oppression overlap to shape the experiences of individuals experiencing “multiple marginality” (Turner, 2002; see also Collins, 1990; Crenshaw, 1989).

In academia, intersectional research demonstrates how the experiences of women faculty of color, for example, can be rendered invisible as they inhabit both the categories of “women” and “faculty of color” (Turner, 2002). Faculty with intersectional marginalized identities, such as being a woman and a racial minority, confront unique obstacles and inequalities in departmental settings beyond those experienced by either white women faculty or men faculty of color, creating a “labyrinth of structurally specific hurdles and disadvantages” (Armstrong & Jovanovic, 2017, p. 217). These inequalities include increased visibility, isolation from collegial networks, additional service loads and mentoring, conflicts of commitment between community and work, and challenges from students and colleagues (Hirshfield & Joseph, 2012; Muhs et al., 2012; Turner et al., 2011; Zambrana, 2018). These issues are exacerbated in STEM fields, many

which continue to be dominated by white men. Specifically, women make up 33.5% of tenured and tenure-track STEM faculty at four-year universities in the United States, with lower numbers in the physical sciences and engineering. Across STEM, Latinx people comprise just 4.7% of tenured and tenure-track faculty, and Black and African American individuals comprise 4% (National Science Foundation, 2017).

Exclusion from professional networks, including collaboration networks, is part of the chilly climate for underrepresented faculty in STEM (Hart, 2016; Pinheiro & Melkers, 2011). Similarly, collaborations involve routine interactions with colleagues, and white women faculty and women faculty of color are more likely to experience negative interactions reducing their attachment to their universities and disciplines (Biggs et al., 2018; Riegle-Crumb et al., 2020). However, most empirical studies on research collaboration typically focus on singular identity groups, examining how gender *or* race shapes collaboration experiences (for an exception see Gaughan et al., 2018). No research to date examines how sexual identity shapes collaboration. Examining the effects of multiple identities simultaneously can be complicated in the design and analysis of quantitative studies of collaboration, which is often limited by small subgroup samples (Gaughan et al., 2018).

Previous studies on gender and research collaboration demonstrate that collaborations typically having a stronger impact on the careers of academic STEM women than men – facilitating women producing more publications and publishing in higher impact journals (Badar et al., 2013; Kyvic & Teigen, 1996). However, women especially must navigate the tensions of establishing their research independence while forming a collaboration network (Smith-Doerr & Croissant, 2016). Women in STEM tend to have fewer opportunities to collaborate compared to men (Bozeman & Corley, 2004; Bystydzienski & Bird, 2006), which also limits their access to

shared grant funding, lab space and equipment, and mentors (Fox, 2008). Some research reports that women engage in fewer collaborations and have smaller research networks compared to men (Bozeman & Corley, 2004; Miller et al., 2012; Kyvik & Teigen, 1996; McDowell & Smith, 1992), but more recent studies suggest a shift, with women having a greater propensity to collaborate (Abramo et al., 2013; Bozeman & Gaughan, 2011; Gaughan et al., 2018).

Men and women in STEM also approach collaborative relationships differently, with women's approaches to collaboration creating tradeoffs that may further disadvantage their careers (Cole & Zuckerman, 1984). For example, while both women and men are more likely to collaborate within their gender group (Belle et al., 2014; Durbin, 2011), the underrepresentation of women in many STEM disciplines, especially in higher ranks, means that women's tendency to collaborate with each other contributes to their having lower status and fewer resources than men (Bozeman & Corley, 2004; Etzkowitz et al., 2000; McDowell & Smith, 1992). With women in STEM, especially women of color, often being demographic minorities in their departments, they often seek connections outside of their departments for emotional support, mentoring, and career advice (Ong et al., 2018; Turner, 2002). Women also engage in interdisciplinary collaborations more frequently than men (Leahey, 2006); interdisciplinary collaborations lead to fewer papers published, but more prominent, innovative research in higher-impact publications (Leahey et al., 2017). Other research shows that women are more likely than men to establish deep relationships in their home institutions and departments (Abramo et al., 2013; Zippel, 2017), and so women's collaboration networks may be less "cosmopolitan" and international than men's networks (Bozeman & Corley, 2004; Long, 1990; Uhly et al., 2017).

Relative to gender, less is known about how race, sexuality, and other social identities shape faculty research collaboration experiences. Faculty from underrepresented racial minority

groups tend to have smaller research networks with lower-status ties (Freeman & Huang 2015; Gaughan et al., 2018; Mehra et al., 1998; Pinheiro & Melkers, 2011). In general, faculty often choose to collaborate within their racial-ethnic groups; one study finds that racially homogenous collaborations produce papers with lower impact factors and fewer citations than other papers with racially diverse collaborators (Freeman & Huang, 2015). With STEM faculty from underrepresented racial minority groups often being the only member of their racial-ethnic group in their departments, locating collaborators with shared identities within their home departments or institutions may be nearly impossible (Mehra et al., 1998; Pinheiro & Melkers, 2011). As such, URM faculty may tend to seek collaborative partners outside of their home institutions (Pinheiro & Melkers, 2011). One study taking an intersectional approach compared faculty networks by race, ethnicity, and gender, and found that white men experienced advantages relative to other groups (Gaughan et al., 2018). White men tended to have larger networks providing more instrumental resources related to career development and productivity. Asian faculty, including men and women, tended to have smaller research networks, but their networks were rich with instrumental resources directly related to productivity.

While no previous studies have examined how sexual orientation or gender identity shape faculty experiences of research collaboration, there is evidence that LGBTQ faculty share experiences of marginalization, isolation, and hostile local climates, particularly in the heteronormative, cisgender institution of STEM (Cech & Waidzun, 2011; Garvey & Rankin, 2018; Patridge et al., 2014). LGBTQ faculty experience bias in the form of exclusion from scholarly and professional networks and communities, resulting in a myriad of negative career consequences (Bilimoria & Stewart, 2009; Patridge et al., 2014). Because of this bias and discrimination, LGBTQ faculty may be reluctant to “out” themselves at work, which in part

contributes to the lack of research on their workplace experiences like collaboration. Our research builds on this emergent body of work by examining whether or how sexual orientation influences research collaboration. Note that our limited sample does not allow us to examine gender identity; see methods section for elaboration. We specifically examine whether queer faculty feel excluded from collaborative opportunities and relationships. While gender theorists have long called for greater attention to intersectionality, there are few empirical studies that compare the career experiences of STEM faculty from multiply marginalized identity groups (Riegle-Crumb et al., 2020). Moving away from the unitary model of categorization to understand how multiple social identities interact to influence careers is an important next step (Preddie & Biernat 2021).

Overview of the present research

Our study extends existing literatures on research collaboration and social identities by illuminating the experiences of STEM faculty from underrepresented identity groups often rendered invisible, specifically those who experience intersectional forms of marginalization in academia. We address three research questions. First, how do the identities of faculty (gender, race, and sexuality) play a role in research collaboration experiences? Second, how do the collaboration experiences of faculty identifying with multiple underrepresented statuses compare to those of their colleagues who have fewer or no marginalized identities? While previous literature suggests that research collaboration differs by gender or race, few studies have accounted for these factors together to examine whether faculty experiencing marginalization because of one of more social identities share common experiences of collaboration. And to our knowledge, no research on collaboration has further examined sexuality. Third, we ask to what extent are these collaboration patterns explained by specific features of the faculty's local

climate such as: (a) the perceived quality of interpersonal relations among faculty within departments, (b) perceived equity in the treatment of majority vs. minority identity groups within departments, and (c) faculty voice in departmental matters. Finally, although the comparative experiences of US- and foreign-born faculty are outside the scope of this study, we acknowledge previous research notes that nationality interacts with gender and other identities to shape collaboration experiences in unique ways, particularly producing advantages for US-born scientists (Zippel, 2017).

Hypotheses

Hypothesis 1. We predict that opportunities for research collaboration and satisfaction with such collaborations will vary as a function of faculty members' social identities, such that STEM faculty who do not fit the "ideal scientist" prototype of a heterosexual White man (Hart, 2016) will have less positive experiences with research collaborations in science and engineering.

Hypothesis 2. We predict that faculty who experience marginalization on multiple dimensions (e.g., women of color, LGBTQ women, LGBTQ women of color) will have worse experiences with research collaboration relative to their colleagues who have fewer or no marginalized identities and thus fit more with the ideal scientist prototype.

Hypothesis 3. We predict that the link between marginalized identities and barriers to research collaboration will be explained by perceptions of department climate on specific dimensions. Given that academic departments are crucial sites for the formation of collaborative relationships (Evans et al., 2011; Fox & Mohapatra, 2007; Larivière et al., 2006) and the overwhelming proportion of research collaborations occur within them (Bozeman & Corley, 2004), we predict the climate within those local units will predict the quality of research

collaborations. Specifically, faculty who identify with multiply marginalized groups are likely to have similar experiences in terms of their department climate, perceiving it as less inclusive, equitable, and providing fewer opportunities to have a voice in department matters; these climate experiences in turn, will be associated with less favorable research collaborations in house.

Method

Participants

Faculty members from a large public research university in the Northeastern United States were recruited to participate in a survey about their professional experiences at the university. This paper focuses on the sample of faculty from STEM departments ($N = 441$). STEM was defined using the National Science Foundation standards and included departments of biological and life sciences, physical sciences, mathematics and statistics, engineering, information and computer sciences, social sciences, linguistics, and management sciences. Recruitment was conducted using a multipronged strategy. An initial e-mail was sent to all university faculty through the Offices of the University Chancellor and Provost. In this communication, the Chancellor personally endorsed the importance of the survey to the campus; appended to his message was the survey and instructions from the research team. One month later, the Deans of each college or school within the university sent a reminder to faculty in their unit. The Deans followed up with a second and final reminder a month after that.

In total, 61.2% of all faculty in above-mentioned STEM departments (441 out of a total 721 faculty) completed the survey, which is a high response rate. Of this sample, 48% were men ($n = 210$), 44% were women ($n = 194$), 0.2% were gender non-binary ($n = 1$), and 8% percent preferred not to answer the gender question ($n = 36$). Note that percentages are rounded so sums of individual categories may not equal exactly 100%.

In terms of race and ethnicity, 72% were White ($n = 317$), 9% Asian or Pacific Islander ($n = 38$), 5% Hispanic or Latinx ($n = 24$), 2% African American or Black ($n = 10$), 1% multiracial ($n = 4$), 0.2% American Indian or Alaska Native ($n = 1$), 3% indicated “other” ($n = 12$), and 13% did not answer the question ($n = 59$). Taken together, 9% of the sample ($n = 38$) self-identified as members of underrepresented racial/ethnic groups (Black, Hispanic, or Native American). In terms of sexual orientation, 10% of respondents ($N = 44$) identified as lesbian, gay, bisexual, or queer (LGBQ), 75% identified as heterosexual ($N = 331$), and 15% did not answer the question ($N = 66$). No faculty identified as transgender, so we use the abbreviation “LGBQ” instead of “LGBTQ” when referring to sexual minorities in our sample. Overall, this sample was representative of the population of faculty at this university in terms of gender and race/ethnicity.

Measures and Procedures

The Institutional Review Board of the authors’ university reviewed and approved the study protocol prior to data collection. After providing informed consent the survey was administered online via Qualtrics. Participants were assured that their responses were confidential and individual-level data would not be shared with department chairs, university leaders, or other faculty. Only aggregated summaries of findings were shared with university leaders and all faculty. No deception was employed. Faculty could optionally provide their e-mail address at the conclusion of a survey to enter a prize drawing; the list of e-mail addresses for the prize drawing were collected and stored on a spreadsheet independent of the survey data. The survey assessed several aspects of faculty professional experiences at the university including: (1) collaboration experiences; (2) workplace culture and climate, including perceptions of equity between majority and minority groups; (3) transparency of department

governance, including tenure and promotion; and (4) demographics. The survey took no more than 10 minutes to complete. See Supplement A in the [online supplement](#) for all survey items reported in this manuscript.

Survey Items

Research collaboration. Four questions asked participants to indicate how satisfied they were with their collaboration experiences at the university. Faculty reported: (1) the frequency of opportunities to collaborate on research with other faculty at the university on a 5-point scale ranging from 1 (*Never*) to 5 (*All the time*); (2) percent of their own research program spent in collaboration with other faculty at the university on a 10-point scale from 1 (*Under 10%*) to 10 (*91%-100%*); (3) enjoyment of research collaboration with other faculty at the university on 5-point scale from 1 (*Dislike very much*) to 5 (*Like very much*), and (4) satisfaction with opportunities for research collaborations at the university on 5-point scale ranging from 1 (*Very dissatisfied*) to 5 (*Very satisfied*).

Local culture and climate. Three sets of questions assessed faculty perceptions of local climate. These climate measures, including interpersonal relationships, perceptions of equity, and transparency of decision-making, initially emerged as significant to faculty collaboration experiences in a pilot study (Misra et al. 2017). The first set of measures focused on interpersonal relationships among faculty on dimensions related to collegiality and inclusion and contained 12 items. Eight of these asked respondents to evaluate the degree to which their department was collegial, collaborative, cooperative, inclusive, supportive, equitable, fair, and respectful on a series of bipolar scales ranging from -2 to +2 anchored by positive and negative words. Two items asked participants if they felt accepted and connected to their department on a 5-point scale ranging from 1 (*Not at all*) to 5 (*Extremely*). Two more items asked participants to

evaluate how satisfied they were with their professional interactions with faculty colleagues, and social interactions with faculty colleagues at the university on 5-point scales ranging from 1 (*Very dissatisfied*) to 5 (*Very satisfied*).

The second set of questions tapped perceptions of equitable treatment of faculty from minority groups relative to majority groups. These items asked about the treatment of faculty along lines of race and gender in terms of recruitment, promotion, access to professional development opportunities, and resources. For example, the question targeting gender equity inquired about how similarly or differently men and women faculty were treated in the department. Participants responded on a 5-point scale ranging from 1 (*Women often get preferential treatment*) to 5 (*Men often get preferential treatment*); the midpoint of the scale, 3, represented gender equality (*Men and women get treated equally*). The question targeting racial equity inquired about how similarly or differently faculty of different races and ethnicities were treated in the department. Participants responded on a 5-point scale ranging from 1 (*Racial minority faculty often get preferential treatment*) to 5 (*White faculty often get preferential treatment*); the midpoint of this scale, 3, represented racial equality (*White and racial minority faculty get treated equally*).

The third set of questions regarding transparency of department governance comprised eight items. Of these, two items asked participants to evaluate if the criteria for tenure and promotion were clear using 5-point scales ranging from 1 (*Not clear at all*) to 5 (*Very clear*). Six additional items asked participants to evaluate other aspects of department governance. Specifically, one item asked about the degree of transparency in decision-making related to policies, procedures, and personnel actions (e.g., tenure and promotion, merit raises, etc.) on a 5-point scale from 1 (*Never transparent*) to 5 (*Always transparent*). Three items asked participants

to evaluate how consultative their department head was; how much the department head valued the respondent's opinion in department matters; and how approachable the head was when the respondent had concerns about departmental matters. Responses to these questions were given on 5-point scales with 1 being the most negative and 5 being the most positive. These three questions were not displayed for respondents who indicated they were department head. One item asked faculty how much their colleagues valued their opinion in department decision-making on a 5-point scale of 1 (*Don't value at all*) to 5 (*Value very much*). A final item asked faculty to report the extent to which decision-making processes in their department were fair on a scale of 1 (*Never fair*) to 5 (*Always fair*).

Results

Descriptive statistics

To investigate the association between underrepresented identities and research collaboration we created a variable representing participants' self-reported identities based on their gender, race, and sexual orientation. Faculty who identified themselves as being in one underrepresented group in academia based on their gender, race-ethnicity, or sexual identity were given a score of "1." This includes women faculty, Black, Hispanic, and Native American faculty, and sexual minority faculty (see Table 1 for full classification of underrepresented identities). Per the definition of the National Science Foundation, Asian male faculty were not included in the URM category (Rivers, 2017). To account for the experiences of faculty from intersecting underrepresented identity groups, we created an aggregate underrepresented identity index. For example, if an individual identified as a member of one underrepresented group, they received a score of 1 (e.g., a straight White woman or a gay White man). If an individual identified with more than one underrepresented group, they received a score of 2 or 3 (e.g., a

straight Black woman would have a score of 2, and a lesbian Black woman would have a score of 3). This resulted in an underrepresented (UR) identity variable with three levels: (1) membership in zero UR identity groups (i.e., heterosexual White men or heterosexual Asian men), (2) membership in one UR identity group, (3) membership in two or more UR identity groups. Based on the UR identity variable described above, 46% identified as belonging to no UR groups ($n = 162$), 37% identified with one UR group ($n = 132$), and 17% identified with two or three UR groups ($n = 59$; see Table 2).

Creating composite variables for collaboration experiences and department climate

The primary dependent variable of interest was collaboration, which comprised four items measuring 1) frequency of opportunities for collaboration, 2) percentage of research program spent in collaboration, 3) how much respondents enjoyed collaborating, and 4) satisfaction with collaboration opportunities. These items were standardized to account for different response scales; all ratings were all highly intercorrelated ($\alpha = .75$). The standardized responses were averaged to create a single index labeled “Collaboration.”

The 22 items from three categories (i.e., quality of interpersonal relationships among faculty, equity across identity groups, and transparency of department governance) assessing department culture and climate were standardized and a principal components analysis (PCA) was conducted with varimax rotation to reduce these items into a smaller number of thematic clusters based on conceptual meaning as well as inter-item correlations. The PCA returned four rotated factors with eigenvalues greater than 1 that, together, accounted for 72.1% of the total variance. The first three factors captured conceptually meaningful themes.

The first factor accounted for 53.7% of variance in responses and consisted of 18 items that, collectively, captured quality of faculty relations. Items included questions about

collegiality, collaboration, cooperation, inclusion, support, fairness, respect, feeling connected and accepted, satisfaction with professional and social interactions within the department, transparency of decision-making, voice in departmental matters, feeling that one's opinions are valued by faculty colleagues and the department head. We averaged the standardized responses to create an index labeled "quality of faculty relations."

The second factor accounted for 7.1% of variance and comprised two items that measured perceived equity in the treatment of majority and minority groups—the degree to which participants felt that faculty were treated equitably based on gender and race/ethnicity. We calculated participants' mean response to these two questions to create an index labeled "equity."

A third factor accounted for 5.4% of the variance and comprised two items that measured the perceived transparency of tenure and promotion decisions (both promotion to associate professor and promotion to full professor). We calculated the mean response to these two questions to create an index labeled "transparency of tenure and promotion decisions."

Underrepresented identities, collaboration, and department climate

We conducted several Analyses of Variance (ANOVAs) using underrepresented identities (0 underrepresented identities, 1 underrepresented identity, 2 or more underrepresented identities) as between-subject factors with two polynomial contrasts. We choose an ANOVA approach because it allows for a comparison of both the experiences of those with zero underrepresented identities and participants with any amount of underrepresented identities and also a comparison of each group (e.g., 0 underrepresented identities, 1 underrepresented identity, 2 or more underrepresented identities) to the other two groups. The first contrast compared the group with 0 underrepresented identities to the other two groups to examine whether membership in any underrepresented group contributes to systematically different experiences

for faculty (contrast 1). The second contrast tested if membership in multiple underrepresented identity groups had a linear effect on faculty experiences (contrast 2; See Table 3 for contrast weights). The four dependent variables used in these ANOVAs assessed faculty experiences regarding collaboration, quality of faculty relations, equity, and promotion criteria.

Collaboration

Consistent with Hypothesis 1 and Hypothesis 2, a significant main effect of UR identity indicated reliable differences in collaboration experiences between faculty who had no UR identities ($M = 0.13$, $SE = 0.06$), one UR identity ($M = -0.01$, $SE = 0.07$) and two or more UR identities ($M = -0.17$, $SE = 0.10$), $F(2, 337) = 3.64$, $p = .027$. Note that the means for this index, as well as the quality of faculty relations index, were calculated after standardizing each variable so the absolute values are relatively small compared to the coding of the answers to the questions in non-standardized form. Both polynomial contrasts analyses were significant (contrast 1: $t = -2.62$, $p = .009$; contrast 2: $t = -2.59$, $p = .010$) indicating that STEM faculty who identified with multiple underrepresented groups, had worse research collaboration experiences than their colleagues who had fewer or no marginalized identities (See Table 4 for all ANOVA results and Figure 1 for a graph of all linear trends.)

Quality of Faculty Relations

A significant main effect of UR identity indicated significant differences in the perceived quality of faculty relations within the department as reported by participants with no UR identity ($M = 0.21$, $SE = 0.05$), one UR identity ($M = 0.06$, $SE = 0.06$) and two or more UR identities ($M = -0.25$, $SE = 0.10$), $F(2, 350) = 9.16$, $p < .01$. Both polynomial contrasts were significant: faculty with 0 UR identities (i.e., faculty from majority groups) had significantly more positive perceptions of the quality of faculty relations in their department than their colleagues from

underrepresented groups ($t = -3.91, p < .01$) and a significant negative linear trend also emerged for quality of faculty relations ($t = -4.26, p < .01$). Overall, these outcomes show that faculty from multiple underrepresented groups had progressively worse perceptions of the climate in their home departments.

Equity

A significant main effect of UR identity indicated reliable differences in perceptions of equitable treatment across gender and race groups between participants with no UR identity ($M = 3.04, SE = 0.05$), one UR identity ($M = 3.50, SE = 0.07$) and two or more UR identities ($M = 3.89, SE = 0.10$), $F(2, 308) = 33.66, p < .01$. Note that the questions comprising this index had response options on identical scales so there was no need to standardize before calculating a mean. Both polynomial contrasts were significant (contrast 1: $t = 8.28, p < .001$; contrast 2: $t = 7.52, p < .001$) indicating that identification with multiple underrepresented groups predicted progressively worse perceptions of gender and race equity.

Transparency of Tenure and Promotion Decisions

A significant main effect of UR identity indicated reliable differences in perceptions of transparency of tenure and promotion criteria between participants with no UR identity ($M = 3.65, SE = 0.08$), one UR identity ($M = 3.33, SE = 0.08$) and two or more UR identities ($M = 3.05, SE = 0.13$), $F(2, 325) = 8.82, p < .001$. Note that the questions comprising this index had response options on identical scales so there was no need to standardize before calculating a mean. Both polynomial contrasts were significant (contrast 1: $t = -4.14, p < .001$; contrast 2: $t = -3.95, p < .001$) indicating that added layers of underrepresentation predicted less clarity around tenure and promotion criteria; that effect is most strongly driven by differences between those with no UR identities and the other two groups.

Climate mediates relation between underrepresented identities and collaboration in STEM

To test Hypothesis 3 regarding the role of department climate in mediating the differential experiences of multiply marginalized faculty in terms of research collaboration, we conducted a series of mediational tests using the PROCESS macro (Hayes, 2013), a computational tool used to conduct moderation and mediation statistical analyses. In three separate mediational models, UR identity was entered as the predictor variable, collaboration was the dependent variable, and each of three indices of department climate (i.e., quality of faculty relations, perceived equity, and transparency of tenure and promotion) were entered as proposed mediators in separate analyses (see Figure 2 for a conceptual diagram).

To determine if all three mediators contributed equally in influencing faculty experiences with research collaborations or if one mediator accounted for the most variance, we conducted a multiple mediation using PROCESS with UR identities as the independent variable, collaboration as the dependent variable, and all three indices of department climate as simultaneous multiple mediators (i.e., quality of faculty relationships, equitable treatment of majority vs. minority groups, and transparency of tenure and promotion decisions, see Figure 2).

Results showed that when multiple mediators were entered into the model, only quality of faculty relations was a significant mediator. Specifically, membership in multiple UR identity groups in STEM significantly predicted less positive research collaboration experiences which was significantly mediated through less positive faculty relations in the department (indirect effect: $B = -0.14$, $SE = 0.04$, 95% $CI = -0.22, -0.08$) but not through perceived equity (indirect effect: $B = 0.02$, $SE = 0.03$, 95% $CI = -0.03, 0.08$) nor transparency of tenure and promotion decisions ($B = 0.01$, $SE = 0.02$, 95% $CI = -0.02, 0.04$). See Table 5 for all statistics.

In summary, faculty from multiple underrepresented identity groups perceived their department climate to be less collegial and inclusive than their colleagues with fewer or no underrepresented identities. More negative perceptions of department climate, in turn, predicted less satisfaction with research collaborations at the university. The specific component of department climate that played a critical mediating role in influencing research collaboration was the quality of faculty relations—the degree to which respondents felt their relationships with their departmental colleagues were cooperative, non-competitive, inclusive, respectful, and so on. Faculty from multiple UR identity groups also perceived less gender and racial equity, as well as less transparency around tenure and promotion decisions as compared to their colleagues from majority identity groups, but these differences did not account for any additional variance in collaboration experiences once the quality of faculty relations within the department was factored into the model.

Discussion

This study compares the collaboration experiences of faculty across multiple marginalized groups to identify how gender, race, and sexual orientation – and their interactions – shape research collaboration. Based on a survey of STEM faculty at a large public research university, we find that faculty from underrepresented groups – including women faculty, faculty from underrepresented racial minority groups, and LGBTQ faculty – had more negative experiences with internal research collaborations. Additionally, faculty with multiply marginalized identities had worse collaboration experiences than others with a single marginalized identity or none. Additionally, this study identifies the role of department climate in shaping collaboration experiences. Faculty from multiple marginalized groups perceive their department climate to be less inclusive, equitable, and transparent; and felt their opinion was less

valued in the department than colleagues from majority groups. Negative department climate, in turn, mediates and predicts less hospitable experiences with department-level research collaboration. Despite important differences between and among minoritized faculty, these data suggest that multiply marginalized faculty do share some common experiences of a “chilly” department climate relative to their peers from majority groups. This “chillier” climate impedes opportunities for scientific collaboration.

Research collaboration is crucial to academic work, particularly as team science has become more prevalent and impactful in STEM fields. Given the increased relevance of collaboration, and ongoing efforts to diversify university faculty, it is notable that previous studies have not examined how researchers from *multiply marginalized* groups experience team research compared to those from majority groups. Our research was driven by three hypotheses aimed at illuminating how gender, race, and sexuality overlap to influence experiences of internal research collaboration, and the degree to which these influences can be explained by aspects of local department cultures. First, we hypothesized that STEM faculty from marginalized underrepresented groups (i.e., gender, race, and/or sexuality) would report less favorable research collaboration experiences in terms of opportunities for, and satisfaction with, such collaborations at their institutions. Second, we predicted cumulative negative experiences for multiply marginalized faculty compared to their colleagues from identity groups that must contend with fewer or no marginalized identities. Even though each identity group and the ways in which individuals experience those identities are distinct, we predicted some shared experiences would emerge for faculty members who were increasingly distant from the “ideal scientist” prototype. Third, we hypothesized that variations in department climate—specifically as related to the quality of faculty relationships, equity, and/or transparency of personnel

action—would mediate and explain the relation between underrepresented group membership and research collaborations.

Consistent with our first two hypotheses, we found that faculty members who identified with one or more marginalized identity groups experienced progressively worse research collaboration experiences. Each added layer of marginalization had a cumulative negative impact. Our findings speak to the importance of examining the psychological antecedents of collaboration and its impact on success for underrepresented faculty (see Bozeman et al., 2013). Specifically, our findings suggest that providing formal collaboration opportunities for underrepresented faculty may not be sufficient unless they are accompanied by broader initiatives to enhance department climate in terms of faculty relations, perceived equity, and voice in governance.

Furthermore, we found similar effects of multiply marginalized status on faculty members' perception of the quality of faculty relations in their department, gender and race equity, and the transparency of personnel actions. In short, STEM faculty who were positioned furthest away from the heterosexual White male prototype, with various intersecting identities (in terms of race, gender, and/or sexuality) had the worst experiences with research collaboration as well as various aspects of department climate.

Our findings complement previous research that found gender or racial status can impede research collaboration (Bozeman & Gaughan, 2011; Freeman & Huang, 2015; Pinheiro & Melkers, 2011), by demonstrating the combined effects of multiple underrepresented identities on STEM faculty's team research experiences. Further, our findings reveal that these effects are explained by lower quality relations among faculty and feeling less heard by one's colleagues and department head. These results complement Gaughan et al.'s (2018) finding that gender and

race intersect to confer advantages to White men in the form of disproportionate access to instrumental resources. Our data extend their analysis by revealing common disadvantages experienced by multiple types of groups—faculty who are women, Black or Latinx, sexual minorities, or all the above—regarding both collaboration and department culture. While our research does not capture nuanced within-group diversity theorized by intersectionality scholars (Browne & Misra, 2003; McCall, 2005), it is striking that different configurations of outsider status (race, gender, sexuality) resulted in shared experiences of marginalization that had similar ripple effects on scientific research collaboration to the detriment of their academic careers. In short, the climate becomes even “chillier” for individuals who are furthest from the traditionally masculine, White, and heterosexual “ideal scientist” norm.

Regarding the third hypothesis, we found that while perceived inequity across identity groups and lack of transparency in tenure and promotion were significant mediators when considered individually, the most important mediator that explained variations in internal research collaboration experiences was the overall quality of faculty relations within the department. Crucially, this included informal interactions that were collegial, cooperative, non-competitive, and supportive—characteristics that capture communal rather than transactional relationships—wherein faculty engage with each other without expectations of strict reciprocity. Another important component of high-quality relations was when faculty felt that they had voice in department decision-making and that their colleagues and department head valued their opinion as equals. Some literature suggests that faculty from underrepresented minority groups tend to rely on external collaborations, with negative organizational climates “pushing” URM faculty to locate collaborators outside their home institutions (Mehra et al., 1998; Pinheiro & Melkers, 2011). Our results provide further evidence that routine interactions and relationships

shape the collaboration networks of faculty, suggesting that women, URM, and LGBTQ faculty facing negative internal dynamics might avoid research collaboration opportunities within their departments. Success in STEM research depends not only on access to material resources, such as funding or lab space, but also on informal or expressive support, including communality and collegiality.

Limitations and Future Directions

The present study focused on faculty at one large public university; future research is needed to test the generalizability of these findings to other universities. We have a diverse and large sample to compare faculty from majority groups and those from underrepresented identity groups, and to examine common experiences among faculty from multiply marginalized groups. That said, we also recognize that our approach does not capture the nuanced and differentiated experiences of faculty that will likely vary as a function of intersectional identities and social contexts. Future research should focus on the interaction among statuses, including qualitative studies exploring variations within and among groups of faculties to capture complex intersectional mechanisms of inclusion and exclusion. For example, will Black women faculty at other types of institutions have similar perceptions of department climate and similar experiences with collaboration? Will the experience of multiply marginalized faculty in departments where they are the only person with such a confluence of identities look different from the experience of another faculty member with similar identities but located in a department where there is a cluster of faculty members with shared identities? What are the common experiences and what are the unique experiences of intersectional identities? Additionally, the minority categories used in this study aggregates diverse populations with varying degrees of representation. Larger scale studies should disaggregate heterogeneous subgroups (e.g. URM, Asian, LGBTQ) to assess

whether they vary systematically in terms of perceived climate and/or research collaboration, and if so, why. Finally, it is striking that, relative to racial and gender minorities, noticeably less research has highlighted adversity faced by LGBTQ university faculty with regard to themes of institutional culture and research collaboration.

Ours is a correlational study that prevents claims of causation. While experiments testing our hypotheses would be ethically and practically impossible to conduct, future research could test our hypotheses longitudinally to assess whether changes in department demographics over time within the same organizational unit produces subsequent changes in culture and collaboration success. Future research could also consider the experiences of foreign-born faculty to further parse how their experiences differ from their US-born colleagues and in light of the various underrepresented identities considered in this project.

While our study focused on respondents' perceptions of collaboration opportunities and satisfaction, we did not consider a possible relation between collaboration satisfaction and research productivity measured by objective metrics. Future investigations could expand on these findings by examining whether faculty from multiple underrepresented identity groups who experience department climate as less favorable are also negatively impacted in terms of quantifiable collaborative products, such as a history of co-authored publications.

Finally, future research would also benefit from a more rigorous unpacking of the components that comprise climate in academic STEM departments. For example, the metric "quality of faculty relations" reported here included collegiality, cooperation, social support, inclusivity, fairness, and respect, combining both professional and social interactions among colleagues, which functioned similarly without differentiation. More robust sampling may reveal that these different components of department climate have differential influences on research

collaboration as compared to other aspects of professional success for underrepresented faculty in STEM.

Practice Implications

The results of our study have several implications for interventions and programs aimed at promoting equity and inclusion among STEM faculty. An important implication of our findings is that the most effective policies and practices for multiply marginalized STEM faculty are likely to be ones that drill down to local departments, because that is the social context that is most important in faculty members' everyday life. By narrowing this project specifically to local experiences, we can use these findings to identify key fault lines that exist at the department level. The exclusion of women and minority faculty from research teams and collaboration may not be conscious, nevertheless in STEM fields the numerically underrepresented and cultural outsider can be tacitly overlooked in professional conversations (Dasgupta, 2016) and from opportunities to the detriment of their careers (Griffith & Dasgupta, 2018). Because we know most collaborations happen at the local level, action by department leaders and influencers are critical to shift social norms and make change. Important consequences of more favorable department climate include greater retention of underrepresented faculty, equitable thriving in research careers, and timely career progression for all STEM faculty (Misra et al., 2017).

We offer three recommendations for policymakers and administrators to inform institutional policies and practices based on our findings. First, to support the careers of multiply marginalized STEM faculty, institutions and departments must design intellectual norms and practices to establish inclusive research communities, create space for faculty to learn about each other's research, give and receive feedback, build trust, and create social and professional glue. Creating equitable opportunities for faculty to collaborate internally on research is crucial. This

may take the form of regular seminars or informal “chalk talks” where faculty present to their colleagues, with priority given to early career faculty and others from underrepresented groups to exchange ideas and create opportunities for new collaborations. Internal seed funding opportunities might incentivize local collaborations or require research teams to outline their approach to equity and inclusion. For these practices to take hold, senior faculty and influencers need to be attentive to the needs of underrepresented faculty, providing mentorship and acting as sponsors and advocates for their colleagues from underrepresented groups.

Second, our findings make clear that institutions and departments must also increase faculty awareness of the needs of their marginalized colleagues and highlight how the latter’s collaboration experiences are often different from that of majority groups, thereby reducing blind spots in the context of research collaborations. One way to do this is to offer faculty trainings on how to create emotionally intelligent teams using evidence-based best practices to maximize productivity in team science as well as the satisfaction of all members (Davidson & Purdie-Greenaway, 2019; Druskat & Wolff, 2001). Such trainings would be particularly powerful if they are incentivized and yoked to research ideation meetings that occur at universities in response to calls for team grants from federal agencies.

Third, universities could encourage faculty embarking on team research to create an internal memorandum of understanding after discussing the roles and responsibilities of all team members. Such an explicitly articulated activity would minimize conflicts that arise from unspoken assumptions that often work to the detriment of faculty who have less power, typically faculty from underrepresented groups and early career faculty.

Conclusion

Research collaboration can offer faculty members career benefits, in terms of productivity, as well as interpersonal resources including mentorship, friendship, and a sense of belonging. However, faculty from underrepresented groups in STEM experience unique challenges to their collaborations, with exclusion from collaboration networks part of the chilly climate for women, faculty of color, and LGBTQ faculty. The STEM faculty from underrepresented groups in our study are diverse in their identities and departments, and yet their experiences show some common patterns based on configurations of intersecting identities: the more their outsider status in departments and disciplines in identity positionality, the chillier the climate they experienced, which had downstream consequences for research collaborations. Understanding these shared experiences of institutional climate and collaboration opportunities is a crucial first step in alleviating intersectional inequalities in STEM faculty careers.

Declarations

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Conflicts of Interest

The authors declare no conflicts of interest.

Availability of Data and Material

The dataset generated and analyzed during the current study are available from the corresponding author on reasonable request.

Code Availability

Not applicable.

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Table 1***Classification of Underrepresented (UR) Identities of Faculty Survey Participants***

Identity Group	Well represented Identities in STEM	Underrepresented Identities in STEM
Gender	Male	Female, Non-binary
Race	White, Asian	Black, Hispanic or Latinx, Native American
Sexual Orientation	Heterosexual	LGBQ

Table 2*Underrepresented (UR) identities of faculty survey participants*

# of UR identities	Gender	Race	Sexual Orientation	<i>N</i>
0	Man	White	Heterosexual	140
0	Man	Asian	Heterosexual	22
Total				162
1	Man	White	LGBQ	7
1	Man	URM*	Heterosexual	10
1	Man	Asian	LGBQ	3
1	Woman	White	Heterosexual	105
1	Woman	Asian	Heterosexual	7
Total				132
2	Woman	White	LGBQ	25
2	Woman	URM*	Heterosexual	23
2	Woman	Asian	LGBQ	3
2	Man	URM*	LGBQ	1
2	Non-binary	White	LGBQ	1
2-3 ⁺	Woman	URM*	No reply	2
2-3 ⁺	Woman	No reply	LGBQ	1
3	Woman	URM*	LGBQ	3
Total				59

Note. The category “URM” marked by an asterisk stands for “underrepresented racial and ethnic minorities.” The respondents marked with a cross (†) did not self-identify for one of the three

Table 3
Coefficients for Polynomial Contrasts

UR Identities	Contrast 1	Contrast 2
0	-2	-1
1	1	0
2+	1	1

Table 4*Influence of Underrepresented (UR) Identity Status on Measures of Faculty Professional Experiences*

Dependent Variable	Participant UR Identity Status	<i>M (SE)</i>	Main effect of UR Identity	Contrast 1 (0 UR Identities vs. 1 or more UR Identities)	Contrast 2 (0 UR Identities vs. 1 UR Identity vs. 2+ Identities)
Collaboration	0 UR Identities	0.13 (0.06)	$F(2, 337) = 3.64,$ $p = .027$	$t(337) = -2.62$ $p = .009$	$t(337) = -2.59,$ $p = .010$
	1 UR Identity	-0.01 (0.07)			
	2+ UR Identities	-0.17 (0.10)			
	Total	0.03 (0.04)			
Quality of Faculty Relations	0 UR Identities	0.21 (0.05)	$F(2, 350) = 9.16,$ $p < .001$	$t(350) = -3.91$ $p < .001$	$t(350) = -4.26,$ $p < .001$
	1 UR Identity	0.06 (0.06)			
	2+ UR Identities	-0.25 (0.10)			
	Total	0.08 (0.04)			
Equity	0 UR Identities	3.04 (0.05)	$F(2, 308) = 33.66,$ $p < .001$	$t(308) = 8.28$ $p < .001$	$t(308) = 7.52,$ $p < .001$
	1 UR Identity	3.50 (0.07)			
	2+ UR Identities	3.89 (0.10)			
	Total	3.37 (0.04)			
Transparency of Promotion Criteria	0 UR Identities	3.65 (0.08)	$F(2, 325) = 8.82,$ $p < .001$	$t(325) = -4.14$ $p < .001$	$t(325) = -3.95,$ $p < .001$
	1 UR Identity	3.33 (0.08)			
	2+ UR Identities	3.05 (0.13)			
	Total	3.43 (0.05)			

Note. The primary dependent variable of interest is collaboration.

Table 5

Mediational Model of Underrepresented Identity Differences in Perceived Climate by Collaboration

Independent Variable (X)	Mediator (M)	a path	b path	
		X --> M	M --> Y	a*b path (indirect effect)
UR Identity	Quality of Faculty Relations	$B = -0.27 (0.06)$, $p < .01$	$B = 0.53 (0.06)$, $p < .01$	$B = -0.14 (0.04)$, $CI: -0.22, -0.08$
	Equity	$B = 0.43 (0.05)$, $p < .01$	$B = 0.06 (0.06)$, ns	$B = 0.02 (0.03)$, $CI: -0.03, .008$
	Transparency of Tenure and Promo. Decisions	$B = -.350 (0.08)$, $p < .01$	$B = -0.02 (0.05)$, ns	$B = 0.01 (0.02)$, $CI: -0.02, 0.04$

Note. B represents regression coefficients; numbers in parentheses are standard errors; ns represent nonsignificant regression coefficients; and CI represent +/- 95% confidence intervals. Confidence intervals that do not straddle zero are statistically significant whereas confidence intervals that do include zero are nonsignificant. The outcome variable (Y) for all models is “Collaboration.” The overall B effect for the c path was $-0.03 (0.06)$ and was not statistically significant. Columns for Y and the c path were omitted from this table to improve readability.

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CHILLIER CLIMATE

Figure 1

Means of Collaboration, Quality of Faculty Relations, Equity, and Promotion Criteria by Number of Underrepresented Identities

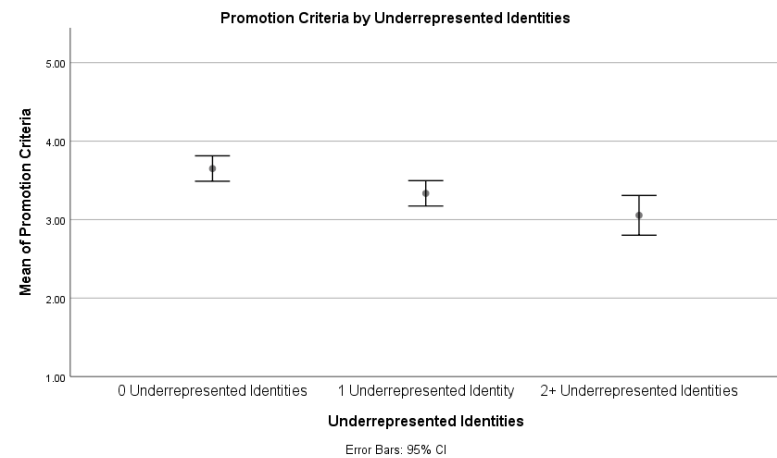
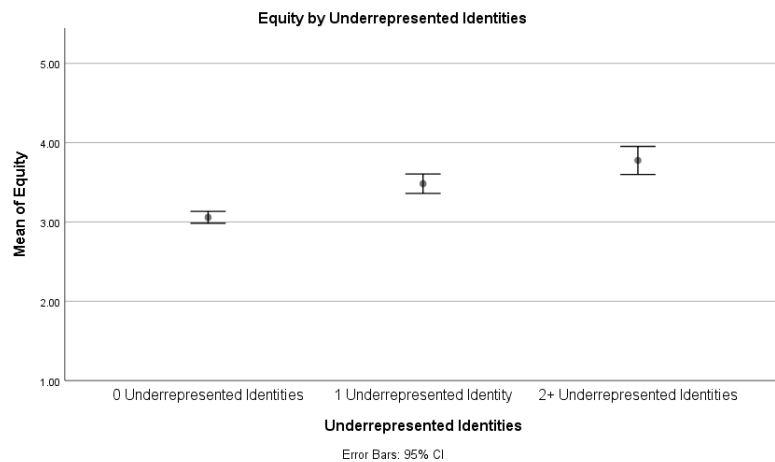
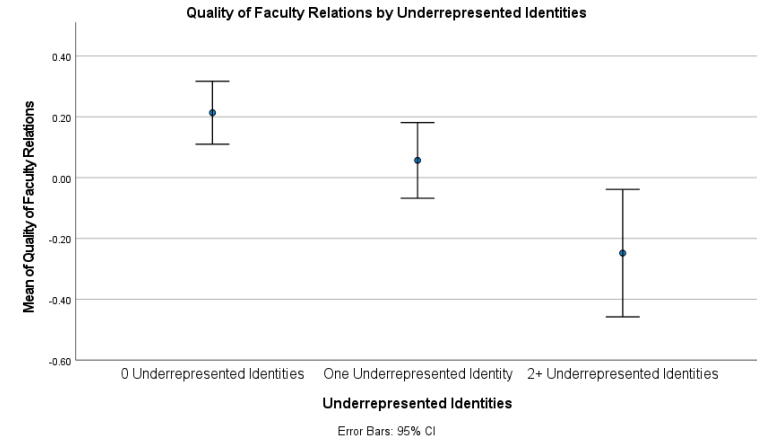
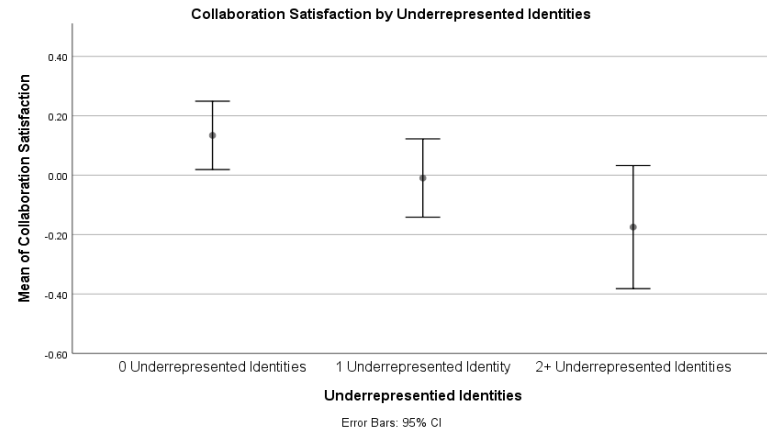
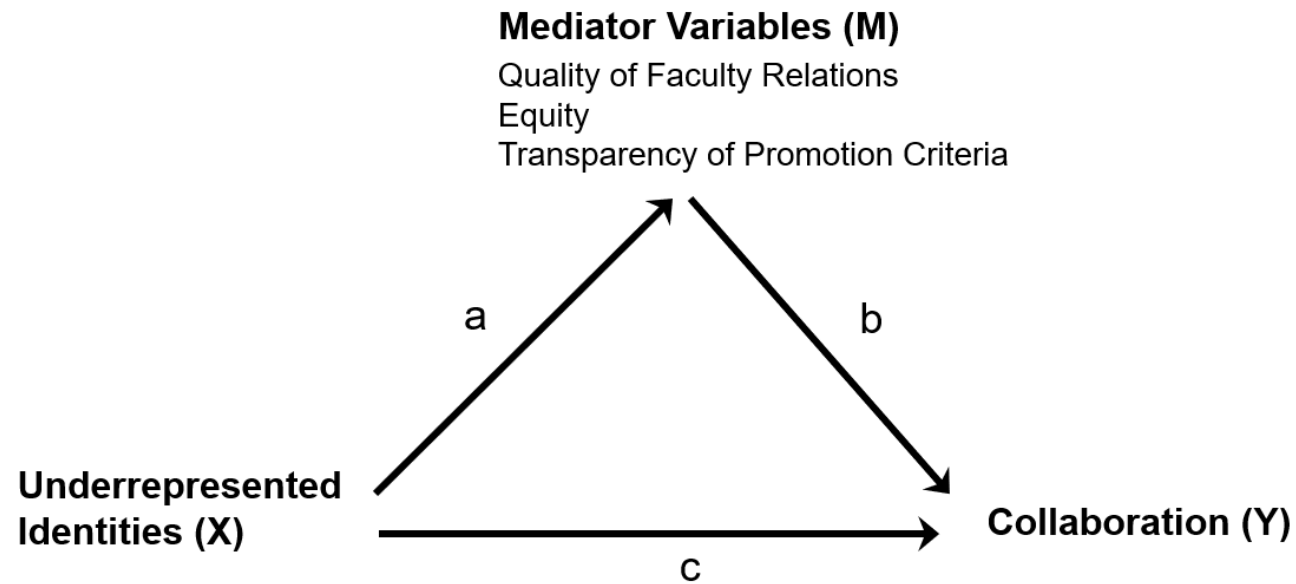


Figure 2

Conceptual Mediational Model Examining Whether Underrepresented Identity Differences in Faculty Members' Satisfaction with Collaboration is Mediated by Differential Perceptions of Quality of Faculty Relations, Equity, and Promotion Criteria



Note. Conceptual mediational model examining whether underrepresented identity differences in faculty members' collaboration success is mediated by differential perceptions of department climate.

Online supplement for Griffith, E.E., Mickey, E.L., & Dasgupta, N. (2021). A “chillier” climate for multiply marginalized STEM faculty impedes research collaboration. *Sex Roles*. Eric Griffith, Duke University. Email: eric.griffith@duke.edu

Supplement A: Survey items hosted on Qualtrics

Section 1: Collaboration Experiences

Q59 How often do you have opportunities to collaborate with other faculty at XXXX on research?

- ☐ Never (1)
- ☐ Rarely (2)
- ☐ Sometimes (3)
- ☐ Often (4)
- ☐ All the time (5)
- ☐ Not applicable (6)

Q60 What percent of your own research program is in collaboration with your faculty colleagues at XXXX?

▼Under 10% (1) ... n/a (11)

Q61 Do you like collaborating with faculty at XXXX on research?

- ☐ Dislike very much (1)
- ☐ Moderately dislike (2)
- ☐ Neutral (3)
- ☐ Moderately like (4)
- ☐ Like very much (5)
- ☐ Not applicable (6)

Q56 How satisfied are you with the amount of...

	Very dissatisfied (1)	Somewhat dissatisfied (2)	Neither satisfied or dissatisfied (3)	Somewhat satisfied (4)	Very satisfied (5)
...opportunities for research collaborations with faculty at XXXX? (3)	☐	☐	☐	☐	☐

Section 2: Workplace Climate

Q36 Please rate your department/program on the following dimensions

	-2 (1)	-1 (2)	0 (3)	1 (4)	2 (5)
Contentious (-2) to Collegial (+2) (1)	☐	☐	☐	☐	☐
Disrespectful (-2) to Respectful (+2) (2)	☐	☐	☐	☐	☐
Individualistic (-2) to Collaborative (+2) (3)	☐	☐	☐	☐	☐
Competitive (-2) to Cooperative (+2) (4)	☐	☐	☐	☐	☐
Unsupportive (-2) to Supportive (+2) (5)	☐	☐	☐	☐	☐
Inequitable (-2) to Equitable (+2) (6)	☐	☐	☐	☐	☐
Unfair (-2) to Fair (+2) (7)	☐	☐	☐	☐	☐
Isolating (-2) to Inclusive (+2) (8)	☐	☐	☐	☐	☐

Q37 Do you feel you connected to your department or program?

- ☐ Not at all connected (1)
- ☐ Slightly connected (2)
- ☐ Somewhat connected (3)
- ☐ Moderately connected (4)
- ☐ Extremely connected (5)

Q38 Do you feel accepted by colleagues in your department or program?

- ☐ Not at all accepted (1)
- ☐ Slightly accepted (2)
- ☐ Somewhat accepted (3)
- ☐ Moderately accepted (4)
- ☐ Extremely accepted (5)

Q39 In your opinion, do men and women faculty in your department/program receive equal treatment in areas of recruitment, promotion, career advice, and resources?

- ☐ Women often get preferential treatment over men (1)
- ☐ Women sometimes get preferential treatment over men (2)
- ☐ Men and women get treated equally (3)
- ☐ Men sometimes get preferential treatment over women (4)
- ☐ Men often get preferential treatment over women (5)
- ☐ I don't know (6)

Q40 In your opinion, do racial minority faculty and White faculty in your department/program receive equal treatment in areas of recruitment, promotion, career advice, and resources?

- ☐ Racial minority faculty often get preferential treatment over White faculty (1)
- ☐ Racial minority faculty sometimes get preferential treatment over White faculty (2)
- ☐ Racial minority and White faculty get treated equally (3)
- ☐ White faculty sometimes get preferential treatment over racial minority faculty (4)
- ☐ White faculty often get preferential treatment over racial minority faculty (5)
- ☐ I don't know (6)

Q56 How satisfied are you with the amount of...

	Very dissatisfied (1)	Somewhat dissatisfied (2)	Neither satisfied or dissatisfied (3)	Somewhat satisfied (4)	Very satisfied (5)
...professional interaction you experience with other faculty in your department or program? (1)	☐	☐	☐	☐	☐
...social interaction you experience with other faculty in your department or program? (2)	☐	☐	☐	☐	☐

Section 3: Transparency of Department Governance

Q42 How clear are the criteria for tenure and promotion and the process by which this decision is made at XXXX?

- ☐ Not at all clear (1)
- ☐ A little clear (2)
- ☐ Moderately clear (3)
- ☐ Quite clear (4)
- ☐ Very clear (5)
- ☐ I don't know (6)

Q45 How clear are the criteria for promotion to Full Professor and the process by which this decision is made?

- ☐ Not at all clear (1)
- ☐ A little clear (2)
- ☐ Moderately clear (3)
- ☐ Quite clear (4)
- ☐ Very clear (5)
- ☐ I don't know (6)

Q48 How transparent are the decision-making processes about policies, procedures, and personnel actions (besides tenure and promotion) in your department/program?

- ☐ Never transparent (1)
- ☐ Rarely transparent (2)
- ☐ Sometimes transparent (3)
- ☐ Usually transparent (4)
- ☐ Always transparent (5)
- ☐ I don't know (6)

Q49 How consultative is your department head or chair in making decisions?

- ☐ Never (1)
- ☐ Rarely (2)
- ☐ Sometimes (3)
- ☐ Usually (4)
- ☐ Always (5)
- ☐ I don't know (6)
- ☐ I am the head/chair (7)

Q50 In the decision-making process in your department, how much does your department head or chair value your opinion?

- ☐ Doesn't value at all (1)
- ☐ Values a little (2)
- ☐ Values moderately (3)
- ☐ Values quite a bit (4)
- ☐ Values very much (5)
- ☐ I don't know (6)

Q51 If you have any concerns about departmental issues, how often do you communicate these to your Head or Chair?

- ☐ Never (1)
- ☐ Rarely (2)
- ☐ Sometimes (3)
- ☐ Usually (4)
- ☐ Always (5)
- ☐ Not applicable (6)

Q52 In the decision-making process in your department, how much do your colleagues value your opinion?

☐ Don't value at all (1)

☐ Value a little (2)

☐ Value moderately (3)

☐ Value quite a bit (4)

☐ Value very much (5)

☐ I don't know (6)

Q53 Is the process by which decisions are made in your department/program fair?

☐ Never fair (1)

☐ Rarely fair (2)

☐ Sometimes fair (3)

☐ Usually fair (4)

☐ Always fair (5)

Section 4: Demographics

Q13 What is your gender?

- ☐ Woman (1)
- ☐ Man (2)
- ☐ Non-binary (5)
- ☐ Transgender (3)
- ☐ Other - please describe how you self-identify: (4)
-
- ☐ Prefer not to answer (8)

Q14 How do you identify in terms of sexual orientation?

- ☐ Bisexual (3)
- ☐ Heterosexual (1)
- ☐ Lesbian/Gay (2)
- ☐ Other (please specify) (4) _____
- ☐ Prefer not to answer (5)

Q15 Are you of Hispanic or Latino origin?

- ☐ No (1)
- ☐ Yes; Mexican, Mexican American, or Chicano (2)
- ☐ Yes, Puerto Rican (3)
- ☐ Yes, Cuban (4)
- ☐ Yes, another Hispanic or Latino origin (please specify) (5)
-
- ☐ Prefer not to answer (6)

Q16 What is your race?

- ☐ American Indian or Alaska Native (1)
- ☐ Asian or Pacific Islander (2)
- ☐ Black (3)
- ☐ White (4)
- ☐ Multi-racial (5)
- ☐ Other (please clarify): (6) _____
- ☐ Prefer not to answer (7)

A “Chillier” Climate for Multiply Marginalized STEM Faculty Impedes Research Collaboration

Compliance with Ethical Standards

Funding

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Conflicts of Interest

The authors declare no conflicts of interest.

Institutional Review Board

This project was approved by the Institutional Review Board at the University of Massachusetts Amherst. The informed consent, which was attached to the survey instrument referenced in this submission, is pasted below for reference under the header “ELECTRONIC CONSENT FORM.”

ELECTRONIC CONSENT FORM

Investigators: Nilanjana Dasgupta, Ph.D., Psychological & Brain Sciences, Joya Misra, Ph.D., Sociology, and Laurel Smith-Doerr, Ph.D., Sociology.

Purpose of this Survey: UMass Amherst is conducting an important survey to learn about faculty members' experiences at UMass: Is there equity in the distribution of resources to promote faculty success, access to professional networks on campus, and access to an inclusive community? What is going well? What areas need improvement? We would like you to fill out an online survey so that we can understand your experiences. The survey is voluntary and will take 15-20 minutes. We ask about your research, professional relationships at UMass, the culture and decision-making norms within your department/program, access to faculty mentoring, professional satisfaction, and other demographics. We know there are multiple demands on your time, but we hope you will take a few minutes to complete this survey. You may skip any questions that you prefer not to answer. The survey is web-based and has been optimized for completion via PC, phone or tablet.

Benefits. This survey is aimed at identifying the strengths and challenges of your professional environment to help the university develop a forward-thinking plan that benefits you and all faculty. We are surveying every faculty member at the university because we want to have everyone's perspective represented in our results. The results will guide new programs to promote faculty development, and influence access to campus resources, to target the needs that emerge from this survey. We hope that these new programs will benefit you and your colleagues. However, all individual respondents may not experience a direct benefit from participating in this survey.

Risks and Discomfort. You will be asked simple questions about your research, teaching, service, etc. The questions may elicit psychological discomfort in some survey-takers if the person has had negative professional experiences on campus. This discomfort is similar to what one might feel while discussing one's work experiences with a colleague or friend. We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a breach of confidentiality is possible. To the best of our ability, your answers in this study will remain confidential. We will protect your confidentiality and minimize any risk of disclosure by assigning a random number to each survey, which will serve as an anonymous numeric code for each survey-taker. We will then strip away all demographic information from each survey (college/school, department, rank, race/ethnicity, gender, gender identity, etc), and store this information in a separate file linked only to the numeric code for each survey-taker. No responses to other (non-demographic) survey questions will be in this data file. A second file will

contain all other survey responses linked to numeric codes but no demographics. These two types of data will be kept in separate password-protected files in password-protected computers. By separating your demographics from your survey responses protects the confidentiality of your responses even if there were a breach because your answers to questions will not be associated with any unique characteristics that identify individuals such as their demographics, rank, or department affiliations. Individuals' decision to participate or not will have no bearing on their standing/employment and results will only be used to assess faculty experiences in their departments. Although we hope that you will fully participate in this survey, please understand that your participation is entirely voluntary and that you have the right to withdraw consent or discontinue participation at any time without penalty. You may also skip any questions that make you uncomfortable.

Costs and Compensation. All participants are eligible to win prizes from a random drawing. Prizes include an iPad, dinner at the University Club, and tickets to the Fine Arts Center Performances. To enter the drawing, you will be asked to send your email address for prize notification in a web-form that cannot be linked to any survey responses. Email addresses for the prize drawing will not be kept after the prizes are distributed.

Length of the Study. The survey will take 15-20 minutes.

Confidentiality. Your responses are confidential and will be analyzed only after being grouped together with faculty across departments. Only the researchers analyzing these data listed in this protocol will see individual level survey responses. Data files will be saved on password-protected computers with access restricted to the researchers on this protocol. Aggregation of results across departments allows us to protect the identity of respondents who are in small numbers in their department. Names will not be linked to responses (only anonymous numeric codes will be attached to individual surveys) and no individuals will be identifiable in any reports, presentations or publications of the results. A high-level summary of results will be shared with each college/school – but no specific data will be shared. If scholarly publications result from this survey, as per rules of many journals that require data-sharing as does the National Science Foundation that funds this survey, de-identified data may be made available to other researchers upon request in a form where individuals cannot be identified—e.g., data averaged across departments or stripped of demographics.

Request for Additional Information. You may ask questions about this research at any time. Dr. Nilanjana Dasgupta, is available by email (dasgupta@psych.umass.edu), telephone (413-545-0049), or postal mail (Department of Psychological & Brain Sciences, Tobin Hall, University of Massachusetts, Amherst, MA 01003) to answer your questions and concerns now and after your

participation in this survey if you would like. If you would like to speak with someone not directly involved in the survey, you may contact John McCarthy, Provost (jmccarthy@provost.umass.edu, 413-545-6223). If you have any questions regarding your rights as a research participant, please contact the Human Research Protection Office at (413) 545-3428 or HumanSubjects@ora.umass.edu. If, for some reason, you find that you are distressed by any part of survey, you may also contact the Health Services at UMass (545-9602) or the Psychological Service Center at UMass (545-0041) for counseling.

If you wish, please print out a copy of this consent form for your records.

Electronic consent: I understand that by clicking the “Click Here to Begin Survey” button below I am signing this form and therefore am providing informed consent to participate in this survey. I have had a chance to read this consent form. I understand that I can skip any questions that I don’t want to answer; I can also quit the study at any time without penalty.

This is a placeholder document. All revision notes are included with the manuscript, per editor's instructions.