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Part 1: ADVANCEing women faculty in STEM

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Guest editorial

ADVANCEing women faculty in STEM: empirical findings and practical recommendations from National Science Foundation ADVANCE institutions

Since its foundation in 2001, the US National Science Foundation's (NSF) ADVANCE program has invested over $315m to support initiatives at more than 175 institutions of higher education (IHEs) and STEM-related nonprofit organizations. ADVANCE is a cross-disciplinary program focused on broadening the participation (BP) of diverse people and institutions. Programs within the ADVANCE portfolio focus on increasing the representation and advancement of women and underrepresented minorities (URM) in academic STEM careers, developing mechanisms to promote gender equity in the STEM academic workforce, and aiding in diversifying the science and engineering workforce. ADVANCE also seeks to contribute to the general knowledge research based on gender equity in academic STEM disciplines, encouraging IHEs to identify and address aspects of STEM academic culture and institutional structures that negatively affect women faculty. A seminal program within the ADVANCE portfolio is the Institutional Transformation (IT) grant, which provides large scale, multi-year funding to IHEs focused on fundamental organizational changes that should BP over the long term.

Consistent with the goals of the NSF ADVANCE program, a vibrant research community has emerged to explore the factors that facilitate or hinder BP efforts. This research, broadly categorized as the Science of Broadening Participation (SoBP), identifies a range of structural and systemic factors (e.g. bias in recruitment and promotion decisions, the absence of peer networks and mentoring opportunities) contributing to the slow pace of change. Yet, broad dissemination of knowledge and adoption of best practices from the SoBP literature is challenging, which limits opportunities for the academy and larger STEM workforce to realize more consistent and widespread gains in BP. We describe four specific challenges below.

First, substantive work in the BP literature describes organization-centered models for change that target specific organizational structures, cultures and practices that can produce or relieve inequities (Bird, 2011; Laursen and Austin, 2014; Morimoto *et al.*, 2013). Because these models are institution specific, they do not translate readily across institutions that vary in mission, size, student population, reward structures, leadership and various other characteristics. Instead, transferring best practices or policies across institutions requires a more nuanced understanding of and adjustment to the local (Bilimoria and Liang, 2012).

Second, the academy is marked by strong and highly demarcated disciplinary cultures. These cultures, or academic tribes (Becher and Trowler, 2001), reflect norms and values developed and internalized over time that govern how faculty in those disciplines interact, allocate their time, conduct their research and evaluate success. Differences between those disciplinary – and thus departmental – cultures often result in resistance to the adoption of institution-wide practices that might advance BP goals in favor of localized approaches that may or may not yield desired outcomes. Thus, many studies of ADVANCE-funded efforts report that IHEs often see advances in BP in some departments but not others (Bilimoria and Liang, 2012; Morimoto *et al.*, 2013). In these cases, BP gains may reflect the people within those departments rather than the practices or policies being used that could be replicated elsewhere.

Third, efforts to disseminate empirical findings relating to the SoBP in mainstream outlets may be hindered by methodological constraints. Because of the institutional and

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disciplinary idiosyncrasies noted above, editors may be reluctant to publish manuscripts based on findings from a single institution because of generalizability concerns. This may help explain why many BP studies appear in niche journals targeting a specific discipline or identity group. Further, due to confidentiality issues for women, especially URM women, who are often the focus of SoBP research, authors may opt to withhold critical details or pieces of data that are important for understanding the experiences of these faculty and demonstrating impact. This might stifle opportunities to publish results.

Finally, as Fealing and McNeely (2016) observed, the SoBP literature lacks an underlying theoretical and methodological framework to guide research and practice. Our own observation of the literature suggests that scholars draw from a wide range of theoretical lenses – including social identity theory, gender role theory, the theory of gendered organizations and more recently intersectionality theory. These are relevant and appropriate choices, of course. Yet, it may also be possible that reliance on such disparate theories prevents the development of an omnibus model of BP that could capture findings to date and prompt new ideas and interventions. On a related note, an on-going challenge within the ADVANCE community is the lack of a shared set of metrics that might allow IHEs to share data in ways that would allow for more robust comparative analyses. This issue is a central focus of more recent ADVANCE solicitations.

While no single journal issue can address each of the preceding challenges in the science and practice of BP, we do believe there is opportunity to highlight – in one place – the important and diverse work being done in the ADVANCE community. To this end, the aim of this two-part special issue of *Equality, Diversity and Inclusion: An International Journal* is to introduce the ADVANCE program to the larger academic community interested in issues related to gender equity, diversity and inclusion in higher education and the STEM workforce.

Contents of special issue

In conceptualizing the special issue, we sought contributions that are directly related to or resulted from ADVANCE grants represented a range of work and addressed some of the challenges noted earlier. Papers could be empirical research articles, theoretical papers, program evaluation, case studies, personal narratives, practical recommendations, lessons learned, reflections on institutionalization, or any other effort related to the ADVANCE program. We welcomed papers from any academic field, particularly those that were multidisciplinary in nature. We also explicitly sought manuscripts focused on the issues of intersectionality for women faculty in STEM.

We believe the 16 manuscripts accepted for inclusion in the special issue reflect our desire to highlight the diverse body of ADVANCE-related work. Collectively, these manuscripts offer important theoretical insights, provocative research findings and evidence-based solutions for BP. Because we had so many outstanding papers, the special issue appears in two parts. Part one includes three sections: introduction to the ADVANCE program; implicit bias in recruitment: evidence and intervention; and climate issues affecting advancement and retention. Part two includes two additional sections: special emphasis on underrepresented minority faculty; and cross-institutional knowledge transfer and collaborations. In the space below, we provide a broad overview of each article and the contribution each makes to the SoBP literature.

Introduction to the ADVANCE program

Part one of the special issue begins with two manuscripts that introduce readers to the history of the ADVANCE program, the scope of its work, the network of interrelated programs designed to boost BP, and the evolution of the program over time. In the first paper, "NSF ADVANCE and gender equity: past, present and future of systemic institutional transformation

strategies," DeAro, Bird and Mitchell-Ryan describe the origins of ADVANCE, key transitions in the program over time, and its national and international reach. They highlight the program's continued focus on systemic barriers to gender equity and the STEM academic workforce and the more recent emphasis on the importance of intersectionality in change efforts. They conclude with comments about the program's future.

In "The changer and the changed: evolving theories and practices of change in ADVANCE calls for institutional transformation," Laursen and DeWeld tracked and analyzed changes in NSF ADVANCE Request for Proposals from 2001 to 2016 to explore how NSF's theory of change relating to BP has evolved since the inception of ADVANCE. This work was motivated by their own research demonstrating that the change strategies undertaken by ADVANCE IHEs shifted from cohort to cohort (e.g. Laursen and Austin, 2014; Laursen *et al*., 2015). The authors argue that these and other changes are important to document as they codify the presence of a community of practice or learning among ADVANCE-IT IHEs in which investigators freely share their successes and challenges, enabling all to adopt and adapt tested ideas to varied institutional settings. They also note that learning happened at NSF as subsequent calls changed in focus and rationale based on what program officers learned through guiding the peer review process, making award decisions and overseeing funded projects.

Implicit bias in recruitment: evidence and intervention

We then turn to three papers focusing on implicit bias in recruitment. Throughout the history of the ADVANCE program, improving recruitment and hiring outcomes for women and URM in STEM has been a central focus, prompting research on how implicit bias impacts recruitment-based outcomes and the efficacy of various policies and practices to reduce it.

Two policies that have received scant empirical attention are dual career and affirmation action hires, both of which have been recommended specifically by ADVANCE for BP. In "Missing or seizing the opportunity? The effect of an opportunity hire on job offers to science faculty candidates," Allen, Smith and Ransdell share results from two experimental studies designed to assess potential biases in recruiting these "opportunity hires." Using shifting standards theory (e.g. Biernat and Manis, 1994), they assessed whether evaluations and job offer recommendations differed for job candidates as a function of whether they required a partner accommodation, were the partner candidate, or were an affirmative action candidate. In Study 1, which used chemistry department chairs as evaluators, no significant gender differences were found in perceptions of the candidates or in recommended resource allocations. However, in Study 2, which used kinesiology faculty as evaluators, gender differences emerged among those evaluating candidates. Although candidates were not penalized for requesting a partner accommodation, support and resources for the candidates depended on if the evaluator was male or female.

In addition to understanding how implicit bias might manifest during the recruitment process, it is also important to consider practical interventions that can directly address it. In their article, "Interactive Theater: an effective tool to reduce gender bias in faculty searches," Shea, Malone, Young and Graham describe an interactive theater-based workshop, GEAR UP, created as part of the ADVANCE program at the University of New Hampshire (UNH). The ADVANCE team developed the workshop in response to data collected at UNH suggesting that increasing the awareness of and reducing implicit gender bias among members of faculty search committees could boost the number of women STEM faculty. The authors detail the process used to develop GEAR UP, including the customization of scripts, hiring professional actors and training a facilitator to implement the workshop. They also share internal and external evaluation data and annual climate survey results that demonstrate the impact of workshop attendance on search committee

processes and on faculty members' ability to recognize and respond to their own and others' biases. Findings also reveal that the representation of women faculty increased significantly at UNH since the implementation of GEAR UP.

While we know that awareness is important for diminishing bias, less is known about the psychological factors that lead to the attitude and behavior changes among workshop participants that could ultimately increase faculty diversity. In "An evidence-based faculty recruitment workshop influences departmental hiring practice perceptions among university faculty," Sekaquaptewa, Takahashi, Malley, Herzog and Bliss address this issue by detailing the impact of a Faculty Recruitment Workshop (FRW) developed and implemented at their institution for members of faculty search committees. During the FRW, a group of faculty experts share results of social science findings relating to gender and race schemas and provide guidance on conducting equitable searches. As part of the workshop, the research team gathered data to assess faculty members' attitudes and behavioral intentions regarding equitable search practices and, at the group level, whether the workshop changed department climates in ways that impacted the attitudes of individual faculty. Results across the two studies found evidence that attending the FRW increased endorsement of equitable search strategies and led to greater intentions to behave consistently with equitable practices.

Climate issues affecting advancement and retention

A review of the BP literature suggests that, at least to date, efforts to recruit and hire underrepresented faculty far outnumber efforts to evolve practices and policies necessary to retain such faculty and ensure their career satisfaction and success. Thus, we included manuscripts in the special issue that would directly address – via research or practice – issues relating to climate and faculty mobility. In the first of these articles, "Examining models of departmental engagement for greater equity: a case study of two applications of the dual agenda approach," Bird and Latimer describe two case studies of department-level climate change from separate institutions. Both efforts used the dual agenda approach, which purports that department members will be more inclined to support organizational changes (e.g. BP) to the extent that both the group's and individual's instrumental goals can be advanced by creating more equal employment opportunities. The authors detail the interventions used at each of their institutions, providing critical points of comparison between the two. For instance, both IHEs employed process interventions to promote gender equity practices and shared definitions of appropriate behaviors between and among academic colleagues. At the same time, the interventions also differed in important ways that reflected the preferences, needs and realities of their own institutions. Despite those differences, the IHEs achieved similar results in terms of policy and practice change, climate improvements and greater representation. Other IHEs might borrow the lessons learned to design context-specific department interventions using the dual agenda approach.

Efforts to create more equitable and adaptable departmental climates are critically important for achieving BP goals. However, a specific need exists relating to the experiences of early-career faculty as women faculty in many STEM disciplines tend to leave their tenure track positions earlier than their male majority colleagues (Diekman *et al.*, 2011; Xu, 2008). One potential explanation for their early departures is that women experience "chilly" or inhospitable climates that can include perceptions of interpersonal mistreatment. Miner, January, Dray and Carter-Sowell explore this issue in their paper, "Is it always this cold? Chilly interpersonal climates as a barrier to the well-being of early-career women faculty in STEM." Across two studies of early-career women STEM faculty, the authors examined the extent to which women faculty experienced working in a chilly interpersonal climate (as indicated by experiences of ostracism and incivility) and how those experiences related to work and non-work well-being outcomes. In Study 1, early-career women STEM faculty

reported greater experiences of ostracism and incivility and more negative occupational well-being outcomes associated with these experiences compared to early-career men STEM faculty. In Study 2, early-career women STEM faculty reported more ostracism and incivility from their male colleagues than from their female colleagues. Collectively, these findings document that ostracism and incivility may help explain the propensity of junior women faculty in STEM academic fields to withdraw from their positions.

A second pipeline issue facing women in STEM is in the advancement from associate to full professor. Although scholars attribute this "clog" in the pipeline to structural barriers or institutional practices that create adverse working conditions or put women at an evaluative disadvantage (Cech and Blair-Loy, 2010), surprisingly little empirical research focuses on women at this point in their career trajectory. In "Unclogging the pipeline: advancement to full professor in academic STEM," Van Miegroet, Glass, Callister and Sullivan detail the results of a successful intervention at their institution to boost promotion rates for women in STEM. The intervention included three interrelated activities: the development of a demographic database to track the gender distribution among faculty ranks over time; attempts to raise awareness and action through workshops, panel discussions and departmental meetings; and policy changes such as clarifying post-tenure review. Evaluative data, including six years of faculty census and promotion data and multiple waves of climate surveys, revealed a significant impact of the intervention on women's mid-career trajectories. There was a particularly noticeable upswing in the number of women promoted to full professor post-ADVANCE, such that nearly one third of those promoted to full professor were women. The authors discuss implementation challenges as well as plans for sustaining activities over the long term.

Social network analysis (SNA) can also be used to track faculty mobility over time. In "Hidden patterns: using social network analysis to track career trajectories of women STEM faculty," Collins and Steffen-Fluhr describe how their institution applied SNA to better understand and address the factors affecting the inclusion of women STEM faculty in their institution. The effort was fueled by an institutional report indicating that women faculty felt isolated and excluded. Their subsequent ADVANCE-IT grant focused on addressing issues of isolation by stimulating research collaborations through seed money and travel grants for woman-led research project teams, interdisciplinary knowledge exchanges, cross-sector research showcases and an informal Research Café. During this time, the ADVANCE team studied collaborations via faculty co-authorships and found that increased collaborations were associated with greater career advancement for women. The ADVANCE team then aimed to demonstrate that SNA and network visualization could be used at their institution and others to support more efficient faculty career management. The authors describe the methodological challenges involved in studying the networks of STEM faculty and the opportunities that SNA affords to both individuals and institutions by making hidden relational patterns more visible.

Special emphasis on faculty of color

Part two of the special issue includes sections on faculty of color and knowledge transfer and collaborations. In "Meeting to transgress: the role of faculty learning communities in shaping more inclusive organizational cultures," O'Meara, Nyunt, Templeton, and Kuvaeva explore whether, how, and why faculty learning communities (FLCs) might foster professional interactions that impact faculty retention, advancement and professional growth. At their institution, FLCs were designed as single, one-year, university-sponsored career development programs that convened a group of faculty (e.g. women assistant professors) to meet regularly for knowledge-sharing, peer mentoring and support. FLCs, which faculty joined voluntarily, were intentionally designed to support women, URM and non-tenure-track (NTT) faculty by addressing issues of marginalization. The authors found

that FLCs provided a liberatory space for women, URM and NTT faculty, which positively influenced retention, advancement and professional growth. The study's contribution to the literature is unique, as only a few studies have tracked the subsequent success of participants in mentoring or networking programs, like FLCs. This is surprising given that the learning community structure is quite common among ADVANCE institutions.

As others have noted, women faculty in STEM often experience work environments characterized by inequitable workloads, incivility and a devaluing of their work. For URM women, there are additional hurdles owing to their multiple marginalized statuses. Yet, as Carter-Sowell, Vaid, Stanley, Petitt and Battle note, there are few evidence-based institutional practices specifically designed to support the experiences of URM women faculty. In their article, "ADVANCE scholar program: enhancing minoritized scholars' professional visibility," the authors describe the ADVANCE Scholars program initiated at Texas A&M University in 2011 designed to support the development, advancement and retention of URM faculty at their institution. The program matched participating faculty with a senior faculty member who served as an internal advocate and with an eminent scholar in their field from a different institution who could provide additional career guidance, subject matter experience, collaboration opportunities, and visibility in the field. Opportunities to network with other participants and advocates were provided via off campus retreats and annual celebrations. Since inception, 40 ADVANCE scholars have completed the program. Evaluation data suggest that both Scholars and Advocates benefitted from participation. For scholars, primary benefits included increased opportunities to network, greater emotional support and the ability to connect with an eminent scholar. For advocates, the program allowed them to connect directly to WOC and to increase their own awareness of challenges facing WOC, particularly early-career faculty. The authors conclude with a summary of lessons learned and recommendations for sustainability.

In "Barriers to the advancement of women of color faculty in stem: the need for promoting equity using an intersectional framework," Corneille, Lee, Allen, Cannady and Guess review the literature on the experiences of women faculty of color (WOC) in STEM. Their qualitative meta-analysis included 42 articles relating to the experiences of WOC, making it the first to holistically review the empirical and conceptual work on this understudied and underserved population. Using an intersectional lens, they revealed three primary themes experienced by WOC faculty: high teaching and service loads, ambiguous standards for tenure and lack of culturally responsive mentorship. In turn, they offer recommendations to address each of these themes through informed, process-centered and data-driven interventions. While instructive for understanding these experiences, the authors note a paucity of research that examines STEM WOC faculty experiences at minority-serving institutions and in leadership roles across all types of IHEs. They also note that more research is needed to examine the long-term efficacy of mentoring strategies and IT efforts for WOC.

Cross-institutional knowledge transfer and collaborations

A number of scholars in the ADVANCE community have examined the individual and collective successes, failures and opportunities in the science and practice of BP (e.g. Bilimoria *et al.*, 2008; Bilimoria and Liang, 2012; Fox, 2008; Hunt *et al.*, 2012; Laursen *et al.*, 2015; Stewart and Valian, 2018; Zippel and Ferree, 2018). An important theme stemming from this work is that institutional differences in culture, practice, policy, mission, etc., make the transfer of best practices challenging. It is not always clear how practices shown to be efficacious at one IHE will translate into another, or if specific interventions are appropriate given one's local context. To this end, in the final section of the special issue, we focus on issues of transferability and cross-institutional collaboration.

As Hardcastle, Furst-Holloway, Kallen and Jacquez argue in "It's complicated: a multi-method approach to broadening participation in STEM," IHEs must be adaptable in their approach to BP and use their own data and learnings to identify and evaluate the most appropriate interventions. The authors share findings from a disparate set of research and evaluation efforts at their institution that included a survey of former faculty, network analysis of faculty collaboration and relationship networks, climate data, and productivity and mobility analysis. They discuss how these efforts separately and then collectively informed the specific interventions they ultimately pursued as part of their ADVANCE-IT grant: improving professional networks, realigning policy documents and departmental practices to better reflect faculty's values and improving departmental climates. The authors detail each of these data-informed efforts and how each informs and is informed by the other. The critical lesson to be gleaned from their approach is that no two sets of BP efforts will look the same. What works for one institution may not work for another. Rather, opportunities for synergy or consistency across ADVANCE and the larger BP community may lie in the sharing of methods, metrics and evaluation processes that allow institutions to identify context-specific challenges, the most appropriate interventions for those challenges and methods for dissemination results.

While the transferability of best practices across multiple institutions is indeed complicated, we highlight two successful efforts to forge cross-institutional collaborations. First, in their manuscript entitled, "Institutions Developing Excellence in Academic Leadership (IDEAL): a partnership to advance gender equity, diversity, and inclusion in academic STEM," Bilimoria and Singer discuss a partnership model designed to affect behavior and policy transformation at multiple universities in the northern Ohio region. The goal of the IDEAL program was to use the learnings from Case Western Reserve University (CWRU)'s initial ADVANCE grant to position six other IHEs in the region to stimulate change and leverage the idea of equity as enhancing regional STEM economic well-being and growth. The specific goal of the IDEAL consortium was to seed IT by creating a learning community of academic leaders empowered to develop and leverage knowledge, skills, resources and networks to transform institutional cultures and enhance faculty diversity, equity and inclusion in STEM disciplines. This collaborative learning community encouraged IHEs to review assumptions and practices regarding women's professional roles in STEM and provided resources to apply those lessons to transform their institutional cultures. The authors describe CWRU's initial program, the IDEAL partner institutions, the theoretical model preceding IDEAL's IT efforts, and IDEAL's specific initiatives and outcomes. The authors also offer an integrative model describing IDEAL's components and outcomes.

As a second example of cross-institutional collaboration, Yen, Riskin, Margherio, Spridakis, Carrigan and Cauce detail the development and dissemination of an online leadership development workshop, LEAD-it-Yourself! In "Promoting gender diversity in STEM faculty through leadership development: from local and national leadership workshops to the online LEAD-it-Yourself! Toolkit," the authors describe the development of the workshop during the University of Washington's (UW) initial ADVANCE grant. A crucial element of that grant was to provide department chairs with tools, resources and best practices to address faculty gender equity, diversity, and inclusion and to make them true change agents. The workshops, which started in 2002 and continue today, were a critical part of this strategy. These workshops are peer-led and cover topics such as constructing job offers, mentoring faculty, recruiting and retaining diverse faculty, having difficult conversations and supporting faculty during family leave. Evaluation data collected during the grant period showed that the workshops contributed to a stronger culture of leadership, increased the sense of community, and addressed issues that impact faculty and department chairs' ability to be successful. Based on the success of those workshops, the UW ADVANCE team applied for additional grant funds to develop the

Leadership Excellence for Academic Diversity (LEAD) national workshop program. A total of 174 participants from 74 different institutions attended three LEAD workshops (held in 2007, 2008 and 2009) that featured 34 speakers from 15 different institutions and organizations. Subsequent demand from other IHEs then led to the development of an online toolkit of planning and instructional materials to enable institutions to develop and run their own LEAD-inspired workshops. The authors detail the introduction of the toolkit and discussion challenges and future directions.

Conclusion

Collectively, we believe that each of the manuscripts in this special issue offer something of value to those with scholarly and practical interests in BP. These efforts represent just a small snapshot of the valuable work being done across the ADVANCE community and the academy more broadly. However, we hope that readers are inspired by the ideas and opportunities highlighted here that have been made possible through the NSF ADVANCE program.

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NSF ADVANCE and gender equity

Past, present and future of systemic institutional transformation strategies

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Abstract

Purpose – Supporting the advancement of science, technology, engineering and mathematics (STEM) in ways that help to ensure the health, prosperity, welfare and security of the nation has been central to the mission of the US National Science Foundation (NSF) since 1950, the year Congress created the agency. Preparing a highly qualified and diverse STEM workforce plays a central role in supporting this mission. The paper aims to discuss these issues.

Design/methodology/approach – Over the past several decades, many positive steps have been taken throughout the US education system to help ensure a more diverse STEM workforce. Even so, women remain underrepresented among STEM faculty in higher education, especially at the upper ranks. Contributing to women's underrepresentation are systemic obstacles to the recruitment, retention and promotion of women of different racial, ethnic, disability, sexual orientations and nationality statuses.

Findings – The NSF ADVANCE Program is designed to address these barriers. Success for ADVANCE is, therefore, best defined in terms of the changes made to the structures and climates of academic workplaces, rather than in numbers of women hired, retained or promoted in any one institution at a given point in time.

Originality/value – This introduction briefly examines the origins of ADVANCE, key transitions in the program over time, its reach nationally and internationally, and its future.

Keywords Gender, Equity, Organizational change, STEM faculty, Culture and climate, Systemic change

Paper type General review

National Science Foundation (NSF) ADVANCE: origins

The NSF ADVANCE program, which was developed under the leadership of the NSF Office of the Director and with the support of a design committee comprised of representatives from each of the seven NSF Directorates, issued the first call for ADVANCE proposals in 2001 (www.nsf.gov/crssprgm/advance/implementation.jsp). Recognizing the need for ensuring attention to gender equity in each STEM discipline, the ADVANCE Implementation Committee (AIC) was also created in 2001 to work with the ADVANCE program officer to implement the NSF-wide program. The first call for proposals included tracks for fellowship, leadership and institutional transformation (IT) proposals (NSF, 2001). Of these three tracks, the IT track with its focus on systemic change within US institutions of higher education (IHEs) represented a new NSF program model for broadening the participation of underrepresented groups in STEM. IHEs seeking ADVANCE IT awards were required to develop strategies for reducing institutionalized gender inequities.

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Multiple factors contributed to the initial focus on supporting systemic change. Among these was the 1999 Massachusetts Institution of Technology (MIT) report which found that systemic inequities were negatively affecting female faculty's compensation and resources and a related report by the leadership of nine prestigious research universities (Campbell, 2001; LaVaque-Manty, 2010; Massachusetts Institute of Technology Committee on Women Faculty, 1999; Vest *et al.*, 1999). Other contributors included recommendations to NSF from researchers studying gender and STEM, data from recipients of NSF grants to women, and over two decades of research pointing to institutionalized inequities, cultural barriers and implicit biases built into organizations in the form of policies, work arrangements, and routinized practices (e.g. Acker, 1990; Britton, 2001; Collins, 2000; Crenshaw, 1995; Foschi, 1996; Kanter, 1977; Long and Fox, 1995; Massachusetts Institute of Technology Committee on Women Faculty, 1999; Reskin, 1978; Rosser, 1995; Rosser, 2004; Rosser, 2017; Steinpreis *et al.*, 1999; Valian, 1998; Xie and Shauman, 2003). Foundational knowledge about institutional inequities has grown with each new ADVANCE IT cohort, revealing the complexity of systemic barriers to equity and the need for more innovative change strategies (e.g. Bystydzienski and Bird, 2006; Mason and Goulden, 2002; Morimoto and Zajicek, 2014; National Academy of Sciences, 2006; Stewart *et al.*, 2007; Sturm, 2006).

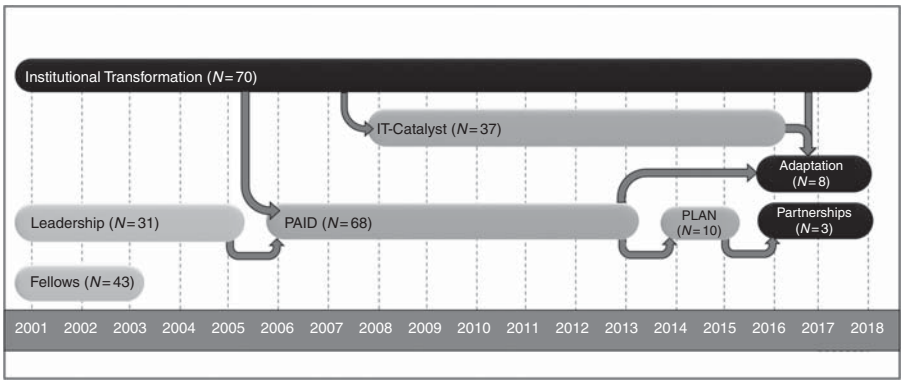
The ADVANCE program's focus on gender, systemic barriers to equity and the STEM academic workforce, vs diversity in general and the broader STEM workforce or the STEM "pipeline" was unique among other broadening participation NSF grant programs. This focus has facilitated the accumulation of knowledge, the translation of that knowledge into actionable change efforts and dissemination of change strategies across IHEs. The focus on STEM faculty is also strategic given the crucial roles STEM faculty have in mentoring undergraduate and graduate students and postdoctoral trainees, developing research questions and methods, communicating science to the public and guiding the national STEM research agenda.

NSF ADVANCE: program portfolio and transitions

Looking back over the past decade and a half of NSF ADVANCE, important transitions have occurred to the program design. In the early years of ADVANCE, aspects of previous models that focused on providing STEM research support to individual researchers were still evident in the fellowship and leadership tracks. Although these "grants [made to individual women] were often powerfully effective for those individuals, the environment those people worked in was not changing and often did not support their success" (Alice Hogan, former ADVANCE Program Officer, cited in LaVaque-Manty, 2010, p. 22). Reports to NSF pointing to the feasibility, impact, sustainability and scalability of systemic change efforts from the first 19 IT institutions and NSF site visits during this time helped move the NSF ADVANCE program even more toward institutional and systemic change. Figure 1 provides a timeline for the different tracks of the NSF ADVANCE program and the total number of awards in each track.

The IT track has been a part of ADVANCE since 2001. As of fall 2018, there are 70 ADVANCE IT institutions (including alumni ITs) nationwide. Recent IT projects have extended earlier ADVANCE research by illuminating the complexities of intersectionality, or the interconnectedness of multiple structures of social inclusion and exclusion, and add to our understanding of why increasingly sophisticated strategies are required to address intersectional inequities (Armstrong and Jovanovic, 2017; Hunt *et al.*, 2012). Other recent studies reveal, for example, the complexities associated with how gender, intersectionality, faculty service workloads, work–life balance and department culture affect faculty advancement (e.g. Campbell and O'Meara, 2014; Jackson *et al.*, 2017). Others build on research about microaggressions in the academic workplace to examine how bystanders can best address these infractions (e.g. Banyard *et al.*, 2015).

Scholars studying the IT cohorts have published numerous journal articles and books focusing on institutional change efforts (Branch, 2016; Bilimoria and Liang, 2012; Fox, 2008;



Notes: *N* = the number of awards (the number of institutions and organizations is larger due to partnerships). Competitions for each track were held every other year. The arrows indicate where lessons learned from the different tracks informed the focus and design of later tracks

Figure 1. The timeline of NSF ADVANCE program tracks

Laursen and Rocque, 2010; Rosser and Chameau, 2006; Stewart *et al.*, 2007). Analyses based on ADVANCE IT cohorts have also resulted in the syntheses of systemic change strategies such as the StratEGIC Toolkit website (Laursen and Austin, 2014).

The ADVANCE literature to date has often focused on the first two cohorts of IT grantees. Researchers investigating the impacts of these projects should keep in mind that these early grants were likely impacted by a 20 percent minimum cost share requirement for IT projects (NSF, 2001), which resulted in an average award of $4.3m for each five-year project. Later IT cohorts did not have the cost share requirement due to changes in the NSF cost sharing policies (National Science Board, 2004). The ADVANCE IT awards following these changes averaged $3.3m for each five-year project, suggesting significant differences in scope between these IT project cohorts.

We now turn our attention to the other ADVANCE tracks, especially those that represent important efforts by NSF to diversify the types of IHEs participating in the ADVANCE program, and to scale-up and disseminate promising systemic change strategies. About one-third of the total ADVANCE investment since 2001 has supported efforts to scale-up and disseminate systemic change strategies.

The NSF ADVANCE program introduced Partnership proposals in 2006 to adapt promising IT strategies to new contexts, support national STEM discipline-specific projects, and to include non-profit organizations. Between 2006 and 2018, 88 IHEs and 11 non-profit STEM organizations were involved in Partnership awards made under the "Partnerships for Adaptation, Implementation and Dissemination," "Partnerships for Learning and Adaptation Networks" and Partnerships tracks. The Partnership awardees include 19 prior IT awardees that proposed to facilitate the adaptation of IT strategies by other institutions and stakeholders, thereby extending the reach of the original ADVANCE investments. In total, Partnership awards supported the adaptation of promising IT strategies to 43 IHEs. One early example is the 2008 collaboration between Skidmore College and Union College, which focused on implicit bias training for faculty, administrators and students, and on addressing related issues including promotion from associate to full professor. This collaboration built on the innovations of earlier IT grantees, including Virginia Tech, University of Wisconsin–Madison and University of Michigan Ann Arbor (NSF award No. 0820080; http://sun.skidmore.union.edu/index.html). The Partnership portfolio also includes non-academic organizations such as professional societies because of their influence on the culture and climate of STEM disciplines and the academic workforce. For example, the Association for Women in Science's (AWIS)

work with the leadership of 18 other scientific societies sought to enhance the transparency of STEM awards and recognition processes, and to implement best practices for increasing gender equity (NSF award No. 0930073; Cadwalader *et al.*, 2014).

To further diversify the types of institutions participating in the ADVANCE program, the IT-Catalyst track (previously "IT-Start") was added in 2008. Between 2008 and 2016, the IT-Catalyst track supported 37 institutions with grants ($200,000–300,000) to undertake institutional self-assessments focusing on gender equity for faculty and to pilot organizational change strategies. The IT-Catalyst track helped diversify the types of institutions participating in the ADVANCE program with 40 percent of IT-Catalyst awards going to minority-serving institutions and over 50 percent to predominantly undergraduate institutions, including the program's first community colleges: Brunswick Community College (NSF award No. 1008660) and Ivy Technical Community College (NSF award No. 1209019). The success of the Partnerships projects to adapt promising IT strategies led to the Adaptation track, which enables IHEs and non-profit organizations to adapt and implement promising IT strategies without the expectation for innovating systemic change strategies or for original research on gender equity in STEM academics, both of which were required as a part of the IT projects.

The 2019 ADVANCE solicitation has four program tracks, all of which focus on systemic institutional change strategies: Institutional Transformation, Catalyst, Adaptation and Partnerships (NSF, 2019). Expectations that all ADVANCE proposals include an intersectional perspective began in the 2016 ADVANCE solicitation (NSF, 2016) and continues in the 2019 ADVANCE solicitation (NSF, 2019). The focus on intersectionality was informed by ADVANCE grantee research and related research on the complexity of barriers to equity confronted by STEM faculty of different social identities – including gender, race, ability/disability, ethnicity, sexual orientation and nationality (e.g. Armstrong and Jovanovic, 2015; Branch, 2013; Brown, 2000; Browne and Misra, 2003; Burrelli, 2009; Caroline and Johnson, 2007; Malcom *et al.*, 1976; Malcom and Malcom-Piquex, 2013; Morimoto and Zajicek, 2014; Ong, 2011; Ong *et al.*, 2011, 2016; Wu and Jing, 2011).

NSF ADVANCE: program reach

The $315m NSF investment in ADVANCE between 2001 and 2018 equates to approximately 0.27 percent of the total NSF budget during this time. This investment has directly reached 177 different IHEs with an NSF ADVANCE grant of some type (i.e. about 5.3 percent of all non-profit US IHEs). Publications by ADVANCE institutions, which commonly center on the changes in academic workplace policies and procedures, have examined topics including faculty recruitment and hiring practices, work–life balance programs, mentoring programs, and promotion and tenure policies. This body of research indicates that institutional changes in policies, practices, and cultures are associated with increases in institutions' collection and use of faculty data, changes in policies that affect how hiring processes are carried out, new mentoring and work–life balance programs, and changes in how promotion and tenure processes are conducted. Systemic institutional changes are, in turn, linked to increases in faculty job satisfaction and commitment, and over the long term the numbers of faculty hired and retained who are women (e.g. Callister, 2006; Rosser and Chameau, 2006; Bilimoria *et al.*, 2008; Lundquist *et al.*, 2012; Mason *et al.*, 2013; Settles *et al.*, 2006; Smith *et al.*, 2015).

The reach of the ADVANCE program extends beyond the program's direct grantees. Dissemination of ADVANCE strategies occurs through grantee research publications and presentations, and through the purposeful dissemination of practices by ADVANCE grantees. Among the ADVANCE program's most significant outcomes are the organizational change models that have been developed, studied and improved by ADVANCE grantees and then adapted by others with and without NSF funds. One early example is the Strategies and Tactics for Recruiting to Improve Diversity and Excellence (STRIDE) committee developed under the University of Michigan at Ann Arbor's ADVANCE *IT* project (NSF award No. 0123571).

The STRIDE model has been adapted by numerous US and international academic institutions, companies, professional societies and US national research laboratories (http://advance.umich.edu/strideCommittee.php). Another promising strategy is the "Advocates and Allies" model based on earlier "equity advisor" models and further developed by the North Dakota State University to recruit male STEM faculty to become allies in the effort to enhance gender equity in STEM (NSF award no. 0811239 and no. 1500604). The spread of ADVANCE strategies, furthermore, has resulted from the mobility of ADVANCE leaders. Over 400 faculty and administrators have served as ADVANCE principle and co-principle investigators and thousands more faculty and administrators participated in ADVANCE activities since 2001. Many of these people have taken ADVANCE-developed strategies and tools with them as they move from ADVANCE institutions to new positions. Dr Luis Falcón, who is now Dean of Fine Arts, Humanities and Social Sciences at the University of Massachusetts–Lowell, conveys one of the many examples of ADVANCE diffusion. Previously, as Vice-Provost for Graduate Education at Northeastern University, Dr Falcón was a co-PI on NU's 2008 ADVANCE IT project (NSF award no. 0811170). Because NU ADVANCE had adapted the Michigan STRIDE model, Dr Falcón had also trained as a STRIDE facilitator. Then, when he moved to the University of Massachusetts–Lowell as a Dean in 2012, Dr Falcón incorporated STRIDE principles and strategies developed by ADVANCE institutions to enhance applicant, interviewee and candidate diversity in hiring processes in his college. These activities were later implemented and expanded across the institution, including to non-STEM colleges without NSF funds. These efforts helped position UMASS Lowell to be more competitive for and receive an ADVANCE IT grant in 2016 to advance additional innovative systemic change strategies (NSF award no. 1629761) (personal communication with Dr Luis Falcón, January 2018; www.uml.edu/Research/ADVANCE).

Another example comes from Dr Theresa Lee who was a Department Chair at the University of Michigan Ann Arbor before moving to the University of Tennessee at Knoxville (UTK) in 2012 to become the Dean of the College of Arts and Sciences. When Dr Lee arrived, she worked with the Provost to support and encourage senior STEM faculty to create their own version of a STRIDE committee. Three UTK faculty members participated in the 2013 "Strategies Toward Excellent Practices (STEP) in Departments" workshop at Michigan (originally supported by ADVANCE Partnership NSF award no. 0620022). The UTK STRIDE committee began soon thereafter, implementing training for search committees. Through the STRIDE committee and with funding from the Office of the Provost, UTK continues to provide search committee training and workshops on retention, inclusion, and departmental climate (https://stride.utk.edu/, personal communication with Dr Soren Sorensen, January 2018). These efforts helped position UTK for an NSF ADVANCE Adaptation award (NSF award no. 1760382) under the leadership of Materials Science and Engineering Professor and Department Head, Dr Veerle Keppens (https://news.utk.edu/2018/08/30/nsf-funds-project-to-help-ut-recruit-retain-female-faculty-in-stem/).

The sustainability of ADVANCE IT initiatives depends on the extent to which institutions and organizations establish and sustain structures and cultures conducive to their ADVANCE equity-enhancement efforts. Examination of ADVANCE IT websites conducted by NSF ADVANCE program personnel revealed approximately two-thirds of these institutions continue to support and promote ADVANCE activities. These activities are often housed in "ADVANCE" or other institutional offices (e.g. Diversity and Inclusion, Faculty Affairs or Faculty Development and Success offices, Women in Science programs). Institutional ADVANCE activities have often expanded to include more than gender and more than just STEM departments and faculty. The University of California at Irvine, one of the first IT awardees, institutionalized UCI ADVANCE in 2006 and expanded the Office of Inclusive Excellence's scope to include race, ethnicity, disability, in addition to gender but maintains a focus on faculty issues (https://inclusion.uci.edu/advance/about-us/).

Another institution with more than a decade of sustained ADVANCE work is the University of Wisconsin–Madison's Women in Science and Engineering Leadership Institute, a research center that leads ADVANCE activities on campus, nationally and internationally (http://wiseli.engr.wisc.edu/).

The NSF ADVANCE program, in addition to its national impact, serves as a model for equity internationally. Governing bodies and research organizations across the globe recognize NSF ADVANCE. A European Commission report by the Expert Group on Structural Change notes, for example, that "the US has led the way with the ADVANCE programme [sic]" in funding initiatives to address "the structural barriers contributing to the well-known leaky pipeline phenomenon," and that these efforts have "led to a shift in focus towards addressing the structural transformation of institutions, using a systemic, comprehensive and sustainable approach" (European Commission, 2012, p. 6). As noted in the 2012 "Equality and Status of Women in Research" report, the Global Research Council, comprised of the heads of national STEM funding agencies from around the world, recognized NSF ADVANCE's unique "approach to encouraging gender equality in research" and its focus on "culture change in RPOs [Research Performing Organizations] through institutional transformation grants" (Metcalfe and Day, 2016, p. 13). The same report recognizes the prestige that ADVANCE awards bring to US IHEs, and explains that the "European H2020 funding for INTEGER [Institutional Tranformation for Effecting Gender Equality in Research] is modelled on the ADVANCE program" (Metcalfe and Day, 2016, p. 13).

NSF ADVANCE: the future

One goal for the future is to facilitate the dissemination and translation of ADVANCE strategies to more stakeholders and organizations. ADVANCE grantees have produced over 200 peer-reviewed journal publications and conference proceedings and at least 28 books or book chapters on systemic change and gender equity in STEM academia. In addition, toolkits, presentations and training materials are available on grantee websites for download and use by others. To capitalize on the potential value of these resources and knowledge, the NSF ADVANCE program awarded a five-year grant to AWIS in 2017 to launch an ADVANCE Resource Coordination (ARC) Network (NSF award no. 1740860). The ARC Network "strives to advance STEM equity in academia" by cultivating collaborations among diverse audiences and sharing evidence-based best practices for affecting change in STEM workplaces (www.equityinstem.org/about/). Also promising for the future are new systemic change projects such as the STEM Equity Achievement (SEA Change) initiative led by the American Association for the Advancement of Science. The SEA Change project, which was catalyzed with NSF ADVANCE workshop support in 2016, seeks to appraise the "[s]ystematic transformation efforts of participating institutions" and "as part of the [SEA Change] assessment" to award "bronze, silver or gold ratings for their efforts" to these IHEs (www.aaas.org/news/sea-change-program-aims-transform-diversity-efforts-stem).

Whether or not the ADVANCE program will be in place for another 18 years is yet to be determined. One positive sign is the February 2019 release of a new NSF ADVANCE solicitation (NSF 19-552) calling for new proposals in fiscal years 2019 and 2020. If the ADVANCE program is sustained in the long term, there is no doubt that it would continue to learn from its past investments and make changes to the program as necessary to address emerging issues, new research, and changing contexts. According to the new solicitation, the future for ADVANCE, at least in the short term, will include more partnerships between IHEs and organizations to scale up and diffuse promising practices, and more discipline specific ADVANCE projects to address the uniqueness of STEM disciplinary cultures and the varying representation of women in each STEM discipline. Given the success of NSF ADVANCE in the first 18 years, prospects are bright. ADVANCE has demonstrated that a

relatively modest federal grant program can contribute important new knowledge and strategies to address systemic barriers to broadening participation in the STEM academic workforce.

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The changer and the changed

Evolving theories and practices of change in ADVANCE calls for institutional transformation

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Abstract

Purpose – The purpose of this paper is to examine the evolving theories of change of the US National Science Foundation's (NSF) ADVANCE program to increase the representation of women on academic faculties in science, technology, engineering and mathematics (STEM). ADVANCE supports efforts to transform the cultures and structures of US institutions of higher education by removing gendered barriers to STEM faculty women's employment, advancement and success, and by developing change strategies that others may adopt.

Design/methodology/approach – The empirical study is based on qualitative, longitudinal analysis of nine requests for proposals (RfPs) for the ADVANCE program (2001–2016), complemented by historical analysis of funded ADVANCE projects using public records.

Findings – The analysis identifies changes over time that suggest shifts in NSF's rationale and theory of change for ADVANCE. Increased guidance directs how institutions should best undertake change, document outcomes and share best practices. The RfPs reveal growing attention to equity, rather than simply to representation, and to intersectionality – how gender, race, social class and other identities intersect to produce disparate experiences and outcomes for individuals differently positioned in social systems. Gendered organizations theory helps to place these experiences and outcomes in a structural context. Iterative processes of organizational learning are postulated to account for these changes over time.

Originality/value – While many studies have examined ADVANCE projects' activities and outcomes, none have examined the premises and design of the ADVANCE program itself. This analysis offers insight into how the ADVANCE RfP has driven innovation and learning about transformative institutional change to advance gender equity in STEM.

Keywords Organizational learning, Intersectionality, Gender equity, Gendered organizations, Theory of change, Institutional transformation

Paper type Research paper

The US National Science Foundation's (NSF) ADVANCE program was announced in 2001 and is still active. This is long-lived for any grants program at NSF, but perhaps especially for a cross-disciplinary program focused on "broadening participation" of diverse people and institutions – at that time, a newly explicit goal at NSF (NSF, 1999). Supported by contributions from directorates in the science, technology, engineering and mathematics (STEM) disciplines, the existence of ADVANCE was no small political feat to orchestrate (Rosser, 2017). Its longevity, thus, speaks to NSF's commitment to foster "the most meritorious ideas" and nurture "talent wherever it may be found" (NSF, 1999, 2008). Within NSF, ADVANCE is also pioneering in its institutional approach to change, seeking to transform

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institutional structures and cultures to improve education and optimize the use of resources through collaboration and networking. Thus, it offers an institutional change model for other education and diversity initiatives at NSF (James and Singer, 2016; Córdova, 2016).

As Rosser (2004, 2010, 2017) traced, decades of experience at NSF had demonstrated that it was not enough to simply recruit women into the sciences and support their career development. Rather, women faced barriers intrinsic to institutional structures, such as biased selection and promotion systems, inadequate structures to support those with family and personal responsibilities, and old-boy networks that excluded even successful women from receiving formal recognition or advancing into top leadership roles (De Welde and Stepnick, 2015). These barriers are enlarged and entangled when multiple marginalized identities intersect for women who are also in non-dominant groups due to their race, ethnicity, social class, sexual orientation, citizenship or physical abilities.

Seeking increased traction on the persistent problem of women's underrepresentation on STEM faculties, ADVANCE represented a shift from dispersed, individual-directed programs intended to "fix women" scientists and engineers, to systemic, institution-directed efforts to fix the environments in which women scientists and engineers work. This shift reflected NSF's then-new understanding of the problem and how it could be solved – a change in its theory of change. While prior studies (e.g. Bilimoria *et al.*, 2008; Bilimoria and Liang, 2012; Fox, 2008; Laursen and Austin, 2014) have focused on the community response to NSF's call – the actions and strategies of ADVANCE awardees – here we focus on the shifting language and meanings of the call itself, as the ADVANCE theory of change continued to develop.

Unpacking NSF's intentions and their evolution offers important context for understanding ADVANCE projects and how they have changed over time. Indeed, our analysis is stimulated by prior research on organizational change strategies in ADVANCE Institutional Transformation (IT) projects (Laursen and Austin, 2014; Laursen *et al.*, 2015), where we noticed differences in the change strategies undertaken by institutions that were funded at different times. We trace some of these changes to community learning from earlier IT projects, as investigators freely shared their successes and challenges, enabling all to adopt and adapt tested ideas to varied institutional settings. But the evolution of NSF's call for ADVANCE proposals suggests that learning also happened at NSF. As program officers guided peer review of proposals, made award decisions, observed funded projects and interacted with the community, their learning as individuals was institutionalized in subsequent calls for proposals, through writers' emphasis and choice of language, and in proposal rationale, guidelines and requirements. Because of this institutionalization by program officers acting as agents of the organization (Argyris, 1977), we consider this an instance of organizational learning (OL) (Crossan *et al.*, 1999), and the requests for proposals (RfPs) a record (albeit incomplete) of what was learned.

Here we examine how the ADVANCE theory of change has evolved over time. We track and analyze changes in NSF ADVANCE RfPs from 2001 through 2016 and make inferences about NSF's theory of change. In doing so, we answer the research questions:

RQ1. How has the ADVANCE request for proposals changed over time, especially the IT program?

RQ2. What can be inferred from these changes about NSF's theory of action for increasing the representation of women in academic STEM?

Conceptual frameworks

To understand the content of the ADVANCE RfPs, we use frameworks that consider inequalities and inequities as outcomes of institutional arrangements – policies, procedures

and practices. Acker's (1990, 1998) notion of "gendered organizations" treats academic work environments as imbued with hierarchies of inequality that disproportionately and implicitly impact women. For women, academic career pathways in STEM are fraught with obstacles that arise from the structures of graduate school, postdoctoral work and faculty careers (De Welde and Laursen, 2011). These structures are "[…] guided by hegemonic masculine ideals that inform decisions about employee (faculty) pay and promotion […] [as well as ways] that women and men academics are segregated to varying degrees into different departments and jobs […]" (Bird, 2011, p. 204).

Horizontal segregation of women across academic disciplines is one source of inequity, as over time some STEM fields become less gender-segregated, while others remain obstinately masculine. While some ascribe these patterns to "choices" (Ceci and Williams, 2011), their ubiquity across institutions, career paths and historical contexts points to their unequivocally structural foundations. Moreover, a simplistic focus on diversity or raw numbers of women may mask the nuanced "organizational logic" (Acker, 1990, p. 147) that shapes the daily experiences of STEM women as interlopers, tokens or competent anomalies. These hierarchies of inequality extend beyond gender too, as women of color are even less visible across all STEM fields (Ong *et al.*, 2011).

Vertical segregation of white women and women of color in STEM fields – their absence in higher-status positions and in roles that offer power and authority – offers additional evidence for disparities as structural and systemic and, ironically, keeps women out of positions to lead institutional changes to remedy that segregation. Effective institutional change initiatives attend to academic careers as unfolding within gendered organizations and address aspects of the academy that produce unequal and unfair outcomes for women. They must be system-wide and structure-focused because "simplistic or piecemeal solutions cannot eradicate systematic, historical, and widespread gender [and race] inequities" (Bilimoria *et al.*, 2008, p. 424).

Because "single axis thinking undermines […] knowledge production, and struggles for social justice," (Cho *et al.*, 2013, p. 787) we use intersectional theory to understand how the experiences of multiply marginalized women are reflected (or not) in ADVANCE RfPs. Gender, race, social class and other identity categories intersect to produce disparate experiences and outcomes for individuals differently positioned in social systems – even as gendered organizations theory places these disparities in a structural context. As Cottom (2017) points out, these framings are related: "By focusing on the parts of the system that are most complex and where the people living it are the most vulnerable, we understand the system best."

To consider the changes in ADVANCE's RfP over time, we draw on theories of OL, defined as "the process of acquiring, distributing, integrating, and creating information and knowledge among organizational members" (Wang and Ellinger, 2008, p. 1). OL, virtually irrespective of theoretical strain, happens through recursive or iterative process(es), whether in spirals (Nonaka, 1994), cycles (March, 1991) or loops (Argyris, 1977). In a comprehensive review of the literature, Scott (2011, p. 13) proposes:

> Learning is both a cognitive and a behavioral process […] [It] is increasingly viewed as an active, social, and dynamic process […] [It is] the process that brings about change […] [It] is acquired through a cognitive process of reflecting and/or through a behavioural process of doing, [and] learning is exploited through a process of applying, spreading, and embedding the knowledge.

For example, Argyris (1977) posits single-loop and double-loop learning processes. Both occur when organizations are reflexive about their practices: using feedback or information from previous results, they adapt their actions to influence improved outcomes. Single-loop learning is a form of error correction, making modifications to procedures or practices in response to unexpected results without altering the underlying

theory of action. In contrast, double-loop learning results in modified values, expectations or assumptions about the influences that govern the activity – a change in the broad strategic approach or theory of change.

In this analysis, we apply OL to ADVANCE RfPs by inferring the likely type of learning process from observed changes in the RfP text. This approach is distinguished from studies that offer advice to funding agencies based on the workings of the projects they funded (e.g. Lyall *et al.*, 2013); here we examine the funder's documents directly. We take this approach because OL processes are complex and challenging to investigate empirically (Easterby-Smith and Araujo, 1999), and still further inaccessible when the organization under study, a federal agency, operates with strict codes of confidentiality around the privileged information it holds. While we infer from the evolving RfP that OL did occur, our data do not elucidate the OL processes themselves; indeed, such data would be difficult to obtain given the procedural and political context in which NSF operates. In this analysis, we focus on what changed rather than why or how changes happened, drawing on OL theories in a bounded way that is appropriate for the evidence we have.

Methods

We examined nine ADVANCE RfPs (called program solicitations by NSF), issued roughly biennially from 2001 to 2016 (see searchable list in NSF, 2001). These documents cover the entire history of ADVANCE to date and govern awards made from 2001 through August 2017, which we also analyzed. Because all sources are publicly available, no IRB approval was necessary.

First, the content of RfPs was inductively coded using Nvivo 10 software for conventional content analysis (Hsieh and Shannon, 2005). Most codes simply marked sections that addressed specific topics (e.g. what project activities were encouraged, allowed or prohibited), though a few conceptual themes emerged at this stage (e.g. how institutional data should be used in proposals and projects). Typically 50–60 passages were coded in each document. Topical codes were then clustered into trees, and passages re-read and re-coded for emergent subthemes. For example, the cluster "program goals" had six subthemes denoting different purposes or rationales for ADVANCE as stated in document texts. Table I offers coding details to clarify how the analysis arose from the text data.

	Topical codes used to identify RfP sections	
Code cluster	Subthemes	Thematic codes not associated with particular RfP sections
Activities	Cautions against "fixing" women, Dissemination, Evaluation, International, Students	Innovation Intersectionality
Award type	10 award types listed	Sustainability
Expectations for proposal	Conceptual framework and research, Impact or outcomes, Plan of work, Problem statement, Status of women	System approach Use of data
Funding level	No subthemes	
Personnel	Management, Social science expertise, STEM expertise	
Program goals and rationale	Knowledge building, Knowledge link to diversity, Nature of problem to be solved, Rationale for focus on higher education, Underrepresentation, Workforce	
Proposal and award logistics	Award administration, Budgeting, Due date, Eligibility, General boilerplate, Program officer, Reporting, Review process, Submission process	
Reference list	No subthemes	
Revision notes	No subthemes	
Summary	No subthemes	

Table I.
Qualitative coding structure for ADVANCE RfPs

Because each of the nine documents analyzed was unique in time, an additional layer of longitudinal analysis was essential. Following qualitative coding, we re-read the coded data to track the occurrence of particular programs, requirements or ideas in a spreadsheet, forming a matrix that displayed key changes by year to easily identify substantive changes over time. In the Findings, quotations and RfP dates provide evidence to support our arguments about change over time. The themes discussed in the Findings largely mirror those in Table I, but some codes showed no meaningful trends over time and are not discussed further.

As we conducted the qualitative analysis, we identified a need for a concise historical record of ADVANCE activity over the program's lifetime. To construct this record, we drew on a second, publicly available source of data. We searched NSF's public awards database (nsf.gov/awardsearch) for ADVANCE-specific program element and reference codes (7690, 7650, 7568, 1739, 1738, 1681) so that we could estimate the total number and dollar amounts of awards made under specific program tracks, such as IT or ADVANCE Fellows. Since NSF's codes are reused when program titles change, we recoded the data on individual awards to group them by broad program strand, where "strand" identifies the general target and nature of the program. For example, the "planning" strand includes two tracks of institutional planning grants that operated under different titles at different times, IT-START and IT Catalyst, and the "individual" strand includes two tracks of awards to individuals, ADVANCE Fellows and Leadership awards (see Table II). Based on start dates, awards were assigned to particular RfP years even though funds were distributed over multiple years and through multiple competitions within each RfP (awards under the 2016 RfP were incomplete at the time of writing). This separate analysis of the awards database enabled us to map the relative reach and degree of activity for different program tracks or strands, and to connect notable shifts in NSF's theory of change to the onset or termination of particular program strands.

Findings from analysis of awards data: history of ADVANCE program activity

To provide context to our text analysis of the RfPs, we summarize the history of ADVANCE programming as constructed from NSF's awards database. For conciseness, we summarize these data in Figures 1–3 and Table II, using the following acronyms: IT for Institutional Transformation; PAID for Partnerships for Adaptation, Implementation and Dissemination; PLAN for Partnerships for Learning and Adaptation Networks; ARC for ADVANCE Research and Coordination Network; ALE for ADVANCE Longitudinal Evaluation. Narrative description of these program tracks is provided in the following section.

Figure 1 shows the lifetimes of specific ADVANCE program tracks, grouped into five broad strands: support for individuals, transformation of single institutions, partnerships and adaptations, planning grants, and central resources.

Table II summarizes available information from the RfPs about award sizes, durations and anticipated funding levels, while Figures 2 and 3 show trends in the actual numbers and amounts of awards within each broad program type. In all, we tallied 338 unique awards totaling $305.0m from 2001 through August 2017, comparable to NSF's own figure of $270m (NSF, n.d.). Both numbers of awards and dollars awarded have clearly fallen since the early years, and emphasis has shifted as new programs were introduced and old ones retired.

These data provide context for the text analysis in the next section of findings, by showing how program activity shifted among strands as NSF tested different elements of its theory of change.

Table II.
Anticipated funding for ADVANCE awards, by year and program strand, from RFPs

Year	Single institutions	Individual support			Adapting and partnering			Planning		Central
	IT	Leadership	Fellows	PAID	PLAN	Partnership	Adaptation	IT-START	IT Catalyst	ARC, ALE
2001	5 yr $750k/yr 5–10 awds	3 yr $200k 8–12 awds	3 yr salary + PD support 20–40 awds							
2002	5 yr $750k/yr 5–10 awds	3 yr $300k 8–12 awds	3 yr salary + PD support 20–40 awds							
2005	5 yr $750k/yr		3 yr $300k	3 yr $500k						
2007	~$750k/yr 8 awds			~$250k/yr 20 awds				2 yr $200k 10 awds		
2009	~$750k/yr 8 awds			1–5 yr 20 awds					2 yr $200k 10 awds	
2010	No data			No data					No data	
2012	~$680k/yr 6 awds			1–5 yr $750k 10 awds					2 yr $200k 6 awds	
2014	5 awds				5 yr $750k 10 awds				3 yr $250k 5 awds	
2016	5 yr $3 M total 5 awds					3–5 yr $1m 6 awds	3 yr $1m 6 awds			1 ARC awd 5 yr, $1m/yr 4 eval awds

Notes: IT, Institutional Transformation; PAID, Partnerships for Adaptation, Implementation and Dissemination; PLAN, Partnerships for Learning and Adaptation Networks; ARC, ADVANCE Research and Coordination Network; ALE, ADVANCE Longitudinal Evaluation. ~ indicates that the annual award amount is estimated from other statements; ADVANCE acronyms used in the table are further discussed in the Findings

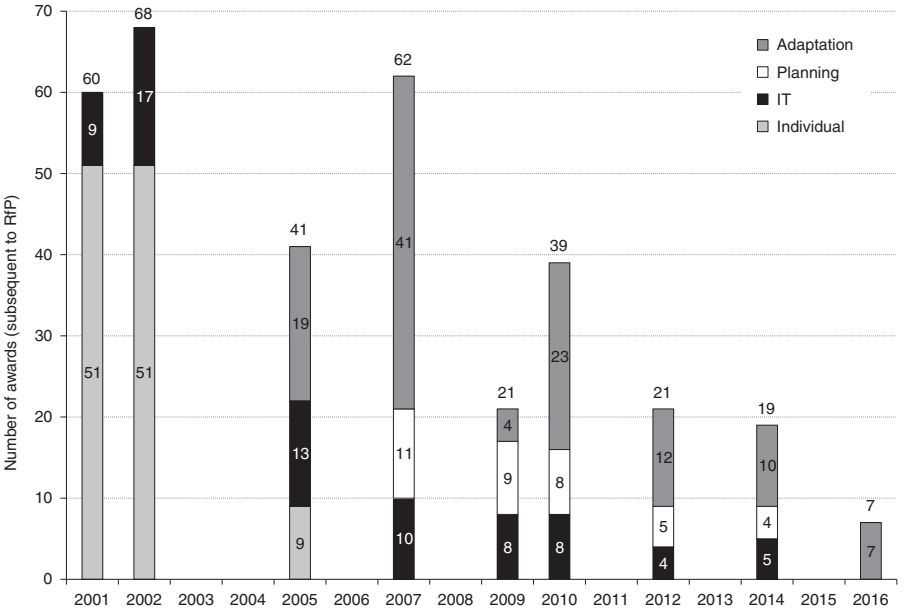

Figure 1.
Lifetime of NSF ADVANCE programs by RfP year

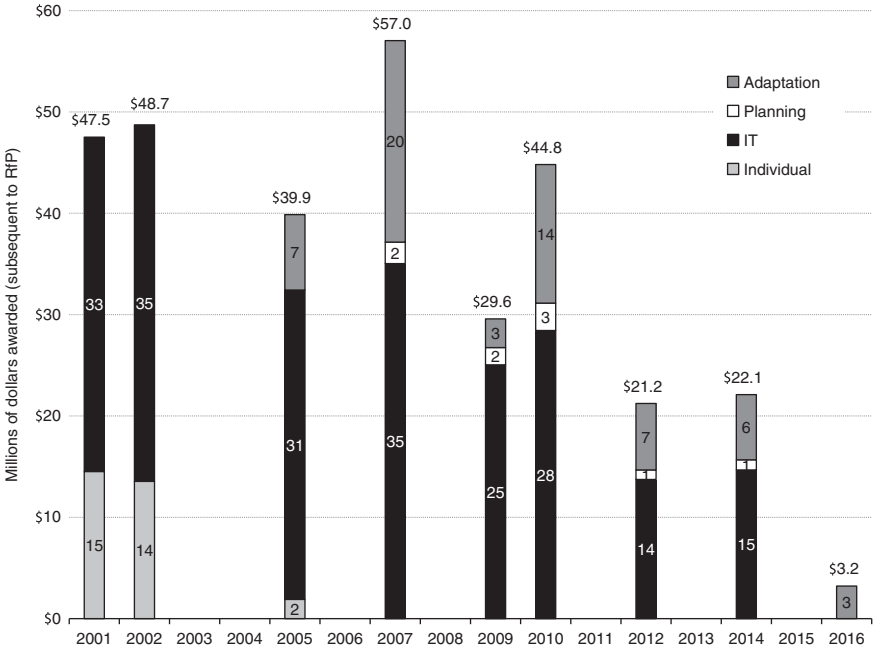

Figure 2.
Number of ADVANCE awards, by program and RfP year

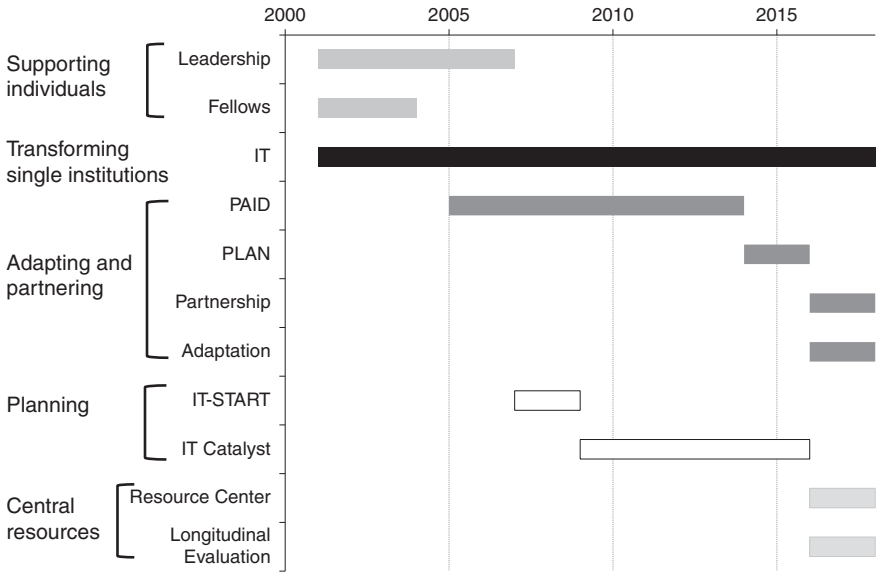

Figure 3.
Dollars awarded by ADVANCE, by program and RfP year

Findings from analysis of ADVANCE RfPs: an evolving theory of change

Based on the qualitative analysis of the RfP texts, we describe patterns of consistency and change of two broad types:

(1) language that communicates evolving understanding of what ADVANCE projects should accomplish, alone or as a group – that is, changes to the goals, design and central ideas of ADVANCE, especially as these may suggest NSF's evolving theory of change for ADVANCE; and

(2) expectations that communicate how ADVANCE projects should do this work – that is, changes giving advice to proposers on organizing proposals and implementing successful projects.

The textual analysis focuses on the long-lived IT program, but we also discuss other programs as windows into the evolution of NSF's theory of change over time (Figure 1). We use the textual and historical evidence to highlight key themes and to make inferences about the existence and processes of OL on NSF's part. We first discuss the RFPs' language on what problem ADVANCE projects are intended to solve and what goals they were to accomplish: both the overall rationale for ADVANCE and the ways that different program strands have addressed different aspects of the evolving ADVANCE theory of action. Then we discuss RfP language that indicated how ADVANCE projects – particularly the large IT projects – should accomplish the desired aims, by considering NSF's expectations and advice for different project components.

Rationale for ADVANCE

In all the RfPs, women's underrepresentation in STEM fields serves to diagnose the problem to be solved: women are underrepresented; this reflects the cumulative effect of multiple causal factors; thus, the very fact of underrepresentation points to problems in the processes and environments for academic STEM work. The language of this argument remained stable for several years (2001–2007):

> A number of factors have been hypothesized to account for the lower proportion of women in the senior ranks of science and engineering faculties, e.g. differential effects of conflicts between work

> and family demands, unequal access to resources such as space and supporting facilities, underrepresentation of women in important departmental decision-making processes, to name a few. The cumulative effect of such diverse factors has been to create formidable barriers to the advancement of women in academic science and engineering. (2001)

Initially, the only evidence for underrepresentation was women's percentage on STEM faculties, but over time additional data were added: the low percentages of minority women on STEM faculties (2002) and in the STEM workforce at large (2005), women's share of STEM full professorships (2007) and of STEM PhDs (2009). The 2010 RfP acknowledged that women's representation varies by "discipline, rank, type of institution, and type of appointment […], race and disability status." These data underscored that women's presence is not only limited, but uneven, and more limited in positions of higher status – facts not explained by their absence among PhD earners. By 2016, however, such statistics were largely abandoned.

The role of multiple factors that together shrink women's representation (Valian, 1999) was also noted from the start. The 2009 RfP made explicit that these factors are "external to [women's] ability, interest, and technical skills," but was still vague as to how and why they affect women. Eventually the barriers were more firmly located, with descriptors of barriers as "institutional" increasing in 2009–2012. In 2016 reference to "organizational" and "cultural" factors increased, and the causal mechanisms by which these may affect women were detailed, as in this excerpt:

> Organizational barriers that inhibit equity may exist in areas such as policy, practice, culture, and organizational climate. For example, practices in academic departments that result in the inequitable allocation of service or teaching assignments may impede research productivity, delay advancement and create a culture of differential treatment and rewards. (2016)

But why does women's representation in STEM matter? Initially, diversity was asserted to improve the quality of knowledge creation, because both "the pursuit of new scientific and engineering knowledge and its use in service to society require the talent, perspectives and insight that can only be assured by increasing diversity" of the STEM workforce (2001–2007). While this language emphasized benefits to the nation from knowledge building, it also suggested that these benefits multiply if diverse perspectives are included (see McClellan *et al.*, 2010). In 2007, national benefit was complemented by benefits of fairness in opportunities and outcomes for individuals through a "broadly inclusive" STEM workforce, expanded "scientific literacy of all citizens," and assertions that "every American" should have "an opportunity to achieve and to contribute." But such aspirations for individual opportunity were not repeated. Rather, the focus shifted to workforce size (2009–2014), where "full participation of women and utilization of their talent is required for sustained US global competitiveness and innovation." Here women were not seen as making distinctive contributions or adding new perspectives, but as simply bolstering the net numbers of STEM workers.

Finally, the 2016 RfP shifted focus to "equity" as a desired goal, using this term 70 times, compared to 0–12 uses in each of the prior RfPs:

> The ADVANCE program is designed to address gender equity through the identification and elimination of organizational barriers that impede the full participation and advancement of women in academic institutions. (2016)

ADVANCE solely targeted academic institutions and their STEM faculties, excluding other knowledge-building organizations such as federal laboratories. This was justified in consistent language about the roles of faculty and administrators as:

> […] intellectual, professional, personal, and organizational role models that shape the expectations of many prospective scientists and engineers. Persistent underrepresentation of women faculty,

> especially in leadership positions, may affect all students' critically important relationships with mentors, participation as members of research and education teams, and self-identification as potential researchers. (2012)

While faculty influence on students remained a central justification for ADVANCE's focus on higher education, in 2016 the language shifted from emphasizing women's presence in STEM learning environments to emphasizing that they must have equal status there:

> The ADVANCE program contributes to the development of a more diverse science and engineering workforce because of the focus on equity for STEM academic faculty who are educating, training, and mentoring undergraduate and graduate students and postdoctoral scholars. (2016)

ADVANCE theory of action

With this understanding of how NSF viewed the problem over time, we can examine the stated goals and infer a theory of action for ADVANCE. The theory of action comprises the logical links from the problem to be solved to the chosen strategies and anticipated outcomes – the assumptions and strategies for how to move from the current state to a desired future (Connolly and Seymour, 2009). Early RfP language stated the primary goal of ADVANCE:

> […] to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce. (2001–2005)

In 2007, a slightly revised goal identified "systemic approaches" as the means to achieve this goal, which remained explicit through 2016. In this section, we describe program strands offered by ADVANCE to achieve this primary goal. We view new program tracks as the most important changes observed across the RfPs, because they reflect major changes in the conception and design of ADVANCE. Such changes offer the clearest glimpses into NSF's theory of action that are possible from the documents – and thus offer strong evidence for double-loop learning that reflected an evolving understanding at NSF of how IT proceeds.

Transforming individual institutions. IT is the flagship program of ADVANCE, with 74 awards totaling over $215m from 2001 to 2016 (Figures 2 and 3). Of these, 58 were the large, five-year IT projects that many consider the signature of ADVANCE. The IT track exemplifies a key feature of the ADVANCE theory of change, that individual institutions are where change needs to happen. Institutions are workplaces for women, but also holders of culture; they are sites in which the multiple and interlinked influences on women's career trajectories are enacted through multi-level processes. To combat the cumulative and systemic barriers that emerge from such institutional arrangements, systemic change is required – a transformation indeed, as these extracts show:

> […] [T]he lack of women's full participation at the senior level of academe is often a *systemic consequence of academic culture*.

> […] Institutional Transformation Awards provide flexibility […] to define and implement effective approaches to increase the participation and advancement of women faculty members into the senior and leadership ranks of science and engineering, and to implement the necessary changes to *institutionalize those approaches*. By supporting the groundwork necessary to transform institutional practices systemically, [IT awards] seek to create *positive, sustainable, and permanent change in academic climates*.

> […] Proposals […] should show an *integrated approach to addressing the complex institutional factors* affecting the full participation and advancement of women in academic science and engineering careers. The project may be directed at review and transformation of one or more departments or schools of science or engineering, or of an entire institution or system. (2001, emphases added)

The long duration and large size of IT awards acknowledged that transformative change would require multiple initiatives to tackle different aspects of the problem. The 2001 RfP suggested a menu of activities – faculty development, mentoring, work/life programs and training for department chairs. However, the menu was soon abandoned for more general guidance on the scope, goals and audiences of activities, which could include direct support to women faculty, institutional self-study to diagnose problems and develop solutions, and work to improve institutional policies and practices (see Laursen and Austin, 2014). Proposers had "maximum flexibility" (2009) to argue which activities would be transformative at their institution and why.

Supporting individual women scientists. While IT applicants were cautioned to "focus on ways in which the institution can foster supportive organizational environments […] rather than […] on ways to augment the skills and experience of women faculty" (2002), other early ADVANCE programs continued to supply just such a boost to individual women (Figure 1, Table II). Awards to ADVANCE Fellows targeted women who had experienced gendered career limitations but who had "high potential to develop or resume" academic careers. Resembling the POWRE program that preceded ADVANCE (Rosser, 2010), the Fellows program may have helped to ease the transition at NSF from individual support to institutional change, and to build buy-in among the STEM directorates that managed Fellows awards; it was phased out after two RfPs. Similarly, Leadership awards to individuals sought to "recognize and encourage outstanding contributions" to advancing academic STEM women. This program seeded smaller-scale innovations and was folded into the Partnerships strand in 2007. As Figures 2 and 3 show, these programs were well subscribed in their early years. Thus, the termination of these program tracks focused on individuals may signal NSF's wholehearted commitment to a theory of change that is firmly focused on institutions and, perhaps, its increasing confidence that this approach would work.

Adapting prior efforts. PAID awards joined the ADVANCE portfolio in 2005 (Figure 1). Through smaller, shorter grants (Table II), this track sought to broaden the impact of IT projects that had developed strategies to advance gender equity, and to expand the networks of people and institutions who knew about these strategies. Drawing on interventions already proven in one setting, PAID projects supported adapters to apply and evaluate selected interventions under new circumstances, or enabled developers to share effective practices by training other change leaders. Explicit language invited proposals from institutions of types thus far underserved, including predominantly undergraduate institutions (PUIs), minority-serving institutions (MSIs) and women's colleges. Partnering among institutions was encouraged but not required. In 2007, new language encouraged projects targeting a STEM discipline, and, in 2009, PAID-Research projects were invited to study gender in the academic STEM workforce. PAID was, thus, intended to "speed the diffusion of innovative approaches" and to "continue building knowledge about effective institutional practices and policies (what works under what circumstances), thereby strengthening the cycle of innovation" (2005). In these ways, the RfP signaled NSF's rising interest in building collective knowledge about how to accomplish these desired but challenging transformations toward gender equity. This suggests double-loop learning: as NSF saw evidence that some interventions developed by early IT awardees were portable to other institutions and need not be reinvented wholesale, the theory of change was expanded to enable change strategies that were still institution-focused but built on ideas first developed by others.

In 2014, PAID was replaced by PLAN, seeking to create "communities of adapters" who would apply an intervention and document their learning about how to make it work in diverse institutional and disciplinary settings. Like PAID, PLAN emphasized adapting prior

innovations, but also called for formal learning from this process. In 2016, PAID's two ideas were formally separated: the Adaptation track supported a single institution to adapt and implement proven strategies, again with special welcome to two-year and masters-granting institutions, MSIs and PUIs, while the Partnership track supported collaborative efforts to increase gender equity within STEM disciplines, highlighting requirements for "sustainability and/or scale-up, communication of outcomes and lessons learned, and evaluation of the project's impact" (2016). In altering program tracks to explicitly place emphasis on formal learning from these adaptation experiments, these recent changes are consistent with other, earlier changes to the RfPs (discussed below) that emphasize ADVANCE's intent to build generally useful knowledge about change strategies and processes. In this respect, they may be viewed as resulting from a multi-year cycle of double-loop learning – not new ideas *per se*, but manifesting this intent in an additional way. In contrast, calls to engage disciplines may be interpreted as trials of a new theory of change that considers the discipline, in addition to the institution, as a locus of change – the type of change that typically results from a double-loop learning cycle. Overall, as Figures 2 and 3 show, attention to adapting and using the work of prior projects has been an explicit part of the ADVANCE theory of change since this strand was formally introduced a few years after the program's onset.

Planning. The IT-START program was initiated in 2007 to support modest planning grants for institutions to take initial steps – data gathering and analysis, policy reviews – to identify specific issues for their women faculty and do the "catalytic groundwork" (2007) to prepare a full IT proposal. It recognized the lack of "administrative and professional staff infrastructure [required] to undertake a comprehensive review and analysis of institutional data" (2007) at many institutions, such as teaching-intensive colleges and MSIs. START was replaced in 2009 by IT-Catalyst, which likewise supported institutional self-assessment to spark transformation. This program strand may reflect single-loop learning, seeking to reduce a barrier that prevented some institutions from doing the preliminary work needed to apply successfully for an IT award. As Figures 2 and 3 show, the planning strand had steady but modest activity through its lifetime. However, out of 37 awards, we could identify only two IT and one adaptation award made to institutions that had previously held START awards.

Centralized programs supporting new goals. The preceding sections describe grant mechanisms by which ADVANCE sought to achieve its main goal of increasing women's representation and advancement in academic STEM careers. Two other goals became explicit in later years: to contribute to research knowledge on gender equity in academic STEM disciplines (2012–2016) and to develop "innovative and sustainable ways to promote gender equity in the STEM academic workforce" (2014–2016). These two goals formalized a growing emphasis on building knowledge so that other institutions – not only those funded by ADVANCE – could use practices and findings developed with ADVANCE support.

Two program tracks introduced in 2016 directly support these knowledge-building goals. ALE awards support collaborative studies of change at previously funded IT institutions, seeking to "develop shared metrics […] and evaluate the long term impact of the ADVANCE IT grants on organizational systems, culture, and climate in these institutions." The ADVANCE Resource and Coordination Network (ARC Network) will "facilitate the adoption and implementation of evidence-based systemic changes" through activities such as research-to-practice translation, curation and sharing of proven tools and materials, and fostering communication among decision makers, researchers and faculty. Combined, these programs seek to strengthen knowledge about and promote use of research-based best practices for change – thus creating, preserving and centralizing community knowledge of how organizations can promote and sustain gender equity.

These programs may reflect a culminating stage of the shift in ADVANCE's theory of change, from a focus on fostering change to studying it and sharing this knowledge.

Project components

The preceding section details what ADVANCE as a whole, and the projects it supported, were intended to accomplish. While the overall rationale for ADVANCE was largely stable, the changing menu of program strands reflects shifts in the ways NSF leaders thought these goals could be achieved. Even more profound changes are seen in the instructions to proposers about how they should organize their work toward these aims. Over time ADVANCE RfPs became progressively more directive, particularly for IT proposals. The RfP nearly doubled in length from some 55,000 words (2001) to nearly 110,000 words (2012), its tone increasingly bureaucratic. But we also see evidence of NSF learning from prior projects in efforts to shape later proposers' work in ways thought to make it more effective and impactful.

Here we examine instructions to IT proposers about proposal content – what writers should address in the proposal – and project structure, or how projects should be conducted. We interpret evolving expectations about project structure as evidence for single-loop learning from experience, as NSF saw and tried to prevent common problems encountered by previously funded projects. In contrast, changes to proposal content requirements tend to offer additional evidence for shifts in NSF's theory of change that we conjecture to result from double-loop learning processes.

Proposal content. The expectations for IT proposals illustrate how NSF imagined a compelling case for transformation. From the beginning, proposals were expected to include data on the status of women. By 2009, this had evolved into lengthy guidance on the use of data to justify the proposed work, capped by an ironic warning not to overdo it:

> Contextual information on the proposing institution […] is important to explain the potential impact of the proposed project. This information should include a description of current and past activities and initiatives that are related to the proposed project and how these activities will be incorporated into the proposed project […].
>
> Comprehensive institutional data on faculty is required in the project description […]. Proposals should present data on the status of women faculty and compare such data to national statistics when possible. […] The data and […] analysis should serve as part of the justification for the proposed IT project and the specific strategies outlined in the proposal. The data should provide the readers a clear understanding of the current status of women at the proposing institution, which will allow the readers to evaluate the impact and feasibility of the proposed project objectives and goals.
>
> […] [T]his section should not consume a significant portion of the project description since it is also very important to fully describe the other aspects of the proposal […]. (2009)

With mounting emphasis on data came growing acknowledgment that, "As indicated by the extremely low number of women of color in science and engineering, different strategies may be required to address their increased representation" (2002). Again, underrepresentation was treated as signaling a problem. Over time, several characteristics identified "special populations" of women faculty who might be targeted in project activities, and about whom data must be provided: race and ethnicity (2002); disability status (2007); sexual orientation (2012); foreign-born and foreign-trained status and faculty appointment type (2016). Even more significantly, in 2016 intersectionality was called out as a guiding theory of ADVANCE, to be addressed by all proposals:

> The ADVANCE program is centrally focused on funding projects to support systemic change for gender equity in STEM academic careers. Barriers to gender equity may not be identical for all

> groups of women faculty in [STEM] disciplines, however. […] All ADVANCE proposals are expected to address intersectionality and should offer strategies to promote gender equity for all faculty. (2016)

This language represents a shift from recognizing that strategies may not benefit all women equally, then sorting women into ever-snugger demographic pigeonholes, to acknowledging that both the lived experience and the social meaning of gender is modulated by women's other characteristics, such as sexual orientation or race – and thus change strategies must accommodate these modulations (Armstrong and Jovanovic, 2017). The appearance of intersectionality as an explicit intention represents a significant revision to the theory of change that is consistent with a double-loop learning process.

Another notable change is the expectation for IT projects to state an explicit theory of change based in scholarship. The first RfP asked proposers to:

> [d]escribe the specific barriers to women's advancement that the project is intended to address; supply relevant data. Discuss the vision, goals, and anticipated impact of the proposed project. (2001)

By 2002, proposals were to be "well grounded in the research and practice on issues affecting women scientists and engineers in higher education." And by 2005, the RfP explicitly called for a guiding conceptual framework or theory of change based in both scholarly work and analysis of the local context:

> [IT] proposals must clearly state the conceptual framework for the proposed project, identify relevant research findings, and build on existing research and practice. […] Proposals should demonstrate the connection between the conceptual framework, the issues identified through analysis of institutional data, and the proposed plan. (2005)

By this time, proposers were also expected to consult the growing body of publicly available work from prior ADVANCE awards in designing their plan. This, coupled with increasing emphasis on "innovation" and the availability of specific program tracks to support adaptation, signaled that IT proposers should not reinvent already-existing wheels.

A major change in 2009 was the required "rigorous social science study" examining some innovative element of the IT effort. Proposers were asked to precisely "illustrate how the study will contribute to the knowledge base and scientific understanding of institutional transformation" through publication in peer-reviewed venues. In an extra five-page document, writers described their conceptual framework, grounding theory, methods and how the study would attend to multiple identity characteristics besides gender. Acceptable research studies were described as experimental, hypothesis-driven designs; not until 2016 did the RfP language accommodate other types of research questions and other ways to consider intersectionality besides disaggregating quantitative data. The inclusion of a social science research study is another example of how RfPs evolved to place more emphasis on knowledge building, an idea increasingly central to the program's theory of change, and thus further evidence for double-loop learning that is evident within the RfP in multiple places.

Project structure. While the prior section details intellectual components of the proposal to lay out an IT project's rationale, justification and plan, other elements of the RfP spoke specifically to how awardees should manage and monitor their projects.

For example, the RfP increasingly specified target audiences for ADVANCE interventions, stipulating inclusion of social and behavioral sciences within STEM, and preventing expenditures to support students, postdocs and non-STEM faculty. Leadership expectations too became more detailed, directing proposers to include men and women (2001), social scientists (2005) and STEM faculty (2014) on the leadership team. The social scientists were tasked to inform the innovation with current scholarly knowledge on gender

issues and organizational effectiveness; as later projects were stacked with social scientists (Laursen and Austin, 2014), teams were reminded to include those with direct experience of and professional credibility within STEM workplaces.

The principal investigator was expected to manage the project and to develop an administrative structure to develop a shared vision and support faculty engagement in achieving project goals. Over time, RfP language spelled out expected elements of this structure, such as the need to coordinate multiple efforts occurring in different arenas of the institution and at differing paces (2005). Proposers were asked to provide "clear evidence of institutional readiness" for this boundary-spanning work. Also, the visibility of ADVANCE IT projects raised expectations to engage with a national network and to establish the value and impact of this work by gathering evidence and sharing useful practices. Thus, project directors and their institutions were put on notice that IT efforts should be well organized and institutionally supported. Signaling that such expectations should be negotiated in advance, letters of institutional commitment for time and infrastructure were required from key people and offices.

To help with these challenges and to monitor them, the RfP recommended (2009), then required (2011), both an internal steering group and an external advisory group. The internal steering group was "to help manage the project implementation, resolve project issues, and ensure that the project is on track for meeting project goals" (2009), and the external advisory group was to advise on project implementation and progress, separate from the external evaluator. Proposal writers were instructed to define these committees' roles and responsibilities, with advice given as to size, composition and meeting frequency.

To buttress local oversight, RfPs also specified increased accountability to NSF. From the start, a list of performance indicators and management goals was included in the binding cooperative agreement between NSF and the institution that defined terms of an IT award (2001). Later accountability measures included a third-year site visit "to conduct an in-depth evaluation of performance, assess progress toward goals, provide advice and recommendations for enhancing project performance, and to determine continuation of support for the project" (2007), quarterly in addition to annual reports (2009), and first-year site visits to provide technical assistance with award management and for evaluative purposes (2012).

Expectations for program evaluation similarly increased over time. Initial requirements for a "credible plan" naming "indicators and specific measurements" and led by someone external to the project (2001) were expanded to require that evaluation "ascertain which of the activities implemented are more or less effective" (2002), then further elaborated to call for "objectives, benchmarks and indicators of progress" that would be used to strengthen project implementation and to define the "essential factors for judging accountability" (2005), complete with examples of such measures. By 2009, the RfP language had stabilized and provided concrete details about the content of formative and summative evaluation plans and the coordinated roles of internal and external evaluators. The 2014 RfP declared that evaluating outcomes of specific activities was "not sufficient" and instead highlighted the need to measure activities' impact on achieving overall project goals.

Expectations for dissemination likewise increased over time. The first RfP required only a "plan for sharing best practices" (2001), but by 2005, institutions were directed not just to transform themselves but to gather and share information so that others could do the same:

> The program encourages dissemination of knowledge […] to organizations and institutions that can implement reforms based on what has been learned. Since the goal of the program is to contribute to a national knowledge base, it is important to show that the investigator is aware of appropriate channels […] and is committed (including allocating resources) to make sure that the investment in the project leads to this contribution and that peers in the community will benefit. (2005)

The 2007 RfP required awardees to attend the annual program meeting, which sought to build awardees' networks for sharing research and practice. By 2009, the RfP declared that "simply making materials, tools, research, and practices available to others is not effective […]. Rather, an effort to teach and/or train [others] how to adopt or adapt the information is expected as well."

Finally, later RfPs ratchet up expectations for institutional commitment – not only to provide administrative and practical support, but to sustain its activities and outcomes after the award period. The 2001 RfP asked reviewers to consider the institution's commitment to sustaining the effort; by 2002 specific tactics were suggested, including participation by senior faculty and administrators, "development of appropriate policies and practices," and "long-term evaluation and intervention." By 2010, detailed post-award sustainability plans for "successful efforts" were required and evaluated under a solicitation-specific criterion. By 2016, the RfP stated that:

> […] sustainability should be considered at every stage of project implementation and should become a specific project activity with dedicated staff time at least from the third-year site visit through to the end of the project.

These changes likely arose from program directors' observations that ADVANCE activities were challenging to sustain without the visibility, funding and committed staff afforded by an award (Rosser and Chameau, 2006). Five years is a short time to accomplish real change in climates for women (UM ADVANCE, 2013) – but projects that began thinking early about institutionalization were more likely to succeed at doing so (Laursen and Austin, 2014).

Discussion

In this section, we consider the broad trends that are evident in the cumulative set of changes observed in the ADVANCE RfPs over time. Some of these are supported by multiple lines of evidence. We also speculate on the processes that led to these changes over time.

Some themes in ADVANCE RfPs are constant: that underrepresentation is a sign of lack of diversity in STEM faculties, that lack of diversity hampers discovering new knowledge and preparing future scientists and that the cumulative effect of multiple societal factors external to women causes this lack of diversity. The emphasis on equity rather than representation in 2016 is important in recognizing that even if women's numbers rise, this does not mean their working environments and opportunities to advance are equitable. These changes over time demonstrate a more nuanced theory of change, consistent with a double-loop mechanism of learning.

Other key ideas in the RfPs also matured over time. Multiple aspects of the RfP reflect growing awareness of how scholarly expertise could assist in designing and running IT projects, and of how these implementation projects afforded parallel opportunities to build new knowledge about the outcomes, processes and challenges for IT in varied contexts, through rigorous research and evaluation. The RfPs evince growing awareness that "one size does not fit all" – both in recognizing variation in women's needs and interests, and in encouraging exploration of ways to adapt successful strategies to new contexts. Driven by what we see as double-loop learning from early projects and the growing community of IT leaders, growing emphasis on innovation, social science research and dissemination throughout the RfP places value on exchanging this learning within and beyond the ADVANCE community. Thus, if ADVANCE cannot single-handedly transform all institutions, it can at least develop and share knowledge of how to do so. In this way, R&D work done by grantees to develop productive change strategies is amplified as good ideas spread to other sites.

In some respects, then, ADVANCE serves as a case study of how NSF operates as both the "changer" and the "changed": the agency issues an open call for new ideas and practices, the community of grantees innovates and pushes the envelope that in turn informs the next cycle of innovation as expressed in the RfP. In contrast with the hands-on approach of other federal funders to actively shape the projects that they wish to support (Colatat, 2015), here the agency itself does not innovate but rather establishes goals and conditions under which community members will innovate.

We view ADVANCE as distinctive among NSF programs in that this cycle of innovation and learning was unusually rapid and open. We conjecture multiple influences arising from the program's content, structure, culture and leadership. Community members were tightly focused on a common challenge and broad strategy of multi-level system change. Since no one had previously tackled this challenge in quite this way, cooperative learning was essential. The community quickly established persistent norms of generosity; ineligible for renewal, grantees had no incentive to withhold ideas. Most ADVANCE projects were led by highly committed senior women with a passion to improve things for those who came after them, who together formed an intellectually unstinting community.

We suggest that, as community members too, and with early access to non-public information through grantee reports and site visits, ADVANCE officers also learned quickly and cycled their learning back into later RfPs. While as researchers we have no direct access to these OL processes, nonetheless the small scale and tight focus of ADVANCE enable us to infer that double-loop learning processes involving iteration between NSF and the ADVANCE community have accounted for refined ideas of how change may occur that are evident in the RfPs. In contrast, single-loop learning processes are responsive to information from funded projects but take place internally at NSF; they have led, for example, to firm guidance of proposers toward organizing structures seen to have aided prior projects to succeed. Indeed, such direction may hint at the high stakes for ADVANCE as a small, cross-directorate program, where it may be politically important that each project succeed.

This analysis also reveals some failures of ADVANCE. Two-year colleges, PUIs and MSIs are not well represented among grantees. With increasing emphasis on knowledge-building comes a privileging of research institutions, where faculty have more time, incentive and infrastructure to undertake the scholarly and administrative work needed to support an IT project, compared to faculty whose roles focus on teaching and service. Discipline-focused projects have also been few in number. Perhaps it is harder for proposers to imagine how to leverage change strategies within disciplinary societies, or feel less compelled to work in that arena than at their home institutions. And, while ADVANCE has supported much important research, its focus on formal, peer-reviewed publication as the main route of dissemination has not led to rapid sharing and uptake of research findings to a degree concomitant with the uptake of best practices shared more informally.

The RfPs do show an increasingly sophisticated appreciation for and understanding of the links between intersectionality and institutional change. Though initially inattentive to women of color and treating women as a monolithic category, the RfP now foregrounds intersectionality and equity – an important shift from an "additive" approach to addressing the unique experiences of minoritized women with a more inclusive scope. As Armstrong and Jovanovic (2017) argue, "Without an intersectional perspective, the systemic issues particular to URM women can remain hidden in a structural 'blind spot,' unseen and unaddressed by the institutions that wish to support them" (p. 226). And while an additive approach may be insufficient for authentic and integrated institutional change, initiatives of this type have nonetheless contributed (in limited ways) to achieving NSF goals across the life of ADVANCE (Armstrong and Jovanovic, 2017). Indeed, intersectionality is a good example of how incorporation of a new theoretical perspective into NSF RfPs may lag decades behind its widespread use by scholars. We speculate that increasing attention to

and application of this theory by leaders of funded projects led to its explicit inclusion in the RfP that in turn elevates this idea within new ADVANCE projects.

With this we argue that the ADVANCE program itself is on an improving trajectory. NSF has seemingly learned to hold institutions accountable for a more inclusive approach to transformation. Double-loop learning informed organizational knowledge creation that led to revised and, from gendered organizational and intersectional perspectives, improved efforts toward inclusivity and diversity. Attention to "organizational" and "cultural" aspects of institutions (2016) foregrounds key areas of institutions where gendering occurs (and thus inequities) and shapes how we imagine transformational change. That this responsive shift is evident and now explicit in ADVANCE RfPs and successful proposals is encouraging. Future research should explore whether explicit attention to intersectionality is influencing other US NSF programs, or initiatives in other countries.

More recent IT projects have learned from earlier successes (and failures) to better integrate change approaches throughout varying levels of an institution and address multiple kinds of barriers: structural, cultural, macro- and micro-climate (Laursen and Austin, 2014). To succeed, the chosen change strategies must mirror the various ways in which an institution is gendered – and racialized, classed and heteronormative. Thus inequalities may be "dismantled on multiple levels: (a) *structurally*, through policies and procedures that privilege certain groups (often in unseen ways); (b) *institutionally*, through institutional cultures that shape social interactions between constituents; and (c) *individually*, through organizational members' individual identities" (De Welde and Stepnick, 2015, p. 288, original emphases).

In sum, we see NSF's shift from addressing disparities for STEM women at the individual level to targeting institutional change as an appropriate response to women's underrepresentation in academic STEM careers, pushing the community toward more effective systemic approaches even if in practice efforts may fall short (e.g. Morimoto *et al.*, 2013). Likewise, the embrace of intersectionality is an encouraging trend, though not yet fully realized (Armstrong and Jovanovic, 2017). NSF's rhetoric remains in flux; its current director speaks of "intentional equity" (Córdova, 2016) yet still invokes a monolithic "equity for women." Thus, we are (cautiously) optimistic that NSF will further develop and encourage the linking of institutional and intersectional transformation efforts to advance women in STEM careers. In documenting the outcomes of OL at NSF that have led to stronger and more inclusive ADVANCE IT initiatives, we hope this linkage will become a signature of other NSF programs.

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Missing or seizing the opportunity? The effect of an opportunity hire on job offers to science faculty candidates

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Abstract

Purpose – As universities grapple with broadening participation of women in science, many ADVANCE funded institutions hone in on transforming search committee practices to better consider dual-career partners and affirmative action hires ("opportunity hires"). To date, there is a lack of empirical research on the consequences and processes underlying such a focus. The purpose of this paper is to examine whether and how two ADVANCE-recommended hiring practices, dual-career hiring and affirmative action hiring, help or hinder women's participation in academic science.

Design/methodology/approach – In two experiments, the authors tested what happens to a science candidate's evaluation and offer when that candidate reveals he or she has a dual-career partner (vs is a solo-candidate, Experiment 1) or if it is revealed that the candidate under review is the dual-hire partner or is a target of opportunity hire (vs primary candidate, Experiment 2). A random US national sample of academic scientists provided anonymous external recommendations to an ostensible faculty search committee.

Findings – Evaluators supported the job offer to a primary candidate requiring a heterosexual partner accommodation. This good news, however, was offset by the results of Experiment 2, which showed that support for the partner or affirmative action candidate depended on the evaluator's gender. Taken together, the research identifies important personal and contextual features that sometimes do – and sometimes do not – impact hiring perceptions of women in science.

Originality/value – The authors believe the effects of such an emphasis on opportunity hires within ADVANCE funded institutions may be considerable and inform changes to policies and practices that help bring about gender equality.

Keywords Affirmative action, Gender equality, Dual-career accommodation, Women in science

Paper type Research paper

Social justice is just one of many very good reasons to care about diversifying the academic workforce (Byars-Winston, 2014; Cech, 2014; Chesler *et al.*, 2005). Diversity in academic science lends itself to more creative and innovative discoveries (Hong and Page, 2004; Page, 2008; Valantine and Collins, 2015), provides role modeling of multiple ways of knowing that appeals to underrepresented students and breaks down stereotypes (Young *et al.*, 2013) and fosters a more inclusive work and social climate for everyone (Pande and Ford, 2011). Knowing these benefits of a diverse working and learning scientific community, universities must grapple with the reality that universities are highly gender and racially homogenous, with white men disproportionally represented as faculty in most science fields in higher education (National Science Foundation, 2017). Efforts to transform

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academic science into a more gender diverse and inclusive workplace must include scrutinizing university policies and programs aimed at rectifying the gender inequity, which have remained a focus of the National Science Foundation's ADVANCE Institutional Transformation grants (Mitchneck *et al.*, 2016). In this study, we examine two of the ADVANCE-recommended hiring practices, dual-career and affirmative action hires, aimed at broadening the participation of women in academic science.

Literature review

Universities are realizing that to recruit academic women in science, hiring practices must move from a "two-body problem" to a proactive "two-body opportunity" (American Association of University Professors, 2010; McCluskey *et al.*, 2016; Schiebinger *et al.*, 2008). The number of dual-career couples in academia is difficult to determine, as existing evidence is mostly anecdotal (Chronicle of Higher Education, 2011; Simmons, 2012). The best (albeit decade old) research by Schiebinger *et al.* (2008) revealed that over one third of faculty (36 percent) partner with or marry other faculty, and compared to men, women are especially likely to have academic partners (40 percent vs 34 percent, respectively). These data also show that dual-career couple rates are highest in academic science, with 54 percent of men and 83 percent of women scientists having a partner who is also in academic science. This means that to recruit women in academic science, university hiring committees must consider dual-career needs. The American Association of University Professors (2010) summarizes the issue as follows: "In the absence of such [dual-career] accommodations, academic couples may find themselves faced with long-distance relationships or the subordination of one career to the partner who succeeds in securing a position. Evidence, such as the high proportion of women in part-time and contingent positions, and the relative lack of women in tenure-track positions in research universities, suggests that the lack of such arrangements may be having an adverse impact on the careers of academic women" (p. 82).

Under US "Equal Employment Opportunity Commission" law, it is illegal to discriminate against someone seeking employment because of their marital or perceived marital status (Title VII of the Civil Rights Act, 1964). Nevertheless, fearing bias, candidates struggle with when to inform a search committee about a dual-career need (Simmons and Chivukula, 2015). Among women in academic science, does it hurt a candidate's job offer when she reveals she has an academic partner? And how does the partner fare when evaluated as a dual-career accommodation? Theories on internalized stigma consciousness (Pinel, 1999) coupled with evaluators' use of shifting standards (Biernat and Manis, 1994) suggest the possibility of a stigma for partner hire applicants who are assumed to be underqualified for a tenure-track position (e.g. Holmes, 2015). Although empirical work examining such experiences is limited, existing evidence points to both perceived and internalized stigma due to a partner hire status. For example, in Schiebinger *et al.* (2008), one faculty member offered this perspective on dual-career hires: "One partner is almost always perceived as better than the other. The other partner then suffers, in terms of what is offered, in reduced long-term support, and also psychologically as a second-class citizen." Therefore, it follows that self-identification in a dual-career academic couple (i.e. as the opportunity hire) may come at a cost.

Opportunity hires are not a "new" idea. Affirmative action programs are a long-standing recruitment tool for increasing women's participation in academic science. Federally contracted organizations in the US (including higher education institutions) are required to take "affirmative actions" to undo a history of marginalization and underutilizing a given population of people (U.S. Department of Labor, 1965). Misunderstandings about and resistance to affirmative action policies abound (Harrison *et al.*, 2006). Affirmative action hiring is not about quotas; affirmative action hiring is about recognizing that a highly

qualified diverse person is a value-added to the university (American Association of University Professors, 2014a). Opposition to such "target of opportunity" affirmative action hires likely stems from a zero-sum mentality (Norton and Sommers, 2011) that assumes less qualified women and minorities take the place of better qualified men (Chesler *et al.*, 2005). This line of thinking is a form of implicit bias that affirmative action programs are meant to combat (Bagenstos, 2007). Search committees might assume that they should ignore a candidate's race and gender and take a "colorblind" approach. Yet, decades of research suggest that people are very good at "guessing" a person's protected class, even when extraordinary measures are taken to conceal it (Jones and Urban, 2013). Seminal research from Heilman *et al.* (1992) illustrates that job applicant materials designated as an "affirmative action hire" reduced a woman's perceived competence relative to other female candidates for the same position; this effect was found in stereotypically masculine jobs (e.g. electrician) as well as more gender-neutral jobs (e.g. lab technician) (Heilman *et al.*, 1992). Thus, even when an affirmative action policy is exercised, how does the candidate fare when it comes time for the job offer? Are they seen as value-added with an "all-in" approach to make them the best offer possible? Or, perhaps, are such target of opportunity hires seen as less worthy with their accomplishments reduced to their status as a minority?

We draw from Shifting Standards Theory (e.g. Biernat and Manis, 1994; Biernat and Kobrynowicz, 1997) to test whether and how evaluations and job offer recommendations might differ for science faculty job candidates as a function of their status as an "opportunity candidate" who either requires a partner accommodation, is the partner candidate, or is an affirmative action candidate. Although the motivational reasons for devaluing a particular type of opportunity candidate (partner compared to affirmative action) may be different, the resulting shift in evaluation can be examined through a shifting standards perspective. Shifting Standards Theory posits that people shift the anchors of evaluations for zero-sum scales (e.g. salary, lab space, start-up funding) in favor of the higher status group (Biernat and Vescio, 2002). Numerous studies show that women, who are socially lower in status than men, receive fewer resources when they occupy higher status positions or are otherwise engaged in a gender role-incongruent domain or task (e.g. Biernat and Vescio, 2002). Non-zero-sum scales (e.g. Likert rating scale of competence) are tricky because it is difficult to know the reference group a perceiver is using. Sometimes a woman is judged competent relative to other women and sometimes she is judged competent relative to men, or relative to everyone; what is considered "competent" shifts depending on the reference group. On the other hand, zero-sum scales (e.g. rankings, salary, days off work) are often clearer because perceivers are using the entire population as a reference point (e.g. Biernat and Vescio, 2002).

Shifting Standards Theory is useful for understanding how the burden of proof for excellence might "shift" in a stereotypical way depending on the gender of the person who is being evaluated (Biernat and Manis, 1994). Case in point, Fuegen *et al.* (2004) asked US college students to make objective ratings about men and women law school graduates applying for an attorney position. Participants examined an identical resume, except the applicant was either described as male or female, and as either single without children or married with two young children. Participants were asked to set zero-sum standards for performance levels (e.g. standardized test scores needed to hire) and time commitment (e.g. how many days each month the applicant could leave early or call in sick). Results showed that the female applicant who was a parent was held to higher performance standards and stricter time commitment allowances than the same applicant who was a father. Indeed, parenthood did not negatively impact the evaluation of the male attorney applicant, and if anything, there was evidence for a fatherhood "leniency bias."

To test whether and how evaluations and resource allocation judgments might shift for opportunity candidates, we used a "resume study" methodology similar to Fuegen *et al.* (2004)

and other applicant-review hiring studies (e.g. Ameri *et al.*, 2015; Moss-Racusin *et al.*, 2012; Smith *et al.*, 2007; Steinpreis *et al.*, 1999). Drawing on a pool of evaluators who believed that they were offering input on an actual candidate under consideration for an assistant professor position in the USA, we sent out job materials with the exact same qualifications; the job vacancy description, cover letter, curriculum vitae and representative publication were identical and any differences in candidate evaluations would be due to modified instructions in the e-mail invitation and/or the perceived gender of the candidate. We used materials that depicted a well-qualified candidate (i.e. meeting minimum qualifications for the position, such as earning the terminal degree and showing potential for external funding). With that said, we intentionally created an ambiguous hiring situation (i.e. showing some weaknesses of the job candidate), which sets up a realistic situation for stereotypes to come into play (Fiske and Taylor, 1991).

Overview and hypotheses

The purpose of the present research was to examine whether and how two hiring practices, dual-career hiring and affirmative action hiring, help or hinder women's participation in academic science. We assessed both non-zero-sum evaluations of the candidate's perceived competence and hireability as well as zero-sum recommendations for compensation and resources. We conducted two studies to test this question with a nationwide sample of tenure-track faculty members across different science fields: chemistry and Kinesiology. In Experiment 1, we focused on how a solo-candidate (male or female) fares compared to the same candidate who makes it known that he/she has a partner and would require an academic dual-career accommodation. In Experiment 2, we focused on the experiences of candidates identified as the "opportunity candidate" (i.e. the partner of a primary candidate or an affirmative action candidate) compared to a primary-solo-candidate.

Importantly, we focused on the gatekeepers whose opinions have considerable bearing on the hiring process: hiring authorities and potential search committee members. We used two faculty samples with different stakes in the hiring process: Department Chairs – often the hiring authority for faculty lines – for whom "opportunity hire" considerations may be salient given top-down administration messages about diversity; and faculty members who serve on search committees, engage in formal and informal evaluations of candidates and importantly, may have varying levels of training and/or awareness of the contributions of "opportunity hires." Drawing from Shifting Standards Theory, we predicted that subjective evaluations would not differ based on the type of candidate, but that more limited zero-sum evaluations would favor the primary-solo hire. Specifically, we expected similar subjective qualification ratings of the "potential for success" across all candidates (*H1*) but predicted larger salaries, start-up packages, and research space for primary hires compared to dual-career or affirmative action opportunity hires (*H2*). We also explored the role of gender in these decision-making processes. Because of the complexity of recruiting a national sample of external evaluators for our candidates, we relied on partial designs isolating the role of gender differently across studies. Specifically, we examined candidate gender on opportunity hiring recommendations (Experiment 1) and the influence of evaluator gender on opportunity hiring recommendations (Experiment 2).

Experiment 1

Method

Participants. A random, nationally representative sample of 48 Chemistry Department Chairs (85.4 percent male, 91.7 percent full professor) from different PhD granting universities in the USA participated[1]. Most of our sample was male, which mirrors national trends in chemistry for chemistry professors specifically and academic

department leaders more generally (American Association of University Professors, 2014b). Department chairs were identified from websites of Chemistry PhD programs using a list of all programs in the nation obtained from the American Chemical Society ($N = 206$). As the "applicant" materials were modeled after a real person's candidate materials, our list of chemistry programs was screened to eliminate schools which were affiliated with the person's educational and career background (e.g. co-author institutions, graduate program attended). Based on these criteria, 185 invitations were sent (26 percent response rate).

Procedure. All department chairs were invited to participate as "external evaluators" via an e-mail request from the ADVANCE principal investigator (the second author) and Dean of the Letters and Science College at the university requesting the review. The request to review was framed as a pilot study "aimed at developing appropriate search protocols for academic job searches," in conjunction with the University's ADVANCE grant. Specifically, participants were told that multiple external reviewers would be asked to review a candidate for a position at the assistant professor level. Evaluators were then asked to provide an "anonymous (expedited) external review" of the candidate using a secure online screening matrix, and then provide feedback on the external review process. After obtaining informed consent, evaluators were directed to a secure website for the candidate, where they accessed a job advertisement (modified from a recent vacancy advertisement from the interdisciplinary Center for Biofilm Engineering at the university), candidate's CV and cover letter and one selected reprint/preprint. Participants were randomly assigned to one condition in a 2 (Candidate gender: female, male) × 2 (type of candidate: primary candidate with partner accommodation need, primary-solo-candidate) between-participants design.

Materials and manipulations. The e-mail invitation differed depending on random assignment to condition. The primary-solo-candidate condition read "Time is of the essence so we can move forward as quickly as possible." In the primary candidate with partner accommodation need, the e-mail invitation read: "Time is of the essence so we can move forward as quickly as possible as the candidate has informed the committee of the need for an academic partner accommodation." The e-mail invitation also indicated the gendered first name of the candidate under review (Gary or Lisa).

The real person who granted us permission to modify her actual application materials was already in a tenure-track position at the university. As such, the candidate's qualifications on the CV were modified to be more ambiguous in merit (i.e. meeting but not exceeding expectations for a junior-level hire) and her first name was changed for confidentiality. For example, although the candidate was described as having significant post-doctoral experience, the publication record was (intentionally) reduced and the candidate lacked external funding. The sample publication and CV were identical across conditions, except for the first name of the candidate, which was manipulated on all the materials as male (Gary) or female (Lisa). These first names were selected for their relative equivalence on competence, attractiveness, and age (Kasof, 1993).

The cover letter was manipulated to include information about the candidate's gender (signed as either Gary or Lisa) and contained information about the need for an academic partner accommodation (or not). Specifically, in the partner accommodation need condition the letter read "When considering where to apply, my partner and I know we need to be in a place where we can both thrive as academics and our hope is that Montana State University is the type of university that will see the positive impact we can both make with our independent lines of interdisciplinary research." By contrast, the primary-solo-candidate condition read "When considering where to apply, I know I need to be in a place where I can thrive as an academic and my hope is that Montana State

University is the type of university that will see the positive impact I can make with my independent line of interdisciplinary research."

Measures. External evaluators were asked to complete a screening matrix for the candidate, containing non-zero-sum ratings of potential for success (7 items, 1–5 scale). Example items included "potential for scholarly impact, potential to teach and supervise undergraduates, and potential for research productivity" (Cronbach's $\alpha = 0.88$). The screening matrix was based on the widely-used candidate tool developed through the ADVANCE funded STRIDE program at the University of Michigan (2016).

Recommendations for zero-sum resources were collected after providing institution and discipline-specific ranges for salary (range = \$63,000–\$85,000), start-up package (range = \$250,000–\$1,000,000), and research space (range = 750–1,500 square feet). We also requested participants' demographics (e.g. gender, academic rank) and experiences with the search process, in addition to whether they themselves were part of a dual-career hire.

Results

A 2 (candidate gender: female, male) × 2 (type of candidate: primary candidate with partner accommodation need, primary-solo-candidate) analysis of variance (ANOVA) was conducted on perceived potential for success. Partial η^2 was calculated to estimate the size of the effects, using 0.01 as a small effect size, 0.06 as a medium effect size and 0.14 as a large effect size (Cohen, 1988; Richardson, 2011). No main effects of candidate gender, $F(1, 44) = 0.44$, $p = 0.51$, $\eta_p^2 = 0.01$, or type of candidate, $F(1, 44) = 0.37$, $p = 0.55$, $\eta_p^2 = 0.01$, nor the candidate gender × type of candidate interaction, $F(1, 44) = 0.19$, $p = 0.67$, $\eta_p^2 = 0.00$, emerged. In support of *H1*, being perceived as having a partner did not affect non-zero-sum perceptions of candidate's potential for success in chemistry, regardless of candidate gender (see Table I).

We next tested zero-sum recommendations using parallel 2 (candidate gender: female, male) × 2 (type of candidate: primary candidate with partner accommodation need, primary-solo-candidate) ANOVAs on salary, start-up package and research space. No main effects of candidate gender, $F(1, 38) = 0.25$, $p = 0.62$, $\eta_p^2 = 0.01$ or type of candidate, $F(1, 38) = 0.36$, $p = 0.55$, $\eta_p^2 = 0.01$, nor the candidate gender × type of candidate interaction, $F(1, 38) = 0.01$, $p = 0.94$, $\eta_p^2 = 0.00$, emerged on suggested salary. Similarly, no

Candidate Gender	Primary-solo-candidate *M* (SE)	Primary candidate with partner accommodation need *M* (SE)
Potential for success		
Male	2.18 (0.17)	2.21 (0.21)
Female	2.23 (0.19)	2.43 (0.20)
Salary		
Male	74,464 (1,371)	73,625 (1,813)
Female	75,400 (1,622)	74,300 (1,622)
Start-up package		
Male	530,769 (47,983)	514,286 (65,390)
Female	613,889 (57,669)	616,667 (57,669)
Research space		
Male	1,112.5 (69.0)	1,064.3 (90.4)
Female	1,106.3 (84.5)	1,194.4 (79.7)

Note: Salary and start-up packages assessed in US dollars, and research space assessed in square footage

Table I. Department chair recommendations for chemistry candidate by condition

main effects of candidate gender, $F(1, 34) = 2.60$, $p = 0.12$, $\eta_p^2 = 0.07$ or type of candidate, $F(1, 34) = 0.01$, $p = 0.91$, $\eta_p^2 = 0.00$, nor the candidate gender × type of candidate interaction, $F(1, 34) = 0.03$, $p = 0.87$, $\eta_p^2 = 0.00$, emerged on suggested start-up package. Finally, no main effects of candidate gender, $F(1, 32) = 0.58$, $p = 0.45$, $\eta_p^2 = 0.02$ or type of candidate, $F(1, 32) = 0.06$, $p = 0.81$, $\eta_p^2 = 0.00$, nor the candidate gender × type of candidate interaction, $F(1, 32) = 0.70$, $p = 0.41$, $\eta_p^2 = 0.02$, emerged on suggested research space. Unexpectedly, *H2* was not supported, such that valuable (and limited) resources such as salary, start-up funding and research space were not differentially allocated by Chemistry Department Chairs based on whether a candidate disclosed the need for a partner accommodation or not (see Table I).

Discussion

Results showed that among a national sample of Chemistry Department Chairs, standards did not significantly shift based on whether or not a candidate revealed the need for a dual-partner career accommodation or based on the candidate's gender. That is, no two-body bias or gender-bias emerged. Instead, male and female candidates who revealed the need for a dual-career accommodation were evaluated similarly to primary-solo-candidates on both subjective and objective measures. This null finding on the zero-sum recommendations runs counter to our Shifting Standards hypothesis, but is, in and of itself, good news for STEM candidates who are part of a dual-career couple. Of course, null results must be interpreted with caution, and the small sample size could mask important small or medium effects. That said, this initial evidence showing no penalty by hiring authorities when an academic woman (or man) in science requests a partner accommodation, suggests that policies and practices are working to normalize two-body opportunities (e.g. McCluskey *et al.*, 2016).

In Experiment 1, both candidates were the primary applicant under review. We next tested how the opportunity candidates themselves fare; do external evaluators shift standards depending on whether the candidate is the partner of a primary candidate or is an affirmative action candidate? We also set out to examine the role evaluator gender plays in hiring decisions. In Experiment 1, over 80 percent of the Chemistry Department Chairs who participated were men, thus we were unable to test for evaluator gender differences. Some research suggests that men, especially men in science, might be especially likely to shift standards of evaluation on gender equity issues (Handley *et al.*, 2015; Moss-Racusin *et al.*, 2015). On the other hand, men and women are prone to similar levels of implicit gender associations (Nosek *et al.*, 2009) and both men and women faculty negatively evaluate women's resumes for a scientific research position (Moss-Racusin *et al.*, 2012).

Experiment 2

Experiment 1 demonstrated that qualification reviews and resource recommendations by Chemistry Department Chairs were not significantly influenced by information about the candidate's need for a partner accommodation. Experiment 2 set out to investigate whether being the opportunity hire resulted in shifting standards or not. We investigated effects using a different male-dominated science discipline (Kinesiology) to provide generalizability. A recent study of Kinesiology department chairs indicated that most were Caucasian (92 percent) and male (61 percent); Kinesiology faculty, although slightly more diverse than department chairs, are still predominately Caucasian and male, especially among tenure-track positions (Ransdell *et al.*, 2018). We, thus, extended reviewer invitations to a random, nationally representative sample of men and women faculty members at all ranks in Kinesiology who may be involved in hiring decisions. Further, we explicitly set out to test the role of evaluator gender. As such, the

design of Experiment 2 was a 3 (type of candidate: affirmative action candidate, partner candidate, primary-solo-candidate) × 2 (evaluator gender: male, female) between-participants design.

Method

Participants. A list of Kinesiology departments and websites ($n = 463$) was obtained from the College Decision website, CAPPEX (www.cappex.com/colleges/majors/kinesiology-and-science-169#!p=1&). Departments were included in the study if they had a minimum of four faculty members holding a PhD Degree. From this list of Kinesiology Department websites, the total number of eligible participants in each department was entered into a random number generator and used to select which faculty member would be contacted from each department. The final stratified random sample of tenure-track male and female faculty ($N = 60$, 45.6 percent male), with females oversampled, resulted in a fairly well-balanced representation of faculty across rank: 41.7 percent assistant professor, 31.7 percent associate professor, 26.7 percent full professor[2]. Data exclusions ($N = 9$) due to incomplete data for gender, or personal experience with partner or target of opportunity hires were evenly distributed across conditions.

Materials and manipulations. Like Experiment 1, participants received invitations from the study principal investigator and the Dean of the appropriate College (Education, Health and Human Development) to participate in an "external review" for a (fictitious) tenure-track assistant professor posting. The cover story and procedure were otherwise identical to Experiment 1.

The vita and cover letter were fictional and created by the third author, using models by actual applicants for Kinesiology faculty positions during previous years. Participants always reviewed the same female job candidate (with the name D. Karen Corbett), increasing our emphasis on women's underrepresentation in science. Participants were randomly assigned to an experimental condition where the candidate was portrayed as a partner candidate, affirmative action candidate, or a primary-solo-candidate condition.

Evaluators for the affirmative action condition received the following instructions in the e-mail invitation: "The candidate for your review is Dr Corbett, who is a potential target of opportunity, affirmative action candidate. As such, time is of the essence so we can move forward as quickly as possible." In contrast, evaluators of the partner candidate condition read "The candidate for your review is Dr Corbett, who is the partner of our finalist, who informed the committee of the need for an academic partner accommodation before being willing to accept an offer. As such, time is of the essence so we can move forward as quickly as possible."

Finally, evaluators for the primary-solo-candidate condition read: "The candidate for your review is Dr Corbett. Time is of the essence so we can move forward as quickly as possible."

Measures. Dependent measures were identical to Experiment 1, with the exception that institution and discipline-specific ranges for each of the limited resources were provided. The zero-sum measures were: salary (range = \$44,000–\$62,000), start-up package (range = \$7,500–\$32,500) and research space (range = 75–250 square feet).

Results

A 3 (type of candidate: affirmative action candidate, partner candidate, primary-solo-candidate) × 2 (evaluator gender: male, female) ANOVA was conducted on potential for success. No main effects for type of candidate, $F(2, 57) = 0.75$, $p = 0.48$, $\eta_p^2 = 0.03$ or evaluator gender, $F(1, 57) = 0.56$, $p = 0.46$, $\eta_p^2 = 0.01$, nor the type of candidate × evaluator gender interaction, $F(2, 57) = 0.89$, $p = 0.42$, $\eta_p^2 = 0.03$ emerged. In support of *H1*, being

perceived as a target of opportunity or partner candidate did not decrease perceived potential for success in Kinesiology, no matter the evaluator gender.

A 3 (type of candidate: affirmative action candidate, partner candidate, primary-solo-candidate) × 2 (evaluator gender: male, female) ANOVA was conducted on recommended salary. *H2* was not supported, as there were no main effects for type of candidate, $F(2, 51) = 0.21$, $p = 0.82$, $\eta_p^2 = 0.01$. We next tested the role of evaluator gender, and although there was no main effect of evaluator gender, $F(1, 51) = 0.11$, $p = 0.74$, $\eta_p^2 = 0.00$, a type of candidate × evaluator gender interaction emerged, $F(2, 51) = 3.11$, $p = 0.053$, $\eta_p^2 = 0.11$ (see Figure 1). The interaction illustrates support for *H2* among male evaluators. Follow-up tests indicated that affirmative action ($M = \$51{,}438$, SE = 1,807) and partner candidates ($M = \$54{,}500$, SE = 1,807) received recommendations for lower salaries (vs primary-solo-candidates, $M = \$56{,}500$, SE = 1,616) if the participant evaluator was male. In contrast, *H2* was not supported among female evaluators: follow-up tests showed affirmative action ($M = \$56{,}083$, SE = 1,616) and partner hires ($M = \$54{,}722$, SE = 1,704) received recommendations for higher salaries (vs primary-solo-candidate, $M = \$53{,}000$, SE = 1,475) if the participant reviewer was female (see Table II).

A 3 (type of candidate: affirmative action candidate, partner candidate, primary-solo-candidate) × 2 (evaluator gender: male, female) ANOVA was also conducted on recommended start-up package. Similar to the findings for salary recommendations, *H2* was not supported overall, as there was no main effect of type of candidate, $F(2, 44) = 1.69$, $p = 0.20$, $\eta_p^2 = 0.07$. However, a significant type of candidate × evaluator gender interaction emerged, $F(2, 44) = 4.97$, $p = 0.01$, $\eta_p^2 = 0.18$ (see Figure 2). The interaction illustrates support for *H2* among male evaluators. Follow-up tests indicated that as with recommended salary, affirmative action ($M = \$14{,}286$, SE = 3,307) and partner candidates ($M = \$20{,}214$, SE = 3,307) were recommended for less start-up funding (vs primary-solo-candidates, $M = \$28{,}625$, SE = 3,093) if the evaluator was male. In contrast, *H2* was not supported among female evaluators: follow-up tests showed affirmative action candidates ($M = \$24{,}167$, SE = 2,916) were recommended to receive more start-up funding compared to primary-solo ($M = \$19{,}500$, SE = 2,767) or partner candidates ($M = \$18{,}500$, SE = 2,916) if the evaluator was female (see Table II).

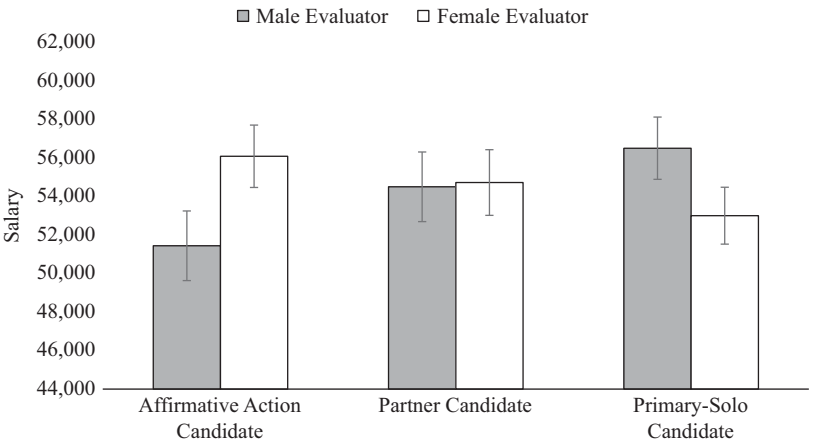


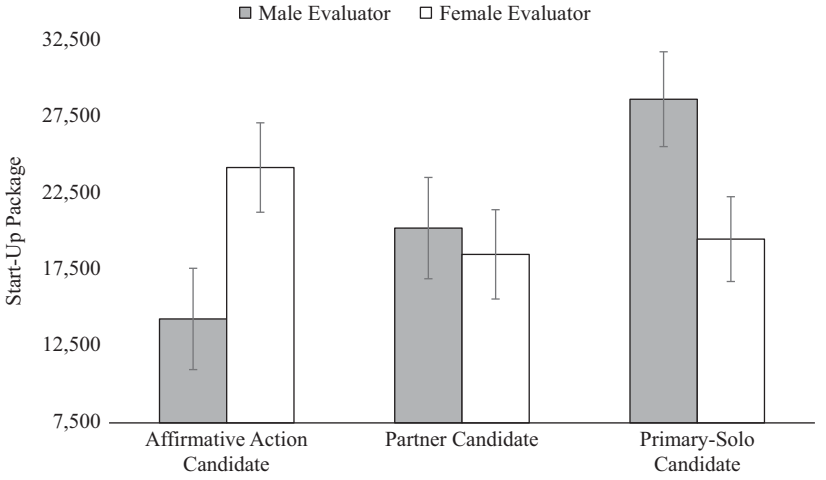
Figure 1.
Salary recommendations for Kinesiology candidates by evaluator gender and candidate type

Notes: Possible starting salaries ranged from $44,000 to $62,000 for new assistant professors in kinesiology (institution and discipline-specific ranges). Error bars represent ±1 SE

Evaluator Gender	Affirmative action candidate *M* (SE)	Partner candidate *M* (SE)	Primary-solo candidate *M* (SE)
Potential for success			
Male	2.05 (0.23)	1.93 (0.21)	1.97 (0.21)
Female	1.90 (0.20)	2.09 (0.21)	1.60 (0.18)
Salary			
Male	51,438 (1,807)	54,500 (1,807)	56,500 (1,616)
Female	56,083 (1,616)	54,722 (1,704)	53,000 (1,475)
Start-up package			
Male	14,286 (3,307)	20,214 (3,307)	28,625 (3,093)
Female	24,167 (2,916)	18,500 (2,916)	19,500 (2,767)
Research space			
Male	170.8 (21.6)	228.6 (20.0)	244.4 (17.6)
Female	200.0 (18.7)	218.8 (18.7)	200.0 (16.0)

Note: Salary and start-up packages assessed in US dollars, and research space assessed in square footage

Table II. Faculty recommendations for Kinesiology candidate by condition



Notes: Possible start-up packages ranged from $7,500 to $32,500 for new assistant professors in kinesiology (institution and discipline-specific ranges). Error bars represent ±1 SE

Figure 2. Start-up package recommendations for Kinesiology candidates by evaluator gender and candidate type

A 3 (type of candidate: affirmative action candidate, partner candidate, primary-solo-candidate) × 2 (evaluator gender: male, female) ANOVA was conducted on recommended research space. A marginal main effect of type of candidate emerged, $F(2, 43) = 2.46$, $p = 0.097$, $\eta_p^2 = 0.10$. Primary-solo ($M = 222.20$, SE = 11.90) and partner candidates ($M = 223.70$, SE = 13.70) were recommended to receive similar square footage for their research spaces, however affirmative action candidates ($M = 185.40$, SE = 14.29) were recommended to receive less square footage for their research space. No significant effects emerged for evaluator gender, $F(1, 43) = 0.30$, $p = 0.59$, $\eta_p^2 = 0.01$, or type of candidate × evaluator gender interaction, $F(2, 43) = 1.97$, $p = 0.15$, $\eta_p^2 = 0.08$. Thus, *H2* was only supported among affirmative action candidates.

Discussion

As predicted by Shifting Standards Theory, limited zero-sum ratings (and not subjective ratings) differed depending on characteristics of the candidate and evaluator. The impact of such shifting standards devaluing the opportunity candidates is clear: despite identical credentials, male faculty evaluators offered primary-solo-candidates up to $5,000 higher salary and twice as much start-up funding compared to offers to an opportunity candidate. In contrast, female faculty recommended up to $3,000 more salary and nearly 25 percent greater start-up funding to an opportunity candidate compared to the identically qualified primary-solo-candidate.

General discussion

Dual-career and affirmative action policies and practices are often part of a "promising practice" approach to transforming universities into more gender equitable places for women in science (American Association of University Professors, 2014a, b). To our knowledge, ours is the first set of experiments to systematically test for the possibility of shifting standards in dual-career and affirmative action hiring practices. We tested whether job offers depend on if the candidate provides the opportunity candidate (has an academic partner, Experiment 1) or is the opportunity candidate (is the partner of another candidate or an affirmative action candidate, Experiment 2).

Results showed that when Chemistry Department Chairs evaluated men and women candidates who explicitly identified the need for a partner accommodation, there was no significant penalty in non-zero-sum perceptions or zero-sum allocations. This good news, however, was tempered by results of Experiment 2, which showed that when Kinesiology faculty members evaluated candidates explicitly identified as the partner or as an affirmative action candidate, male evaluators offered the highest salaries and start-up compensation to primary candidates, followed by partner and affirmative action candidates; women evaluators offered the highest salaries and start-up compensation to the two opportunity candidates, with the lowest offers going to primary candidates. Space allocated by male and female faculty evaluators was similar for the primary and partner candidates, and less for the affirmative action candidate. Taken together, results suggest that although a candidate was not penalized for requesting a partner accommodation, support and resources for the opportunity candidates depended on if the evaluator was male or female. This means that while it might be fine for a woman to disclose a dual-career need in her job application, her partner might not receive the resources needed to be successful when it comes time for the job offer to be extended.

At this early stage of the research in understanding dual-career and affirmative action hiring processes, we opted to focus on department chairs in one science field and faculty members who serve on search committees in another science field. Certainly, it would be a herculean effort to recruit the necessary large and gender diverse sample from the same science field to examine all conditions within the same study. Although this research offers initial insight into shifting standards processes involved in "opportunity hires," replicating and generalizing results are an essential next step. We acknowledge that Chemistry and Kinesiology are but two of the many diverse scientific fields; however, Kinesiology findings may be generalizable to other science fields because the discipline of Kinesiology is diverse, typically including faculty with expertise in subfields related to biology, physiology, biomechanics/bioengineering and psychology. Given that our candidates were perceived to be actual candidates (rather than hypothetical applicants, e.g. Williams and Ceci, 2015) and evaluations were not constrained by institutional norms at a single university, we believe this set of studies offers an important contribution to both theory and practice.

Limitations and future directions

This set of studies provides a first glimpse into the decision-making processes involved in diversity hiring in academic science, but it is not without its limitations. Three potential

alternative explanations deserve consideration for the null findings revealed in Experiment 1: external vs internal evaluators, low statistical power and priming of gender-egalitarian norms. First, one difference between the external reviewers tested in our studies and actual internal stakeholders (e.g. department heads, faculty) is the degree of separation in working with (and working to accommodate) the potential hire. That is, it is possible that the null findings from Experiment 1 would show biases in resource allocation (as predicted by *H2*) if the potential hire was being considered at the same institution as the evaluator. Second, given the complex realistic nature of our data collection, it is possible that Experiment 1 was insufficiently statistically powered to detect small and medium effects. Third, recall that respondents received a joint invitation to participate in the external review from the Principal Investigator of the ADVANCE grant and College Dean. We cannot rule out the possibility that simply receiving the request that mentions ADVANCE may have primed gender-egalitarian mindsets among some respondents. It is thus too soon to rule out shifting standard biases, as future research must replicate and address these (and other) possible explanations.

It is important to use caution when interpreting the null results of Experiment 1, as it is also possible that there is something unique to Chemistry as a field (e.g. greater awareness of gender diversity issues) or to department chairs specifically (e.g. specialized training about broad hiring practices) that limit generalizability of the null results to other fields. It is also possible that the null hypothesis is true and that a primary candidate is reviewed similarly by a hiring authority in science no matter if the candidate explicitly notes that they are part of a dual-career couple and will require a partner accommodation. We feel it is important to add these informative (albeit null) data to the literature in keeping with the current era of open science that calls for avoiding confirmation bias in publications that too often results in a "file drawer" full of null results (e.g. Nosek *et al.*, 2015).

Another question for future research, is whether the departmental placement of the partner accommodation may impact hiring recommendations. Partner hires may occur in the same department or a different department. Experiment 2 tested whether a partner hire in Kinesiology – in the same discipline as the primary hire – was favorably perceived and supported. Given that many academic women in science partner with other men or women in the same field (Schiebinger *et al.*, 2008), Experiment 2 modeled many real-world situations. However, when a dual-career couple is seeking hiring in the same department, there may be more departmental interest (and control over funding) to make this type of hire happen. It helps the department, the new hire, and the partner – so all benefit.

By contrast, when the partner's area of expertise falls in a department other than the primary hire's, it could be seen as a "loss" or something "forced on" the other department, making it potentially more difficult to convince the other department of the merit of the hire – even if funding is provided by the hiring department of the primary candidate and Academic Affairs. The perceptions of "loss" by an outside department may include (though is not limited to): lower likelihood to justify a future faculty line within the department, less individual support and assistance from existing departmental resources (e.g. sharing of administrative assistant, departmental budget), and reduced autonomy for shaping formal (i.e. course selection) and informal (i.e. social dynamics of the department) practices. Such diverging responses to dual-career candidates based on departmental placement can be understood through the lens of zero-sum beliefs, within the Shifting Standards Theory framework (e.g. Norton and Sommers, 2011; Wilkins *et al.*, 2015). Specifically, zero-sum beliefs may be more strongly endorsed by faculty members in an outside department, which could explain the increased resistance to the dual-career candidate. Here is where emphasizing the cost-benefit of dual-career accommodations is especially important, including reassuring the partner's department of long-term benefits of what is statistically likely to be a highly productive and loyal faculty member (McCluskey *et al.*, 2016).

Future research would do well to test the impact of departmental placement and zero-sum mentality on perceptions of dual-career hires, as well as the role of gender equity initiatives such as ADVANCE. This could be accomplished by conducting in-depth interviews of department leaders, colleagues, and the partners and primary hires themselves. An analysis that examines partner hires who are in the same unit compared to a different unit, in universities that do – and do not – have policies or practices about dual-hires would provide nuance and depth to what is a very complex situation.

Practical implications

There are numerous barriers to recruiting and retaining women and other underrepresented minority faculty in academic science, including (but not limited to): less than optimal mentoring and networking (Ransdell, 2014), fewer prestigious post-doctoral opportunities (Sheltzer and Smith, 2014); lukewarm recommendation letters that overemphasize personality (Schmader *et al.*, 2007); devalued scholarship (Knobloch-Westerwick *et al.*, 2013) and less success securing grants and start-up funding (Ginther *et al.*, 2011). This list, unfortunately, can go on and on, but boils down to pervasive, structural, and subtle biases in the academic workplace (e.g. Carnes *et al.*, 2015; Fox, 2015; Moss-Racusin *et al.*, 2012; Reuben *et al.*, 2014).

The preliminary good news from the current data was that being a Chemistry assistant professor applicant with a dual-career need was not yet another source of bias. Identifying the need for a partner accommodation is only the first step; that partner must also interview and then compete for limited zero-sum resources. Experiment 2 illustrated that a two-body opportunity candidate and a target of opportunity candidate may not necessarily receive the resources they need to be successful, depending on the gender of the person with whom they are negotiating. One possible explanation is that in Kinesiology, men (currently in more leadership roles and in the numerical majority in this discipline), are less familiar with the need for enhancing diversity and the benefits ensued by supporting opportunity candidates, whereas women in the field may be more aware of the current lack of diversity and are thus more supportive of opportunity candidates. Although we did not test for this possibility, this speculation is in line with Cultural Matching Theory (Rivera, 2012), which predicts that people tend to have an "affinity bias" and want to hire others who share a similar plight to themselves via a commonality in knowledge, experience, interests, and self-presentation skills. Future research could test this possibility to explain why primary-solo-candidates received higher salary and start-up resources from men whereas partner and affirmative action candidates received higher salary and start-up resources from women.

It is important to stress that men in academic science serve as gatekeepers, and their skepticism about gender-bias (Handley *et al.*, 2015), coupled with their social power to maintain the status quo (Jost *et al.*, 2004), especially when in competition for limited resources (Norton and Sommers, 2011) are a barrier to diversifying the academy. As such, efforts that aim to diversify the institution must not just focus on "fixing" the women candidates and coaching them on how to apply for jobs, but must also emphasize changing implicit attitudes, especially among men who are most often in positions of power to transform their institutions. Bias literacy training, for example, is an effective tool that improves faculty's feelings of self-efficacy for engaging in gender equity behaviors (Carnes *et al.*, 2015). Modeling an inclusive democratic process through facilitated departmental-level workshops is also an effective tool for building feelings of collective efficacy toward gender equality (Latimer *et al.*, 2014). Indeed, theoretically informed search training interventions targeted at faculty are effective in improving the number of women faculty hired in science, engineering and mathematical fields (e.g. Sheridan *et al.*, 2010; Smith *et al.*, 2015). Our results suggest that it is important that such search training efforts incorporate modules that specifically address eliminating possible bias toward opportunity candidates.

Results point to the need for changes to academic search protocols to safeguard against shifting standards toward affirmative action and partner accommodation candidates. We situate our findings on dual-career and affirmative action opportunity hires within the broader context of environmental factors and institutional norms. Applying a gendered organizations perspective, higher education institutions have been considered a "gendered bureaucracy," with gender equity issues not solved by solely increasing representation (Mitchneck *et al.*, 2016; Morimoto *et al.*, 2013). Indeed, considerations regarding opportunity hires must be coordinated across all bureaucratic levels of the university – from administrators (e.g. investment by senior diversity officers), to college leadership (e.g. budgeting for opportunity hires by Deans), to individual faculty members (e.g. partner accommodation and affirmative action training provided to search committees). As Morimoto and colleagues (2013) assert, because "policies are susceptible to backlash if deeply embedded gendered culture, climate and cognitive schemas are also not simultaneously addressed," careful attention must be given to the initial experiences of opportunity hires to ensure that they are provided quality mentoring, develop a sense of belonging, and that university messages reinforce values of equity and inclusion at all ranks (e.g. faculty, staff, and student) (Morimoto *et al.*, 2013, p. 410).

These findings inform current sustainability efforts at ADVANCE funded institutions and offer insight to other universities that are considering opportunity hire practices. For example, the ADVANCE Project TRACS program at Montana State University considered partner accommodations and target of opportunity hires as part of the "enhancing cultural attunement initiative" because of the education needed to counteract possible biases toward the candidates, while simultaneously affording autonomy to committees to not feel "forced" into a given hire. To do this, the Project TRACS program designed a process to request such opportunity hires, in which department heads complete a form (see the partner request form, for example, www.montana.edu/provost/faculty/hiring.html) to detail the strengths of the candidate, how the candidate contributes to the university's strategic plan, how the partner adds to the diversity mission, and what resources are needed for the hire. Clear instructions for considering the opportunity candidate are outlined on the form, empowering the department for a successful recruitment. Candidates themselves are made aware of these opportunity hire options during their on-campus interview meeting with a "Family Advocate," who is a trained faculty member that is a confidential point of contact about these (and other) issues (see Smith *et al.*, 2015 for details on the family advocate candidate meetings).

This research is important because small differences in pay or start-up result in an "accumulation of disadvantage" (Valian, 1998). Even if we assume a very small shifting standard toward a partner hire or an affirmative action hire (accounting for as little as 5 percent of the variance) research shows that such "death by a 1000 cuts" results in a loss of opportunity somewhere between 29 and 50 percent (Martell *et al.*, 1996). Although we explicitly focused on hiring decisions, institutions must go beyond just hiring more women and underrepresented minorities in science, and truly transform the institution to be more inclusive and equitable (Mitchneck *et al.*, 2016) so that once that person is hired, they continue on a long, productive and satisfying journey at the institution. To do this, necessarily means ensuring that everyone has the resources they need to be successful.

Notes

1. Based on 80 percent power estimates using G*Power 3.1 (Faul *et al.*, 2007), there was likely sufficient power to detect a large effect size ($N = 52$) but insufficient power to detect a medium ($N = 128$) or small effect size ($N = 787$).
2. Based on 80 percent power estimates using G*Power 3.1 (Faul *et al.*, 2007), there was likely sufficient power to detect a large effect size ($N = 64$) but insufficient power to detect a medium ($N = 158$) or small effect size ($N = 967$).

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Interactive theater: an effective tool to reduce gender bias in faculty searches

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Abstract

Purpose – The purpose of this paper is to describe the development, implementation and impact evaluation of an interactive theater-based workshop by the ADVANCE program at the University of New Hampshire (UNH). The workshop is part of a larger institutional transformation program funded by the National Science Foundation.

Design/methodology/approach – This institutional transformation program relied upon a systems approach to diagnose potential causes for the underrepresentation of women faculty in certain disciplines. This revealed that increasing awareness of, and reducing, implicit gender bias among members of faculty search committees could, in time, contribute to increasing the representation of women faculty at UNH. A committee charged with developing a faculty workshop to achieve this change identified interactive theater as an effective faculty training approach. The committee oversaw the development of customized scripts, and the hiring of professional actors and a facilitator to implement the workshop.

Findings – The workshop's effectiveness in fulfilling its goals was assessed using faculty hiring and composition data, program evaluations, participant interviews and questions in an annual faculty climate survey. Findings indicate that the representation of women faculty increased significantly at UNH since the implementation of the interactive theater workshop. Analysis of the multiple sources of data provides corroborating evidence that a significant portion of the increase is directly attributable to the workshop.

Originality/value – This paper demonstrates the effectiveness of interactive theater-based workshops in an academic environment and of the systems approach in diagnosing and solving organizational problems.

Keywords Gender, Recruitment, Higher education

Paper type Case study

How can universities increase the representation of women in fields in which they have traditionally been underrepresented? This is one of the questions at the core of the University of New Hampshire (UNH) ADVANCE program. After receiving a National Science Foundation (NSF) ADVANCE Institutional Transformation award in 2012, UNH ADVANCE launched a series of initiatives to improve the representation of women faculty in STEM disciplines as part of its larger goal of institutional transformation. A centerpiece of the UNH ADVANCE program, the Gender Equity and Recruitment of Underrepresented People (GEAR UP) interactive theater workshop was designed to improve the search committee process by increasing transparency at all stages of the search process and

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reducing the prevalence of implicit bias. By increasing transparency and reducing implicit bias, GEAR UP strives to ensure that faculty searches are conducive to increasing the representation of underrepresented groups, particularly women faculty in STEM disciplines. In this paper, we briefly describe the 2012 baseline representation of women faculty at UNH and the systems view of organizations that has guided our work. We then discuss the development of GEAR UP and present quantitative and interview data that point to its effectiveness in enhancing the faculty search committee process, and consequently facilitating the recruitment of women faculty at UNH.

2012 baseline representation of women faculty

Baseline institutional data collected in 2012 underscored the need to improve the representation of women faculty at UNH, particularly in STEM disciplines. In 2012, 37 percent of UNH faculty were women. Women represented the smallest share of STEM faculty at 21 percent, followed by Social and Behavioral Sciences (SBS) at 36 percent, and non-STEM disciplines at 48 percent. Across ranks, the category in which women were most underrepresented was STEM full professors, with only 24 percent of STEM women faculty at this rank. In contrast, 59 percent of men faculty in STEM were full professors. While the percentage of SBS women faculty at the full professor rank was higher at 31 percent, it also lagged the percentage of SBS men faculty (i.e. 40 percent were full professors). At lower ranks, the representation of women was much higher, although women still comprised only 32 percent of assistant professors in STEM.

Historical trends can explain part of these problems of representation. In the past, men faculty have traditionally dominated the STEM disciplines, leading to higher percentages of men in the rank of full professor. It is possible, however, that this historical legacy has also created a lingering culture of values, beliefs and norms that fosters implicit bias, which impedes the hiring and promoting of women in fields in which they have long been underrepresented (Eagly and Karau, 2002; Fine and Handelsman, 2012; Phelan *et al.*, 2008; Trix and Psenka, 2003). To reach its goal of increasing the representation of STEM faculty women, UNH ADVANCE would have to find a way to change this aspect of the organization's culture.

UNH ADVANCE uses a systems view of organizations (Nadler and Tushman, 1980) to diagnose and address potential causes of suboptimal organizational outcomes. This approach takes into account how external forces, work processes, people, informal organization and structure interact to produce the outcomes of interest. Using this approach, we determined that in order to increase the representation of women STEM faculty, UNH would need to address potential bias in the faculty search process. Thus, UNH ADVANCE mapped out a strategy to work with all stakeholders (i.e. deans, department chairs and faculty search committee members) to build awareness, change norms and alter behavior related to the hiring of women faculty.

The GEAR UP workshop

In order to achieve lasting change, UNH ADVANCE involves as many faculty as possible in designing and implementing its initiatives. In keeping with this strategy, we recruited faculty from both STEM and non-STEM disciplines to develop a program that would improve the representation of women and other underrepresented groups at UNH. The committee met weekly from May to August 2013 and evaluated university hiring practices and what other ADVANCE programs had done to increase the representation of women and other underrepresented groups. They reviewed a host of information relevant to faculty hiring, including what should be included in a hiring packet, suggestions on how to broaden the applicant pool, how to develop evaluation criteria, what people can and cannot say during a hiring interview, and how to write the job description and the job advertisement.

In the end, the committee became convinced through their research that implicit bias in applicant screening was a significant impediment to hiring women in disciplines in which they have traditionally been underrepresented. Borrowing from the work of the University of Michigan's ADVANCE program, the committee decided to raise awareness about implicit bias through a faculty search committee workshop that used interactive theater to portray and deconstruct subtle and not-so-subtle instances of bias that sometimes stand in the way of hiring women for STEM faculty positions.

Interactive theater has become an increasingly popular method of engaging audiences in simulated activities for teaching purposes, ranging from sexual assault prevention to improving doctor–patient interactions (Finelli and Kendall-Brown, 2009; Kaplan *et al.*, 2006; Kumagai *et al.*, 2007). In one study, Skye *et al.* (2014) examined the efficacy of using interactive theater to teach medical students how to break bad news to patients. Post-workshop evaluations showed that participants found the scenarios to be realistic and helpful in thinking about different perspectives involved in the way patients and healthcare providers communicate. Using post-performance evaluations as well as three months to one-year follow-ups, Kaplan *et al.* (2006) demonstrated the efficacy of using interactive theater to change faculty behavior. As they reported, faculty are drawn into making sense of the issues portrayed, relating them to personal experience and strategizing about how to transform a difficulty situation. Several empirical studies indicate that such interventions can significantly reduce the impact of bias in search process and promote transparency and diversity in candidate selection (Carnes *et al.*, 2012; Fine *et al.*, 2014; Smith *et al.*, 2015; Stewart *et al.*, 2004). In the present paper, we evaluate the effectiveness of interactive theater by examining multiple objective, quantitative and qualitative indicators to determine whether institutional change has been achieved.

The committee invited Jeffrey Steiger, an expert in using interactive theater in diversity-related workshops at the University of Michigan and in medical education to work with the UNH ADVANCE team and Department of Theater and Dance. Together, they developed an in-house capability and customized the scripts based on interviews and focus groups with UNH faculty to maximize attendees' ability to relate to the scenarios. The workshop utilizes applied theater techniques to examine institutional climate and culture, unconscious biases and issues of status through the lens of a fictional search committee. To develop the script, the committee consulted several sources to understand how bias incidents arise, and their impact in academic settings (Fine and Handelsman, 2012; Jones and Urban, 2013; O'Connell, 2010; Smith *et al.*, 1996; Sue, 2010a, b; Steinpreis *et al.*, 1999).

The resulting workshop begins with a 20 min "activation play" called *The Search* that follows five members of an academic search committee: the "old guard" tenured professor reluctant to change; the progressive junior faculty member not wanting to make too many waves; two long-standing colleagues wrestling with messy interpersonal dynamics amid conflicting views of the future direction of the department; and the search committee chair trying to hold it all together. The play consists of five brief scenes that were the same for all the workshops:

(1) The faculty meeting: the department chair announces the formation of the search committee and asks for volunteers to serve on it.

(2) The job posting: the committee meets for the first time. The chair quickly loses control of the meeting as issues of gender bias dominate a conversation about where and how to post the opening.

(3) The gripe: a retiring faculty member expresses his concerns to the department chair, arguing that hiring one of the candidates (who is apparently underrepresented in this field based on her gender and race) would undo his whole career's worth of work, which has made the department what it is today.

(4) The conversation: two candidates remain. We follow the five committee members as they engage in contentious back-room conversations, deliberating the different ways in which the hiring of each candidate would impact the future direction of the department.

(5) The welcome: the department chair has flown to a conference, leaving the long tenured, "old guard" senior faculty member to awkwardly welcome the new hire.

The play includes several instances of implicit bias. For example, while male candidates are usually referred to as Dr or Professor (last name), some committee members frequently refer to the woman candidate by her first name. One committee member (man) mistakenly assumes and argues that she was not the first author on a research publication. In another instance, one committee member (man) approaches another committee member (woman) about her disagreeing with him at a committee meeting. He ends the exchange with the statement "why can't you just be nice?" The play also integrates examples of gender bias in how recommendation letters are written and read, how bias can be used to diminish accomplishments and the false assumption that increased diversity comes at the cost of merit.

A facilitated discussion session follows the play, and the moderator asks audience members to identify moments of tension they had witnessed within this department and try to explain what went wrong. Audience members are then able to question the characters directly in a "public" or "private" manner as they remain in, and speak from the point of view of, their assigned roles. In the public mode, all characters are assumed to be present and able to hear other characters' replies. In the private mode, a character can respond to an audience member's question without other characters hearing the answer. The actors give "public" or "private" answers about their motivations, actions and inner thoughts as they grapple with the tough decisions, problems and challenging behaviors present in their institution's hierarchy, history and culture. This interactive model highlights any differences between what a character might say when he or she knows that other, perhaps more senior "faculty" are listening and what they might really be thinking. It is a useful way to uncover character implicit biases or internal, emotional reactions to bias incidents that may not be directly aired or addressed in real life. Audience members are given the opportunity to suggest alternative strategies to navigate these sticky situations, and the actors can replay the scenarios to see how effective those strategies might have been. It also allows participants to bear witness to familiar interpersonal dynamics and then play Experimenter and Director from the comfort of their own chairs, with trained actor improvisers taking on the emotional risk of role-play training.

GEAR UP workshops were held on seven separate occasions from December 2013 through October 2016. From the outset, the UNH Provost's Office was a staunch advocate of the program and its goal of increasing the representation of women in disciplines in which they were underrepresented. All of the leaders and faculty under the Provost's Office have the potential to influence the hiring of a woman in STEM or SBS either now or in the future through search committee membership or by making the final hiring decision (in the case of an academic leader). Therefore, the Provost instructed all members of the search committees for senior administrative staff to attend the GEAR UP pilot held in December 2013. Deans, associate deans, Provost Office staff and faculty serving on senior administrative staff and STEM faculty search committees attended the workshop. While our focus was on increasing the representation of women faculty in STEM disciplines, we invited faculty from all disciplines to attend as we argued that institutional transformation via the removal of bias in the search process must be comprehensive. During the period from Fall 2013 through Fall 2016, 275 UNH faculty and staff attended a GEAR UP workshop.

GEAR UP's effectiveness

Faculty composition

During the four-year period from 2012 to 2016 when GEAR UP workshops were held, the number of tenured and tenure-track faculty at UNH increased from 607 to 637. During the same period, the representation of women faculty at UNH overall increased from 224 (37 percent) to 268 (42 percent). The representation of women tenure-track faculty in STEM increased from 21 to 26 percent. In SBS, the women tenure-track faculty increased from 36 to 44 percent of faculty. While the numbers are small (i.e. 54 and 41 women tenure-track faculty in STEM and SBS, respectively, in 2016), the increase is significant.

By rank, a similar change has occurred. During the four-year period from 2012 to 2016, the number of women tenure-track faculty at the full professor rank in STEM increased by 80 percent from 10 to 18. In contrast, the number of men STEM faculty at the full professor rank decreased by 13 percent from 94 to 82, reflecting the high representation of men faculty at retirement age. Both of these changes contributed to an increase in the percent women STEM faculty at the full professor rank from 24 to 33 percent, and a decrease in the percent STEM men faculty at that rank from 59 to 53 percent.

In SBS, the number of women faculty at the full professor rank decreased from 10 in 2012 to 9 in 2016, while the number of men faculty at the full professor rank remained the same at 23 in 2012 and 2016. The percentage of women at the full professor rank in SBS decreased from 31 percent in 2012 to 22 percent in 2016. This change is due to an overall increase in the number of women SBS faculty, particularly at the associate professor rank. During the same period, the percentage of men at the full professor rank in SBS increased from 40 percent in 2012 to 43 percent in 2016. Overall, women represented 25 percent of full professors at UNH in 2016 compared to 21 percent in 2012.

In order to determine the extent to which GEAR UP may have contributed to the increased representation of women faculty at UNH, we rely upon workshop evaluations and participant interviews, answers to relevant questions on the annual UNH ADVANCE faculty climate survey and gender composition of faculty hired. All of these methods revealed many direct and indirect benefits of the interactive theater approach for increasing and overcoming implicit bias in the hiring process.

Workshop participant evaluations and interviews

The external evaluator for UNH ADVANCE conducted surveys and interviews to determine whether GEAR UP was achieving its goals as part of the program's annual evaluation and to report successes from which others can learn. The workshop was evaluated against the following desired learning outcomes:

- increase participants' ability to recognize biases in self and others;
- increase participants' understanding of how biases operate and their negative impact;
- assist participants in developing strategies to eliminate such biases and improve search committee processes; and
- increase the number of women and underrepresented faculty in STEM and more widely.

Analysis of post-workshop evaluations indicated that, from the beginning, over 90 percent of participants who completed the form "agreed" or "strongly agreed" that the workshop had increased their understanding of how gender impacts the evaluation of candidates. Further, over 85 percent of the participants "agreed" or "strongly agreed" with statements that GEAR UP had increased their understanding of how subtle and unconscious put-downs based on implicit biases related to an individual's social identity group(s) impact the faculty search process. Finally, over 70 percent of participants "agreed" or

"strongly agreed" that they had learned ways to: reduce gender biases in the evaluation of candidates, eliminate or reduce the impact of microaggressions and/or implicit biases in the evaluation of candidates, and create or support group discussion in which everyone is able to contribute equally.

The external evaluator provided additional evidence of GEAR UP's positive impact. In interviews with GEAR UP participants, the external evaluator found that participant evaluations were overwhelmingly positive, with participants reporting that the workshop shaped their own behavior:

> GEAR UP taught me to pay attention to how candidates are being evaluated. It also taught me to look at the larger context in terms of the political culture and the people involved. They are all human and have insecurities and fears. It helped me understand where others might be coming from and I learned skills for listening and communicating.

Participants also noted a difference in the dynamics of their search committee post-workshop because it reinforced institutional norms around equality and provided a practical vocabulary for addressing inequities in the process:

> It provided a language, a set of vocabulary, that could be used to ensure the committee's evaluation of candidates was fair. If someone raised an issue that was perhaps a source of bias, we could say, "Remember in the search committee training – we aren't supposed to use that (sic) criteria."

> I had served on search committees before this training. I would say that there were stark differences […]. One thing that I would attribute to the ADVANCE program was the ability to rein in discussion when perhaps it was digressing into areas that were illegal or not following the institutional norms. I think that was something that I noticed was very different that we didn't have before.

Participants also emphasized the value of GEAR UP's training to the university. One observed, "It's a big investment to hire faculty. The institution needs to invest in this, as it makes our faculty better." Additionally, those interviewed considered the interactive component to be an extremely successful and even enjoyable way to relay the information, a viewpoint consistent with the results from the evaluation forms.

Workshop participants also provided some constructive feedback, noting that it would be helpful to provide "more concrete" and "more specific" strategies and best practices to apply in the faculty search process. Participants noted that the discussion around these strategies should incorporate issues of diversity, race and sexuality more effectively. In response, UNH ADVANCE has continued to improve on the GEAR UP workshops, with content evolving from a focus on awareness to action and including characters and issues that reflect the experience of faculty at the intersection of gender, race/ethnicity, gender identification and sexual orientation.

Climate survey results: tenure-track faculty

Since fall of 2013, UNH ADVANCE has conducted an annual faculty climate survey that has included questions about GEAR UP to gauge the workshop's impact on the faculty search process. The survey questions asked about respondents' perceptions of the following desired organizational outcomes:

- department and/or search committee deliberately engages in strategies to enhance gender diversity in the applicant pool;
- evaluation criteria are applied consistently across applicants;
- committee members are made aware of unintentional biases that can affect everyone's evaluation of applicants;

- increasing gender diversity in the department is a priority of the committee; and
- discussions are not dominated by one or two committee members.

Results from the 2016 faculty climate survey suggest that faculty members who attended GEAR UP have a significantly more positive perception of search committee processes compared to those who did not attend. Specifically, the climate survey asked participants about the extent of their agreement on each of the above goals (on a 1–4 scale, from strongly disagree to strongly agree). As shown in Table I, tenure-track faculty who attended GEAR UP reported a higher overall mean (i.e. $M = 3.15$ for attendees and 2.97 for non-attendees) and on each of the items. Importantly, responses on the questions related to gender diversity (i.e. the first and fourth items) were significantly different for attendees and non-attendees.

Longitudinal climate survey results

In addition to analyzing the most recent survey data, we also examined longitudinal trends to determine if faculty perceptions of the search committee process had improved over time. We compared data from 2013 to 2016, using Analysis of Variance to determine significant differences based on group membership, and a Tukey test to confirm where the differences occurred and whether perceptions were significantly higher in later years of the data compared to earlier years. The results suggest that the workshop had a significant impact on at least one aspect of the search committee process. That is, compared to 2013, in 2016, faculty were more likely to agree that search committee members were aware of unintentional biases that might influence evaluation of applicants ($M = 2.68$ in 2013, $M = 2.96$ in 2016, $f = 4.25$, $p < 0.01$).

Finally, we examined whether change over time in search committee process evaluation – particularly on the third goal, that faculty were made aware of unintentional biases – could be attributed specifically to the GEAR UP workshop. Perhaps more so than any of the five dimensions of search committees we measured, this most directly related to the interactive theater presentations and other portions of the GEAR UP program. In our annual faculty climate surveys, we asked faculty to provide a survey code that we could use to connect responses from the same individual over time while retaining anonymity. This code allowed us to match pre- and post-workshop ratings of respondents' search committee perceptions. Of the 141 respondents who attended GEAR UP, 50 took the survey at least one year prior to attending the workshop and also had at least one year of post-workshop data.

	Attended GEAR UP?	*N*	Mean	SD	*t*
1. The department and/or search committee deliberately engaged in strategies to enhance gender diversity in the applicant pool	No	132	3.04	0.79	−2.85**
	Yes	89	3.34	0.74	
2. Evaluation criteria were applied consistently across applicants	No	132	3.33	0.70	−0.52
	Yes	90	3.38	0.76	
3. Committee members were made aware of unintentional biases that can affect everyone's evaluation of applicants	No	130	2.89	0.88	−1.59
	Yes	89	3.07	0.74	
4. Increasing gender diversity in my department was a priority of the committee	No	130	2.57	0.84	−2.16*
	Yes	88	2.82	0.84	
5. Discussions were dominated by one or two committee members (reverse coded)	No	132	2.99	0.77	−1.50
	Yes	88	3.14	0.74	
Overall mean	No	132	2.97	0.61	−2.263*
Scale reliability: $\alpha = 0.803$	Yes	89	3.15	0.57	

Notes: *$p < 0.05$; **$p < 0.01$

Table I.
GEAR UP workshop attendance impact on search committee process evaluation

We found that after attending GEAR UP, faculty were more likely to agree that committee members were made aware of unintentional biases that can affect evaluation of applicants. The pre-workshop mean was 2.63 for faculty who would eventually attend GEAR UP, and it increased to 3.04 following their attendance, a statistically significant difference ($t = -3.218$, $p < 0.01$). We ran subsequent paired-sample t-tests among faculty who never reported attending GEAR UP to determine if any perceptions of search committees changed among non-participants over time. We did not find any significant changes for faculty who never participated.

Faculty hiring data

We also evaluated the impact of GEAR UP by tracking faculty hiring by gender over time. First, we noted that more faculty were hired at UNH overall in 2016–2017 (42) compared to 2011–2012 (10). In 2011–2012, 40 percent of the faculty hired at the assistant professor rank were women. In 2016–2017, 78.2 percent of faculty hired at the assistant professor rank were women. Great strides were also made in the hiring of women STEM faculty, where the percentage of women hired increased from 40 percent in 2011–2012 to 63.6 percent in 2016–2017.

Summary and conclusions

Our analysis finds strong support for the effectiveness of the UNH ADVANCE GEAR UP workshop. Using interviews and survey results, we find evidence that attending GEAR UP changes faculty perceptions of the search process and faculty gender representation, especially in the STEM disciplines. A series of analyses from annual faculty climate data related to perceptions of search committee processes reveal three important trends. First, those who participated in GEAR UP have significantly more positive perceptions of faculty search committees compared to those who never attended the workshop. Second, one important dimension of the search committee process improved over time – faculty reported that they were increasingly aware of unintentional biases that might impact everyone's evaluation of the applicants. Third, changes in awareness of unintentional biases occurred only for those who participated in GEAR UP, and only after having attended the workshop (faculty who did not participate in GEAR UP did not experience such an increase between 2013 and 2016). Thus, the change over time of faculty's awareness of unintentional biases can be attributed to the GEAR UP workshop, as only faculty who participated experienced any change in this important dimension.

The above findings align with actual hiring pool data that indicate an increase in percent women hired over time since 2011. By altering aspects of UNH's faculty search process to increase the awareness of the impact of bias in candidate evaluations, GEAR UP contributed to changing outcomes in favor of improved faculty gender representation. During the period studied, there was an increase in the percentage of women faculty hired, including in the STEM disciplines, as well as a sharp increase in the percentage of STEM women at the full professor rank.

While we have attempted to demonstrate GEAR UP's impact using various methods, there are many other forces at play that may also have contributed to the increased representation of women in underrepresented disciplines at UNH. Since the inception of UNH ADVANCE, there have been three different provosts at the helm of the UNH's academic mission. Throughout the years, they have been strong supporters of the initiative. During the same period, deans of the STEM colleges have been involved in the ADVANCE leadership team and steering committee and have been strong advocates for increasing the representation of women and other underrepresented faculty in hiring pools. While our results point to GEAR UP's contribution in this regard, it is by no means the only influence on faculty hiring decisions.

One notable limitation of our analysis is that we can only examine hiring data and not the retention rates of these new hires. Still, while other factors are also at play, the results of analysis of annual survey responses, workshop evaluations, faculty composition and hiring data together provide corroborated evidence that a significant portion of the change is directly attributable to the workshop.

An important indirect result of this work has been its contribution to the development of a world-class interactive theater capability at UNH. The impact of these highly trained professional actors has reached beyond our campus to other institutions that have retained their services to create realistic, customized scenarios for their faculty and staff.

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An evidence-based faculty recruitment workshop influences departmental hiring practice perceptions among university faculty

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Abstract

Purpose – Many university programs seek to promote faculty diversity by reducing biases in hiring processes. The purpose of this paper is to conduct two studies to test the individual- and department-level impact of a faculty recruitment workshop (FRW) on faculty attitudes toward evidence-based, equitable hiring practices.
Design/methodology/approach – Study 1 included 1,188 faculty who had or had not attended an FRW. Respondents were surveyed about their attitudes and their intentions to use specific equitable search practices. The authors assessed the proportion of faculty in each department to test for the impact of department-level workshop attendance on individual faculty attitudes. Study 2 employed a similar design (with 468 faculty) and tested whether effects of workshop attendance are explained by changes in beliefs about social science research.
Findings – Faculty had more favorable attitudes toward equitable search strategies if they had attended a workshop or if they were in a department where more of their colleagues had. Workshop attendance also increased intentions to act on two of three recommendations measured, and led to greater belief in evidence-based descriptions of gender biases. Some evidence suggested that these beliefs mediated the influence of the FRW on attitudes.
Research limitations/implications – Because faculty were not randomly assigned to attend the workshop, no strong claims about causality are made.
Practical implications – The present studies demonstrate that an evidence-based recruitment workshop can lead faculty to adopt more favorable attitudes toward strategies that promote gender diversity in hiring.
Originality/value – These studies provide evidence of the role of belief in social science research evidence in explaining the effectiveness of a program designed to increase faculty diversity.

Keywords Organizational culture, Women, Recruitment, Psychology

Paper type Research paper

Diversity in group settings has been found to be related to improved performance and decision-making, innovation and creativity (Ely and Thomas, 2011; Page, 2007, 2017), suggesting that in the university context, greater faculty diversity can enhance institutional excellence in teaching and scholarship and benefit an increasingly heterogeneous student body (Stewart and Valian, 2018). Therefore, many colleges and universities have developed initiatives, including training workshops for faculty search committees, to increase the representation of women and underrepresented racial-ethnic minority (URM) faculty.

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Although hiring trends are typically tracked and training workshops evaluated by attendees, there is less understanding of the psychological factors that lead to the attitude and behavior change among attendees that could ultimately increase faculty diversity. Greater understanding of these factors would help inform the development of effective faculty diversity initiatives. In this paper, we examine the role of education about social science findings and principles in shaping specific attitudes and behavioral intentions among faculty search committee members, which highlights the importance of basing faculty search training workshops on compelling scientific evidence.

Initiatives to increase faculty diversity and their evaluation

Many higher education institutions have focused on increasing faculty diversity, particularly in disciplines where there are substantially fewer women and/or faculty of color. The National Science Foundation's (NSF) ADVANCE Program is offered to "increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse scientific and engineering workforce" (ADVANCE at a Glance, 2018). In particular, the ADVANCE Institutional Transformation grant program supports initiatives designed to increase the representation of women faculty in STEM fields through efforts to escalate their hiring, promotion and retention. To date, more than $270m has been invested by the NSF to support ADVANCE projects at more than 100 institutions in 41 states, the District of Columbia and Puerto Rico (ADVANCE at a Glance, 2018).

At odds with the expanse of the ADVANCE program is evidence suggesting that programs to increase diversity may fail outright or fail to be sustained. Much of this research focuses on "diversity training" or bias reduction workshops in corporations and businesses. Several factors have been identified that lead such programs to fail. For example, the use of top-down efforts to control behavior that reduce feelings of autonomy in decision-makers can result in backlash against diversity initiatives (Dobbin and Kalev, 2016). In addition, singular reliance on seemingly objective bases for decision-making such as job qualification tests often fail, because they can be misused by managers unaware of their own biases such that they discount the performance of women and people of color (Rivera, 2012). Use of these strategies has resulted in negative gains in diversity (Dobbin and Kalev, 2016). Fortunately, this research has also revealed factors that lead to greater success; for example, increasing engagement of an organization's constituents in diversity matters can lead them to feel personally invested in these issues. Other positive factors include promoting intergroup contact, which improves perceptions of the competence of women and people of color, and increasing social accountability by using diversity task forces and diversity managers that ask questions about employment decisions. Use of these strategies has also been shown to increase diversity and reduce bias (Dobbin *et al.*, 2015; Kalev *et al.*, 2006).

Because faculty search training programs may not always follow these recommendations, evaluation of their effectiveness is critical. Therefore, ADVANCE initiatives and programs are evaluated not only to solicit suggestions for improvement, but also to test whether they are effective in achieving a more diverse faculty. The effectiveness of these programs can be assessed in several ways. Most obviously, one may evaluate changes in the numbers of white female and URM faculty hired as a result of the training. One study tested this following a three-step intervention on members of faculty search committees in STEM at a large public university in the USA. Faculty search committee members who were randomly assigned to the intervention group heard a short presentation of social science research on gender bias, received a "faculty search toolkit," and their job finalists were provided with a "family advocate" to discuss dual career issues and family friendly policies during their interview visit. Those assigned to the control group simply engaged in the university's standard human resources training for search committees.

The search committees in the intervention group were 6.3 times more likely to make an offer to a female candidate, and female candidates who were made offers were 5.8 times more likely to accept their offer (Smith *et al.*, 2015). This research suggests that evidence-based interventions that also provide information on family and partner issues can increase faculty diversity. Further research on how these programs impact faculty and departments may be invaluable for improving workshops and maintaining change.

Although outcomes such as hiring trends and program evaluations are tracked by ADVANCE-funded programs, there is less known about the psychological factors that are influenced by this programming, and the role they play in producing the change in attitudes and behaviors that may lead to increasing faculty diversity. Understanding how and why particular faculty search training programs work to increase faculty diversity would help identify the specific elements that are important to include in such programs. In the present research, we incorporated knowledge from social psychology to examine the role of attitudes, behavioral intentions and perceived norms regarding equitable faculty search processes among faculty search committee members at one university, and explored the psychological antecedents that shape them.

The importance of changing attitudes, intentions and norms

Because the prevailing attitudes and culture of the setting influence the success of institutional change efforts, institutional climate can play an important role in increasing diversity among its members. That is, well-conceived, evidence-based initiatives may be instituted but fail if the institution's constituents are not "on board" to accept and sustain them. Therefore, it is critical that such initiatives serve to promote attitudes and beliefs supporting the idea that institutions benefit from greater diversity. Bias reduction workshops are one way to influence how people think about diversity and inclusion. One study found that faculty who were randomly assigned to attend a "bias literacy" workshop reported higher sensitivity to and awareness of bias in their academic setting, and greater intentions to use bias reduction strategies taught in the workshop (Carnes *et al.*, 2012). An important next step is to evaluate whether interventions also affect some of the specific attitudes that would help to sustain more equitable hiring practices.

Attitudes about specific behaviors (e.g. attitudes about specific hiring practices and procedures) tend to be better predictors of those behaviors than attitudes about the general topic (Ajzen, 1991). Attitudes about the general idea of increasing faculty diversity are certainly important, but people may be unlikely to act on them if they do not approve of the specific strategies that would ultimately promote faculty diversity. Along these lines, assessing whether people endorse and intend to behave in line with equitable hiring practices after an intervention should also grant insights into the process by which such programs translate to hiring practices and into the specific equitable practices to which faculty may be more or less receptive.

In addition to understanding individual-level attitude change, examining attitudinal processes at the group level may also help to assess the impact of faculty search interventions. When many individuals in a setting such as a workplace hold particular attitudes, the nature of these attitudes can shape the behaviors typically enacted in that setting, thus establishing both attitudinal and behavioral norms (Cialdini *et al.*, 1990). Faculty members in departments where many other faculty members have attended a faculty search training workshop may thus perceive a norm of positive attitudes toward hiring practices promoted in the workshop within their departments. If holding positive attitudes regarding conducting equitable faculty searches is perceived as the norm, and spreads among members within departments in which larger proportions of members have attended a faculty search training workshop, this would provide evidence of the value of such efforts to enact institutional change regarding faculty diversity.

The importance of belief in social science research evidence

To achieve real change in diversity, institutions must want to change; therefore, it is critical to convince its members of the importance of the issue and motivate them to take action (Mitchneck *et al.*, 2016; Stewart and Valian, 2018). Such motivation may develop as faculty members engage in "change narratives" about "where we are, where we want to be, and how we will get there" (Ely and Meyerson, 2000). Perhaps particularly in academic settings, effective faculty search training workshops should provide attendees with compelling empirical evidence for the benefits of equitable search processes, i.e., those that take deliberate steps to reduce the influence of unintended bias.

To meet this goal, it is important that faculty search training workshops draw from the social science literature on topics relevant to bias and evaluation. Of fundamental importance is research demonstrating our reliance on schemas: the generalized beliefs we hold about the characteristics of people, objects and events (Fiske and Taylor, 2013). Our ingrained reliance on schemas asserting white men's prowess in science fields can lead to under-evaluation of members of other groups, as demonstrated in research on unintended or implicit bias. Faculty search training workshops can include studies showing, for example, that white and male job applicants are evaluated more favorably and are more likely to be recommended for job offers than racial minority and female applicants, despite having resumes that are identical except for the race and gender of the applicant (Bertrand and Mullainathan, 2004; Moss-Racusin *et al.*, 2012). Social science research on stereotyping and its effects on performance and motivation may be reviewed to raise awareness of the detrimental consequences of stereotype threat (Steele, 2010). Other related topics include accumulation of disadvantage (the idea that even small instances of bias accrue over time to significantly disadvantage members of negatively stereotyped groups in hiring, promotion and retention; Valian, 1998) and the general assertion that increasing diversity promotes excellence as opposed to diminishing the quality of our faculty (Page, 2007, 2017; Stewart and Valian, 2018).

Educating faculty search committees about this body of research and its relevance to the faculty hiring process can be an effective strategy for faculty recruitment training workshops (Carnes *et al.*, 2012). This study examines one such workshop and considers whether exposure to the content of the workshop influences attitudes and behavioral intentions among faculty participants.

The faculty recruitment workshop (FRW)

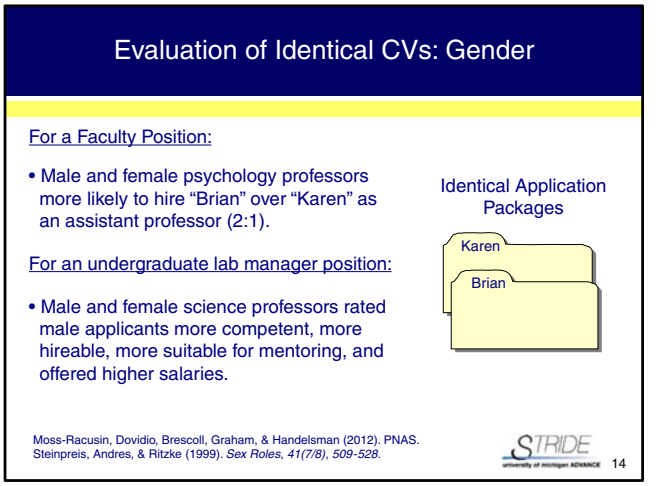
This research focuses on a workshop to promote gender diversity in STEM during the hiring process as part of one university's NSF ADVANCE Institutional Transformation grant. This FRW was developed in 2002 by a committee of eight faculty members who studied social science research relevant to the goal of hiring for diversity and excellence and created the content and format of the FRW. The committee expanded over time to include 13 faculty members from across the university, in both STEM and non-STEM fields, with a goal of achieving gender and racial diversity in the committee membership. The FRW was presented by the committee members, rather than by external "diversity consultants," following recommendations to include local leaders (one's fellow faculty members) as deliverers of the message (Anderson, 2011; Mitchneck *et al.*, 2016; Stewart and Valian, 2018, Wood, 2000).

A series of FRWs were offered to members of faculty search committees at the university during each fall semester beginning in 2003. The two-hour workshop was presented by a subset of the committee members (typically three), with the remaining committee members assisting in the audience. The content of the FRW (presented in a PowerPoint slideshow) included research findings on gender and race schemas, implicit bias, the accumulation of disadvantage and the value of diversity in promoting excellence, particularly in hiring and academic contexts. The FRW was designed to educate faculty about the social science research findings on these issues and to provide concrete guidelines for conducting more

equitable faculty searches (see Figure 1 for FRW slide examples, and the below given list for recommended recruiting strategies). The workshop included small group or table exercises (e.g. comparison of recommendation letters typical of those written for male vs female candidates) and a question and answer section. The FRW was revised every year to incorporate new research findings and address faculty feedback from post-workshop evaluations, although the basic content and message stayed the same. Faculty members serving on search committees in the largest units at the university (College of Literature, Science, and the Arts, and College of Engineering) were required to attend as a condition of serving on the search committee; attendance was encouraged in other units.

Equitable search strategies presented during the FRW:

- build an effective search committee that is vigilant about unconscious bias, stereotype threat, and the challenges of fair evaluations;
- actively develop a diverse pool of applicants through networking and outreach;



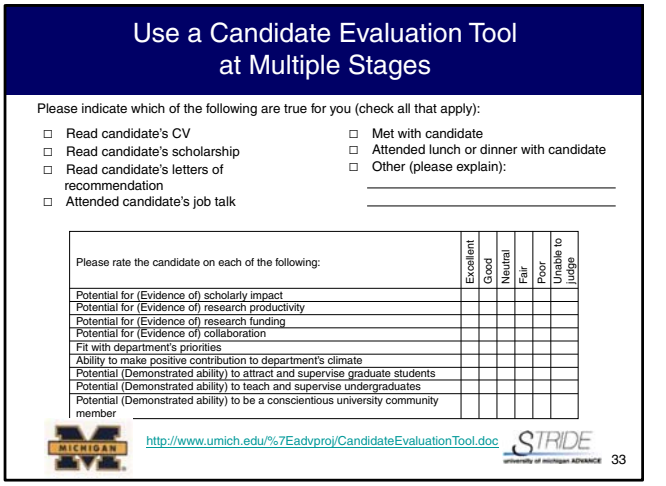


Figure 1.
Example presentation slides with information about gender biases in hiring (left) and guidelines for more equitable search strategies (right)

- define the disciplinary area for your search as broadly as possible;
- ask for the information you need from applicants, using a template or checklist with clear instructions about the application process;
- make sustained and conscious efforts to counter potential evaluation bias, by defining specific evaluation criteria before the search, using candidate evaluation tools, avoiding early ranking and global evaluations that fail to consider all of the search criteria;
- provide a welcoming environment during the interview, avoiding "tokenism" and ensuring that candidates meet a diverse group of people;
- encourage circumstances that will allow you to see candidates at their best, by providing complete information about the visit well in advance and eliminating environmental cues that could trigger stereotype threat or a feeling of not belonging;
- ensure that all candidates know about dual career support and family friendly policies;
- consider only job relevant criteria in evaluating candidates: do not ask about their personal life including age, marital status, children, even in social situations such as dinner (such issues can be discussed after an offer is made); and
- recruit the selected candidate, providing detailed information to ensure the negotiation process is positive and effective for all candidates.

These strategies were developed based on recommendations based on previous research findings and best practices identified from university leaders with long-standing experience, as summarized by Stewart and Valian (2018).

Overview of current studies

The current studies test whether attending the FRW may influence individual attitudes and behavioral intentions regarding equitable search practices. We predicted that faculty who attended the FRW would show more favorable attitudes toward equitable search strategies and report greater intentions to enact them. The studies also tested whether the workshop can change department climates in ways that may ultimately impact the attitudes of individual faculty. We predicted that faculty will have more favorable attitudes toward equitable search strategies if they are in departments where a greater proportion of faculty have attended the FRW, perhaps even for individual faculty who have not attended an FRW themselves. Finally, we explored whether the FRW was more effective for persuading faculty to adopt some search strategies more than others. In Study 2, we examined attitudes regarding the social science principles underlying the FRW. In doing so, we hoped to highlight specific ways these workshops may encourage intentional efforts to promote faculty diversity.

Study 1

Method

Participants. Survey data for Study 1 were collected in 2012, 2013 and 2014. In each year of the data collection, faculty members who attended the FRW ($n = 201$) were surveyed at two time points: pre- and post-FRW in the year they attended the FRW. In addition, in each year we recruited samples of faculty who had attended an FRW within the previous three years (between 2009 and 2013), and faculty who had not attended a workshop within the previous three years (according to ADVANCE records) to complete the survey. The research team recruited these additional samples to reflect proportionally the colleges/schools represented in the pre-/post samples; that is, colleges/schools that were well represented at the

2012–2014 workshops (due, in some cases, to required attendance by college leadership) were comparably represented in the final FRW- attendee in previous three years ($n = 407$) and no-FRW groups ($n = 781$).

Because gender is known to impact receptivity to diversity messages (Holladay *et al.*, 2003), faculty gender was assessed as a moderator. Race/ethnicity was measured, but there were too few non-white faculty members to test for moderation. Similarly, analyses by faculty rank (assistant, associate and full professor) were not possible due to small sample sizes in the earlier ranks.

Overall, 61 percent of faculty respondents were men and 39 percent were women; nearly one-quarter (23 percent) were faculty of color (12 percent were Asian/Asian American and 11 percent were URM). Half of all respondents were full professors (53 percent), and the remaining respondents were associate (23 percent) or assistant (22 percent) professors.

Measures. Personal endorsement of equitable search strategies. Respondents used a scale of 1 (not at all important) to 5 (very important) to rate how important they personally believe it is for search committees to use 13 different guidelines highlighted in the FRW (e.g. "Use specific criteria (such as a candidate evaluation tool) in review of candidates"; $\alpha = 0.71$). These strategies were developed based on the recommendations of previous research findings and best practices identified from university leaders with long-standing experience (summarized by Stewart and Valian, 2018). See Appendix for items.

The items were developed to reflect the content of the workshop so that together, they reflect general endorsement of the recommended strategies. However, to explore differential effects of the FRW on specific strategies, we conducted an exploratory factor analysis (EFA). This suggested a three-factor solution: conducting equitable search and review strategies that address identity, disparities and bias (six items; $\alpha = 0.77$), providing family policy information for all candidates (two items; $\alpha = 0.92$), avoiding personal inquiries into a candidate's family (two items; $\alpha = 0.83$); the remaining three items acted independently. Single items were only retained as their own indices if they independently represented key content areas emphasized in the workshop. For this reason, one item about open searches was retained in addition to the three factors because it represented strategies to avoid limiting the applicant pool (see Table I for details).

Behavioral intentions. Respondents (in years 2013 and 2014 only) were asked to rate how likely they would be to respond in a specific way to four job search scenarios regarding the intention to object to: speculations on a candidate's motivation to accept an offer and to move to the university's geographical location; discussion of a candidate's partner or spouse; and accepting non-diverse shortlists (see Appendix for items). Ratings were on a scale of 1 (not at all likely) to 5 (very likely). The two items about speculating on a candidate's motives accept an offer and to move to the university's geographical location were significantly correlated, $r(398) = 0.87$, $p < 0.001$, and because they both concerned speculation about a candidate's motivation to take the job if offered, they were averaged into one composite score. The questions about intentions to object to discussions of a candidate's partner and to object to a non-diverse shortlist were reworded from 2013 to 2014 in order to reduce demand characteristics[1]. For this reason, analyses of those items included collection year as a factor.

Departmental FRW attendance. The percentage of faculty in each department that had attended an FRW was calculated using attendance records from the ADVANCE program and departmental information from the university's human resources office.

Results

Data were analyzed with three analytic approaches. The first was a comparison of those who attended an FRW within the past three years of participating in the study (2009–2013)

	Factor 1	Factor 2	Factor 3
1. Be mindful of the composition of the search committee in terms of gender and race/ethnicity	*0.63*	0.04	0.01
2. Decide and agree on specific applicant review criteria before the search begins	*0.63*	−0.15	−0.07
3. Use specific criteria (such as a candidate evaluation tool) in review of candidates	*0.59*	−0.07	0.01
4. Take steps to reduce the influence of unconscious bias during applicant review	*0.55*	0.09	0.08
5. Avoid interviewing only one candidate from a particular social group (e.g. gender or race)	*0.65*	−0.02	−0.07
6. During the visit, ensure that the candidate meets a wide variety of people from various social groups (e.g. gender or race)	*0.62*	0.09	−0.03
7. Ensure that every candidate receives family friendly policy information	−0.06	*0.92*	0.11
8. Ensure that every candidate receives dual career policy information	−0.10	*0.95*	0.14
9. During the visit, show we are a "family friendly" department by asking job candidates about their children and families (reverse scored)	−0.13	−0.03	*0.90*
10. Try to find out if the candidate has dual career issues by asking if he or she has a partner (reverse scored)	−0.07	−0.04	*0.81*
11. Avoid referring to a candidate in terms of his or her social group membership (e.g. as the woman or the minority candidate)	0.17	0.08	0.21
12. Focus the search on narrow content areas rather than using a broad or "open search" (reverse scored)	0.02	0.02	0.12
13. Engage in active recruiting of specific individuals prior to the official opening of the search	0.01	0.10	−0.08
Cronbach's α for each factor	$\alpha = 0.77$	$\alpha = 0.92$	$\alpha = 0.83$

Notes: Coefficients are standardized loadings from the pattern matrix. This EFA was conducted with principal axis factoring and an oblique (promax) rotation. The number of factors was determined through parallel analysis. Italic coefficients are those that load strongly onto one factor (at least 0.4) with no substantial cross-loadings

Table I.
Study 1 personal endorsement of search strategies items and EFA results

and those who had not attended (individual FRW attendance: FRW vs no-FRW). Second, pre- and post-FRW attendance was compared for the subset of participants who attended from 2012 to 2014 (pre-FRW vs post-FRW). Finally, linear mixed-effects model tested the role of departmental participation in the FRW (departmental FRW attendance: proportion of a department's members who had ever attended an FRW). All analyses included gender as a factor. For the endorsement items, the primary analyses used an aggregate of all 13 items; and the linear mixed-effects models allowed us to test all hypotheses with both the aggregated and disaggregated (three factor) indices.

Regarding the ANOVAs reported below, an examination of the boxplots and a Levene's test suggested the data deviated somewhat from the assumption of equal variances ($F(3, 1{,}097) = 5.01$, $p = 0.002$). For this reason, we tested all ANOVAs across both studies with a Welch correction for heterogeneity of variance; results were virtually identical to conventional ANOVAs. We report the conventional ANOVAs below for ease of interpretation.

Personal endorsement of equitable search strategies

FRW vs No-FRW analysis. A 2 (faculty gender) × 2 (individual FRW attendance: FRW vs No-FRW) between-subjects ANOVA revealed that faculty members who attended an FRW within the previous three years reported stronger personal endorsement of equitable search strategies than those who had never attended an FRW ($F(1, 1097) = 11.43$, $p = 0.001$, $\eta_p^2 = 0.010$). Female faculty endorsed the strategies more than male faculty ($F(1, 1097) = 14.53$, $p = 0.001$, $\eta_p^2 = 0.013$). These main effects were not qualified by an interaction ($F < 1$, $p > 0.30$).

Pre-post FRW analysis. A 2 (faculty gender) × 2 (time: pre- vs post-FRW) mixed model ANOVA, with time as the within subject factor, mirrored these findings. Faculty endorsed equitable search strategies more after attending the workshop than before (main effect of time $F(1, 199) = 116.73$, $p = 0.001$, $\eta_p^2 = 0.37$). This analysis also revealed a main effect of gender ($F(1, 199) = 4.43$, $p = 0.05$, $\eta_p^2 = 0.019$), but no interaction ($F < 1$, $p > 0.40$). See Table II for descriptive statistics on personal endorsement of equitable search strategies.

Behavioral intentions

Intentions to object to speculation of candidates' motives

FRW vs No-FRW analysis. Results of a 2 (FRW vs No-FRW) × 2 (faculty gender) ANOVA revealed that faculty who attended an FRW reported marginally stronger intentions to object to speculation on candidates' motives than those who had never attended an FRW ($F(1, 394) = 3.02$, $p = 0.08$, $\eta_p^2 = 0.01$). Female faculty reported stronger intentions to object than male faculty ($F(1, 394) = 7.86$, $p = 0.005$, $\eta_p^2 = 0.02$). However, there was no interaction between FRW attendance and gender ($F(1, 394) = 1.07$, $p = 0.301$).

Pre-post FRW analysis. Results of a 2 (faculty gender) × 2 (collection year) × 2 (time) mixed model ANOVA with time as the within subjects factor showed the same pattern. Intentions to object to speculation on candidates' motives were significantly higher after attending the FRW than before ($F(1, 132) = 31.70$, $p = 0.001$, $\eta_p^2 = 0.19$). Intentions to object were somewhat higher among female than male faculty ($F(1, 132) = 3.99$, $p = 0.048$, $\eta_p^2 = 0.03$). No other significant effects emerged (all Fs < 1.19, ps > 0.27).

Intentions to object to discussions of candidate's partner

FRW vs No-FRW analysis. Results of a 2 (FRW vs No-FRW) × 2 (faculty gender) × 2 (collection year: 2013 or 2014) ANOVA revealed that faculty members who attended an FRW ($M = 4.29$, SE = 0.14) reported significantly stronger intentions to object to discussing a candidate's partner than those who had never attended an FRW ($F(1, 390) = 4.48$, $p = 0.04$, $\eta_p^2 = 0.01$). No other main effects or higher order interactions were significant, all Fs < 2.32, ps > 0.12.

	Study 1		Study 2	
	No FRW attendance	Past FRW attendance	No FRW attendance	Past FRW attendance
n	781	407	333	135
General endorsement (all items)	*4.16* (0.51)	*4.26* (0.56)	*3.77* (0.42)	*3.99* (0.50)
Equitable search and review strategies	4.19 (0.71)	4.21 (0.74)	3.99 (0.62)	4.15 (0.62)
Providing family policy info	*4.51* (0.86)	*4.68* (0.71)	–	–
Avoiding personal questions about family[a]	*4.34* (1.06)	*4.54* (0.94)	*3.67* (1.33)	*4.00* (1.11)
Avoid limiting candidate pool[b]	*3.63* (1.21)	*3.88* (1.13)	*2.87* (1.03)	*3.34* (0.90)
Intentions to object to discussions of candidate's motives	3.22 (1.24)	3.49 (1.34)	–	–
Intentions to object to discussions of a candidate's partner	*3.95* (1.25)	*4.29* (1.19)	–	–
Intentions to call attention to a non-diverse shortlist	3.68 (1.27)	3.75 (1.35)	–	–
Belief in social science principles	–	–	*4.03* (0.68)	*4.15* (0.62)

Table II. Means for endorsement, behavioral intentions and beliefs for Studies 1 and 2

Notes: [a]This strategy has two items in Study 1 that were collapsed into a single item for Study 2. [b]This strategy has one item in Study 1 and two in Study 2. Standard deviations are in parentheses. Italic shows means that are significantly different between the no FRW and past FRW groups

Pre-post FRW analysis. Results of a 2 (faculty gender) × 2 (collection year) × 2 (time) mixed model ANOVA with time as the within subjects factor showed that the only effect that approached significance was a collection year × time interaction ($F(1, 132) = 2.76$, $p < 0.10$, $\eta_p^2 = 0.021$). During collection year 2014, intentions to object to discussing a candidate's partner were stronger after attending the FRW compared to before ($F(1, 134) = 4.13$, $p = 0.044$), whereas these intentions were not significantly different in collection year 2013 ($F(1, 134) = 0.30$, $p = 0.59$), when wording of the item was changed to reduce demand characteristics. No other significant effects emerged, all Fs < 1.40, ps > 0.23.

Intentions to object to non-diverse shortlists

FRW vs No-FRW analysis. Results of a 2 (FRW vs No-FRW) × 2 (faculty gender) × 2 (collection year) ANOVA revealed a significant main effect of gender ($F(1, 387) = 8.16$, $p = 0.005$, $\eta_p^2 = 0.02$). Female faculty reported stronger intentions to object to non-diverse shortlists than male faculty did. A significant main effect of collection year emerged; faculty in 2013 ($M = 4.31$, SE = 0.13) reported stronger intentions to object than faculty in 2014 ($M = 4.31$, SE = 0.12; $F(1, 387) = 39.91$, $p = 0.001$, $\eta_p^2 = 0.09$), when wording of the item was changed to reduce demand characteristics. No significant main effect of past FRW attendance emerged, nor any higher order interactions, all Fs < 1.13, ps > 0.29.

Pre-post FRW analysis. Results of the mixed model ANOVA revealed only a significant main effect of collection year ($F(1, 131) = 41.93$ $p = 0.001$, $\eta_p^2 = 0.24$). Intentions to object were significantly higher in collection year 2013 ($M = 4.47$, SE = 0.14) than in 2014 ($M = 3.33$, SE = 0.11), when wording of the item was changed to reduce acquiescence. No other significant effects emerged (all Fs < 0.53, ps > 0.46). See Table II for descriptive statistics on behavioral intentions.

Mixed models testing department-level effects

We used a series of linear mixed-effects models to test whether the percentage of faculty in each department who had attended a workshop predicted personal endorsement of these same practices among each department's faculty respondents. All analyses were conducted in *R* using the lme4 package (Bates *et al.*, 2015) with the lmerTest package to extract *p*-values (Kuznetsova *et al.*, 2016).

The percentage of faculty in each department who had previously attended a workshop (departmental FRW attendance) ranged from 0.0 to 67.5 percent ($M = 33.4$ percent, SD = 16.8 percent). The total number of faculty within each department represented in the analyses ranged from 1 to 54 ($M = 19.2$, SD = 12.2).

We specified five models, each with individual department code included as a random intercept to address clustering (e.g. attitudes may be more similar within than between departments due to factors unrelated to workshop attendance). Model 1 had the percentage of faculty at the department level that had previously attended a workshop (departmental FRW attendance) as the independent variable; Model 2 had departmental FRW attendance, respondent gender (0.5 = female, −0.5 = male) and their interaction. Model 3 had departmental FRW attendance, individual workshop attendance (0.5 = respondent has attended, −0.5 = respondent has not attended) and their interaction term. Model 4 had all three aforementioned variables (departmental FRW attendance, respondent gender and individual workshop attendance), as well as all two- and three-way interactions. At last, Model 5 disaggregated the endorsement dependent variable into the specific strategy types identified in EFA and treated them as within subjects factors. For this model, we entered three centered dummy codes for the four strategy types (three factors and one retained single item) with the largest factor as the reference category. Testing the interaction between these codes and FRW attendance allowed us to assess differential effects of the FRW across strategy type.

Departmental attendance and general personal endorsement (aggregate index). The percentage of faculty within a department who had attended a workshop (departmental FRW attendance) was a significant, positive predictor of respondents' personal endorsement of equitable search strategies (see Table III). Gender and individual workshop attendance independently predicted personal endorsement, but the only somewhat significant interaction was between departmental attendance and gender. In sum, the effect of departmental FRW attendance influenced respondents' personal endorsement of equitable search strategies independent whether they had themselves attended an FRW, and this was slightly stronger for women.

Departmental attendance and endorsement of specific strategy types (disaggregated index). The significance of the interactions introduced in Model 5 suggested that in addition to a robust effect of FRW on endorsement of these strategies in general, the FRW was more effective for some strategies more than others (see Table III). We conducted additional analyses to extract simple effects for each strategy type in this model (see Table IV). These revealed that past FRW

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
	Fixed effects				
Intercept	4.22****	4.23****	4.25****	4.26****	4.26****
Departmental attendance	0.32**	0.41***	0.19	0.30**	0.30**
Gender		0.10***		0.10**	0.10**
Individual attendance			0.14****	0.15****	0.15****
Dept. attendance × Gender		0.39*		0.51**	0.51**
Dept. attendance × Individual attendance			−0.22	−0.13	−0.13
Gender × Individual attendance				−0.04	−0.04
Dept. attendance × Gender × Individual attendance				0.42	0.42
Individual attendance × Strategy 1[a]					0.17**
Individual attendance × Strategy 2[a]					0.19**
Individual attendance × Strategy 3[a]					0.24**
	Random effects in SD				
Intercept for strategy type	0.37	0.37	0.37	0.37	0.26
Intercept for participant	0.31	0.31	0.31	0.30	0.30
Intercept for department	0.08	0.09	0.09	0.09	0.09
Residual	0.89	0.90	0.90	0.90	0.90

Table III. Unstandardized coefficients from linear mixed effects on personal endorsement of search strategies for study 1

Notes: $n = 1{,}066$. [a]Strategy 1 is providing family policy information. Strategy 2 is avoiding inquiries about candidates' families. Strategy 3 is avoiding limited candidate pools by using open searches. Strategy 4 reflected search strategies that address social identity, disparities, and bias and served as the reference category for centered dummy codes. Past FRW attendance is uses centered dummy codes past attendance = 0.5, no attendance = −0.5 as does gender female = 0.5, male = −0.5. The main effects of strategy type were included in Model 5, but not included in this table to conserve space. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$; ****$p < 0.001$

	Study 1					Study 2				
Search strategy	*B*	SE	df	*t*	*p*	*B*	SE	df	*t*	*p*
Strategies addressing identity, disparities and bias	−0.01	0.07	5,883	−0.19	0.85	0.06	0.10	2,048	0.60	0.55
Providing family policy info	0.18	0.07	5,904	2.66	0.008	–	–	–	–	–
Avoiding personal questions about family	0.16	0.07	5,901	2.36	0.018	0.23	0.10	2,048	2.15	0.032
Avoiding limited candidate pool	0.23	0.07	5,890	3.36	< 0.001	0.37	0.10	2,048	8.82	< 0.001

Table IV. Simple effects of FRW on endorsement for each strategy type from LME model

attendance was primarily associated with greater endorsement of recommendations to: provide family policy information to all candidates, avoid seeking personal details about candidates' families and avoid limiting the candidate pool by implementing an open search; however, past FRW attendees were no more likely to endorse recommendations to conduct equitable search and review strategies that address identity, disparities and bias.

Discussion

These results provide initial evidence that attending the FRW can influence attitudes toward evidence-based search strategies to promote faculty diversity through hiring. Analyses of endorsement of 13 equitable search strategies (e.g. use open searches; avoid asking personal questions of candidates) showed that faculty were more likely to endorse these strategies if they themselves had attended an FRW in the past three years or if more people in their department had. Even faculty who had not attended a workshop themselves were more likely to endorse these strategies if they were in a department where more of their colleagues had attended one, suggesting that a norm of equitable search strategy endorsement developed and spread in departments with high departmental FRW attendance. These results are promising given the importance of an institutional climate supportive of sustained change.

There was also suggestive evidence that the FRW increased intentions to engage in behaviors consistent with the equitable search strategies. Intentions to object to speculations on a candidate's motives about the job were increased after attending the FRW in the pre-post FRW analyses. However, objecting to discussions of the potential role of a candidate's partner in whether they would take the job appeared to depend on how the question was phrased (see footnote 1). This suggests that researchers should vary the wording of behavioral intention items to decrease the tendency for respondents to respond in a way that seems expected or desired. Finally, in either version of the item used, behavioral intentions to object to non-diverse shortlists were not affected by individual FRW attendance, indicating that this topic may be a particularly difficult issue in equitable faculty searches. There may be strong dissent to the idea of changing a homogenous (i.e. all male) shortlist especially after an effortful applicant review process, whereas it is easier to consider objecting to speculation on a candidate's motives and partner issues.

Analyses of the disaggregated equitable search strategies shows that consistently, FRW attendance was less effective at promoting more positive attitudes toward equitable search and review strategies that address social identities, disparities and bias (e.g. "Avoid interviewing only one candidate from a particular social group, e.g., gender or race"). This aligns with research demonstrating that people are often less receptive to diversity messages that directly mention group differences (Kidder *et al.*, 2004), and may be also be consistent with the noted resistance to object to non-diverse short-lists (which also involves calling direct attention to social identities). In sum, these findings suggest that attending the FRW can successfully impact many attitudes relevant to getting faculty on board with more equitable search strategies, but more can be done to bolster the effects of the workshop on other attitudes and behavioral intentions.

Study 2

Although evidence-based workshops like the FRW have demonstrated positive effects, it remains to be tested whether these are at least in part attributable to greater belief in the social science principles (e.g. gender schemas, implicit bias, accumulation of disadvantage) highlighted by these workshops. Study 2 was designed to directly test whether the education provided on these social science findings underlie the effects of the FRW. Study 2 thus aimed to replicate the effect of FRW on endorsement of equitable search strategies and test whether

they were mediated by increased belief in the social scientific principles (e.g. the belief that stereotyping and implicit biases occur and affect outcomes for women and URM individuals) highlighted in the FRW. The sampling in Study 2 also allowed comparison of the long-term effects of the FRW (i.e. comparing beliefs and attitudes of those who had attended an FRW any time in the past to those who had never attended) as well as short-term effects (i.e. comparing those who had recently attended to those who never attended).

Method and measures

The design of Study 2 was similar to Study 1, with two differences. First, belief in the social science principles was measured. Respondents used a scale of 1 (strongly disagree) to 5 (strongly agree) to indicate agreement with five statements corresponding to evidence-based information from the FRW, for example, "Our assumptions about a person's traits and abilities can subconsciously influence hiring decisions." Second, the items assessing personal endorsement of equitable search strategies was modified from 13 to 12 items, and included additional strategies beyond those examined in Study 1 to match changes in the strategies most heavily emphasized in the FRW at the time (e.g. avoiding early ranking of candidates; $\alpha = 0.62$; see Appendix for items). Some items with the same content were also reworded to reduce potential ceiling effects and acquiescence bias. Because the items were different, we conducted another EFA to explore effects on different strategy types. This resulted in a factor for search and review strategies addressing identities, disparities, and bias ($\alpha = 0.77$), another for strategies to avoid limiting the candidate pool ($\alpha = 0.60$), and three single items that did not load strongly onto a single factor. Only one single-item index was retained because it was a collapsed version of a key factor identified in the previous study (one item for avoiding personal inquiries about both partners and children). This left three key strategy types of interest as the focus of exploration (see Table V).

Participants

A total of 468 tenured/tenure-track faculty were recruited in 2015 and 2016 to participate in Study 2. Among them, 344 were registered to attend the FRW during the study period and 124 were not. Overall, 63 percent were men and 37 percent were women; nearly one-quarter (23 percent) were faculty of color (12 percent were Asian/Asian American faculty and 11.3 percent were URM faculty). Half of all respondents were full professors (54.5 percent), and the remaining were associate (25.6 percent) or assistant (20 percent) professors.

Like Study 1, our primary analyses used past FRW attendance to test whether people who had attended an FRW in the past differed from those who had not attended. Because there were fewer people in this sample who had attended in the three years prior to the study ($n = 30$), we also included faculty who attended the workshop any point since attendance data were first recorded (2003; $n = 105$) to compare to those who had never attended ($n = 333$).

We also used a secondary comparison comparing the post-FRW responses for those who attended an FRW and completed the post-FRW survey during the study period ($n = 212$) to the control group who did not attend an FRW ($n = 124$). In other words, the primary comparison tested the longer-term effects of having attended an FRW at any point in the past; the secondary comparison tested the short-term effects of having attended an FRW within the same semester as completing the survey. Analyses testing the longer-term effects were selected as the primary comparison reported because they provide a more conservative test of hypotheses and a closer match to the group comparisons in Study 1. We focus results on the primary (long-term) comparison; any notable differences between the primary and secondary (short-term) comparisons are identified below.

	Factor 1	Factor 2	Factor 3
1. Encourage search committee members to be vigilant about unconscious bias throughout the search	*0.71*	0.06	0.03
2. Actively search for potential faculty recruits from institutions that train diverse students	*0.71*	0.02	−0.06
3. Provide applicants with a checklist and clear instructions about the application process	*0.60*	−0.15	0.13
4. Systematically use defined criteria in evaluations such as by relying on a candidate evaluation tool	*0.54*	−0.30	0.10
5. Make it a priority to bring in more than one female/racial-ethnic minority candidate for an interview	*0.60*	0.02	−0.17
6. Take steps to ensure a diverse audience for the candidate's job talk	*0.46*	0.10	−0.08
7. Discourage speculation among search committee members of the likelihood that a candidate would accept the job if offered	*0.40*	0.10	0.08
8. In the job posting, state very specific areas of expertise as required for the position (reverse scored)	−0.16	*0.69*	0.01
9. Develop a rank order of candidates as early in the search process as possible (reverse scored)	0.01	*0.64*	−0.03
10. Try to find out whether candidates have a partner or children so that you can provide information about dual career services/family friendly policies to them (reverse scored)	0.23	0.34	0.42
11. Inform candidates that you are especially interested in them because of the diversity they will bring to your department (reverse scored)	0.06	0.31	0.38
12. Assign a faculty member to host the candidate's visit	0.09	0.04	−0.30
Cronbach's α for each factor	$\alpha = 0.77$	$\alpha = 0.60$	

Notes: Coefficients are standardized loadings from the pattern matrix. This EFA was conducted with principal axis factoring and an oblique promax rotation. The number of factors was determined through parallel analysis. Italic loadings are those that load strongly onto one factor at least 0.4 and no substantial cross-loadings. We extracted three factors, but the third factor did not have its own strong loadings and was not a substantive factor

Table V.
Study 2 EFA results

Consistent with Study 1, we also tested the within-subject effect of time for the subset of participants who were registered for the FRW during the study period and completed both the pre- and post-FRW surveys ($n = 212$).

For the ANOVAs, the boxplots and a Levene's test showed no heterogeneity in the variance of strategy endorsement (primary comparison: $F(3, 449) = 0.75$, $p = 0.56$; secondary: $F(3, 332) = 0.57$, $p = 0.64$). There was heterogeneity for belief in social science principles, however (primary: $F(3, 445) = 4.77$, $p = 0.003$; secondary: $F(3, 327) = 5.00$, $p = 0.002$). Results of tests with Welch corrections were identical to those with conventional ANOVAs, and we report the conventional ANOVAs below for ease of interpretation, as in Study 1.

Results

Personal endorsement of equitable search strategies

FRW vs No FRW. Replicating Study 1, a 2 (FRW vs No FRW) × 2 (faculty gender) ANOVA revealed that faculty who had attended an FRW endorsed equitable search strategies more than those who had never attended ($F(1, 449) = 24.84$, $p < 0.001$, $\eta_p^2 = 0.05$). Although female faculty reported more endorsement of these strategies ($F(1, 449) = 24.84$, $p < 0.001$, $\eta_p^2 = 0.05$), the two-way interaction was not significant ($F(1, 449) < 0.001$, $p = 0.99$, $\eta_p^2 < 0.001$).

Pre-post analyses. A 2 (faculty gender) × 2 (time: pre- vs post-FRW) mixed model ANOVA with time as the within subjects factor revealed that faculty members were more likely to

endorse equitable search strategies after attending the FRW ($M = 4.29$, SD = 0.51) compared to before ($M = 3.98$, SD = 0.44; $F(1, 197) = 78.56$, $p < 0.001$, $\eta^2 = 0.29$). There was also a main effect of gender ($F(1, 197) = 5.51$, $p < 0.05$, $\eta^2 = 0.03$), but no interaction ($F(1, 197) = 1.36$, $p = 0.25$, $\eta^2 = 0.01$).

Belief in social science principles

FRW vs No FRW. A 2 (FRW vs No-FRW) × 2 (faculty gender) ANOVA revealed that faculty who had attended an FRW believed these social science principles more than those who had never attended ($F(1, 445) = 5.15$, $p = 0.02$, $\eta_p^2 = 0.01$; see Table II). Faculty gender also significantly predicted belief in these principles ($F(1, 445) = 53.90$, $p < 0.001$, $\eta_p^2 = 0.11$), but it did not interact with past attendance ($F(1, 445) = 1.56$, $p = 0.21$, $\eta_p^2 = 0.003$).

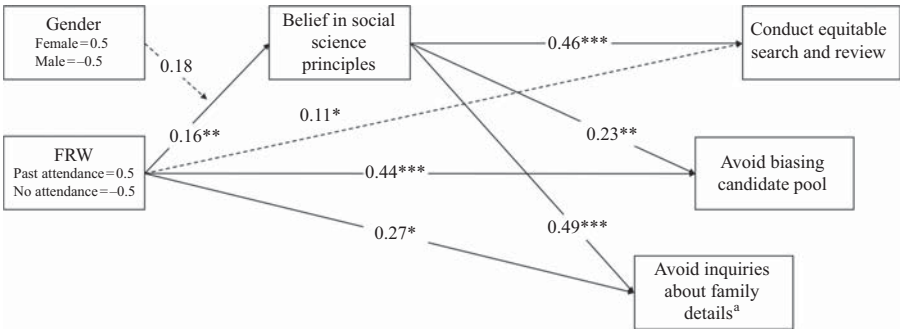
Pre-post analyses. We find the same pattern when testing for change in beliefs from pre- to post-FRW. A 2 (faculty gender) × 2 (time: pre- vs post-FRW) mixed model ANOVA, with time as the within subject factor, revealed that faculty members believed in the social science principles significantly more after attending the FRW than they did before ($F(1, 197) = 41.11$, $p < 0.001$, $\eta^2 = 0.17$). There was also a main effect of gender on beliefs ($F(1, 197) = 8.39$, $p < 0.01$, $\eta^2 = 0.04$), but no interaction ($F(1, 197) = 0.31$, $p = 0.58$, $\eta^2 = 0.002$).

Mediation analyses

Primary comparison: past FRW vs no FRW attendance. We next sought to test whether the effect of any previous FRW attendance (long-term effect) on general endorsement of equitable search strategies was mediated by belief in the social science principles. To do this, we estimated indirect effects in *R* using the Lavaan package (Rosseel, 2012). All mediation models used bias-corrected and accelerated bootstrapped standard errors with 5,000 bootstrapped samples. Analysis of the primary comparison showed the indirect effect was close to significance but did not meet conventional thresholds (indirect effect: $B = 0.04$, SE = 0.02, CI: [−0.003, 0.09]). This analysis thus gives weak evidence that belief in the social science principles help to explain the relationship between past attendance and general endorsement of equitable strategies (aggregated index).

To explore this question further, we also ran a mediation model to assess indirect effects on each specific strategy type (disaggregated index). These tests revealed that insofar as past FRW attendance predicted greater belief in the social science principles underlying the workshop, faculty were more likely to endorse search and review strategies that address identities, disparities and bias ($B = 0.07$, SE = 0.03, CI: [0.02, 0.13]), that avoid limiting the candidate pool ($B = 0.04$, SE = 0.02, CI: [0.01, 0.08]), and that avoid asking personal details about partners and children ($B = 0.08$, SE = 0.03, CI: [0.03, 0.15]). None of these indirect effects were moderated by gender ($|z|$ for all indices of moderated mediation < 1.6). In sum, these findings suggest that belief in the evidence-based portions of the workshop helps to explain the effect of FRW attendance on endorsement of three key strategy types (see Figure 2).

Secondary comparison: recent FRW vs no FRW attendance. Comparing differences between faculty who just attended the FRW and those who never attended (short-term effect), belief in social science principles did help to explain differences in general endorsement of equitable strategies, aggregate index ($B = 0.19$, SE = 0.03, CI: [0.13, 0.25]). Furthermore, the indirect effect was significantly different for men and women (index of moderated mediation: $B = -0.24$, SE = 0.06, CI: [−0.36, −0.14]). Specifically, belief in social science principles mediated the short-term effect of FRW attendance on general personal endorsement among men ($B = 0.49$, SE = 0.07, CI: [0.35, 0.63]), but not among women ($B = -0.11$, SE = 0.08, CI: [−0.27, 0.05]).



Notes: This model uses the primary comparison (long-term effects). Dashed lines show non-significant paths. Indirect effect on strategies to address identity, disparities, and bias: $B = 0.06$, SE = 0.03, 95% CI: (0.02, 0.12). Indirect effect on avoiding biased candidate pools: $B = 0.04$, SE = 0.02, 95% CI: (0.01, 0.08). Indirect effect on avoiding inquiries about family: $B = 0.09$, SE = 0.04, 95% CI: (0.03, 0.17). *$p<0.10$; **$p<0.05$; ***$p<0.01$; ****$p<0.001$

Figure 2.
Moderated mediation model for specific strategy types

Examining this relationship separately for each strategy type reveals a consistent pattern. Beliefs in the social science principles helped to explain greater endorsement of strategies that address search and review strategies addressing identities, disparities and bias ($B = 0.24$, SE = 0.04, CI: [0.17, 0.33]), that avoid limiting the candidate pool ($B = 0.18$, SE = 0.05, CI: [0.10, 0.28]), and that avoid asking personal details about partners and children ($B = 0.22$, SE = 0.06, CI: [0.12, 0.34]). For this comparison, all significant indirect effects were also moderated by gender ($|z|$ for all indices of moderated mediation > 3); specifically, increased belief in these social science principles explained greater endorsement of three key strategy types among men who had just attended the workshop, but not women who had just attended.

Mixed models with department-level effects

Departmental attendance and general personal endorsement (aggregate index). We ran linear mixed-effect models to test whether faculty's general endorsement of equitable search strategies is influenced by their own past FRW attendance as well as by the percentage of faculty in their department who have attended using the primary analysis comparison. We specified the same five models as Study 1 (see Table VI for all models).

Departmental FRW attendance predicted endorsement on its own (Model 1, $p < 0.05$) and with gender in the model (Model 2, $p < 0.05$). However, unlike in Study 1, this effect disappeared when individual FRW attendance was added to the model (Models 3, 4 and 5). Instead, individual FRW attendance remained a significant predictor in Models 3, 4 and 5 ($p < 0.001$). There was a marginally significant interaction between gender and department-level workshop attendance, but this weak effect disappeared when other variables were added to the model, providing insufficient evidence that gender and departmental attendance interact. Results were similar using the secondary comparison (short-term effect).

Departmental attendance and endorsement of specific strategy types (disaggregated index). The significant interaction in Model 5 suggested again that individual FRW attendance was more effective for some strategies more than others (see Table VI). Consistent with Study 1, the interaction suggested that individual FRW attendance was more predictive of endorsement of strategies to avoid limiting the candidate pool than for those that address identity, disparities and bias. Simple effects reveal that individual FRW attendance was predictive of greater endorsement of all strategies except for those that address identity, disparities and bias (see Table IV).

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
	Fixed effects				
Intercept	3.60***	3.62****	3.69****	3.69****	3.70****
Departmental attendance	0.75****	0.67***	0.36	0.36	−0.36
Gender		0.18***		0.21***	0.21***
Individual attendance			0.28****	0.26****	0.26****
Dept. attendance × Gender		0.57*		−0.69	−0.69
Dept. attendance × Individual attendance			−0.78*	−0.63	−0.63
Gender × Individual attendance				0.12	0.12
Dept. attendance × Gender × Individual attendance				−0.48	−0.48
Individual attendance × Strategy 1[a]					0.17
Individual attendance × Strategy 2[a]					0.31**
	Random effects in SD				
Intercept for Strategy Type	0.53	0.53	0.53	0.53	0.53
Intercept for Participant	0.32	0.30	0.31	0.29	0.29
Intercept for Department	0.13	0.15	0.12	0.14	0.14
Residual	0.93	0.93	0.93	0.94	0.93

Table VI.
Unstandardized coefficients from linear mixed effects on personal strategy endorsement for study 2

Notes: $n = 453$. [a]Strategy 1 is avoiding inquiries about candidates' families. Strategy 2 is avoiding limited candidate pools by using open searches. Strategy 3 reflected search strategies that address social identity, disparities, and bias and served as the reference category for centered dummy codes. Past FRW attendance is uses centered dummy codes past attendance = 0.5, no attendance = −0.5 as does gender female = 0.5, male = −0.5. The main effects of strategy type were included in Model 5, but not included in this table to conserve space. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$; ****$p < 0.001$

Discussion

Results of Study 2 replicated and extended findings from Study 1. Personal endorsement of equitable search strategies was again greater among those who previously attended an FRW, a pattern that was corroborated by pre-post FRW attendance analyses. In addition, FRW attendance was associated with greater belief in the social science research principles emphasized in the workshop, a pattern apparent in both methods of comparison. Importantly, there was evidence that these beliefs mediated the relationship between FRW attendance and increased endorsement of equitable search strategies. Although the evidence was somewhat mixed for when examining more long-term effects of FRW attendance, the role of beliefs was clear in the short term – particularly for men. This finding suggests that educating people (especially men, who constitute the majority of many departmental faculties) about social science research principles may play an important role in determining their attitudes about equitable search practices soon after attending the FRW.

The mediation analysis using the primary comparison, which included faculty who attended the FRW longer than three years ago did not show strong evidence that social science belief endorsement mediated the effect of FRW attendance on general endorsement of equitable search strategies (aggregate index). However, exploring these relationships for specific strategy types separately revealed significant indirect effects for strategies addressing identity, disparities and bias, for avoiding limiting candidate pools, and for avoiding personal inquiries about family and children. These analyses suggest that insofar as FRW attendance leads to greater belief in the social science principles underlying the workshop, people are subsequently more likely to endorse even those strategies that seem most resistant to change – those that address social identity, disparities and bias more directly. The significant indirect effect absent a significant direct or total effect for this strategy would suggest that there are likely psychological factors other than these beliefs that may be counteracting attitude change for this strategy. One potential opposing force may be the negative reactions evoked by strategies that call attention to group differences (Kidder *et al.*, 2004).

Results of mixed-effects analyses of department-level effects differed from Study 1; although proportion of one's department members who had attended an FRW predicted personal endorsement on its own, this effect was overwhelmed by individual FRW attendance in Study 2. Although it is unknown why this difference across studies emerged, it is possible that factors such as differences in proportions of departmental FRW attendance across the studies may have played a role, as this variable ranged from 0 to 67 percent in Study 1, and from 5 to 100 percent in Study 2. The difference in range likely reflects the increase in the total number of FRW attendees over time, as more faculty members joined search committees and were required to attend. Similar to Carnes *et al.*'s (2015) finding that the effect of departmental participation at a bias reduction workshop on faculty had a "tipping point" of approximately 25 percent, it may be that the effect of departmental FRW attendance levels off at a particular point, allowing the influence of individual FRW attendance to play a larger role among departments with departmental attendance exceeding this point.

General discussion

Across two studies spanning five years we find evidence that attending an ADVANCE FRW increased endorsement of equitable search strategies. Among samples of faculty members, individual FRW attendance was associated with greater personal endorsement of equitable search strategies (Studies 1 and 2) and greater intentions to behave consistently with those practices on two out of three items (Study 1). Endorsement of equitable search strategies was greater among faculty members when a greater proportion of their academic department colleagues had attended an FRW, even among respondents who had not attended an FRW themselves (Study 1). Finally, there was suggestive evidence that having recently attended an FRW increased endorsement of equitable search practices because attendance moves people (especially men) to accept the social science research principles on which the FRW is based (Study 2 secondary comparison). Belief in these social science principles also seemed to play a role in explaining more long-term effects of the FRW (Study 2 primary comparison), albeit more tenuously. As a whole, these studies provide empirical evidence that being exposed to an evidence-based equitable FRW can increase faculty members' beliefs in the social science research evidence on which it is based, leading to increased support of equitable search practices and intentions to enact those practices, and that this positive influence may be spread throughout a department the more that its members have attended the workshop.

Attending the FRW increased faculty members' acceptance and approval of equitable search strategies that could reduce the implicit biases contributing to the lower number of female and URM compared to male and white faculty members (Bertrand and Mullainathan, 2004; Moss-Racusin *et al.*, 2012; Stewart and Valian, 2018; but see Williams and Ceci, 2015 for an exception). Focusing on attitudes and behavioral intentions regarding equitable search practices extends efforts to document the impact of these initiatives beyond hiring statistics, i.e., the number of women and URM faculty hired. Demonstrating changes in faculty attitudes and behavioral intentions is important because relying only on changes in hiring numbers as evidence that these initiatives work might lead to underestimation of their potential. Sizable change in the ratio of female-to-male faculty in heavily male-dominated fields, for example, may be quite slow to emerge, given that often very few faculty members are hired in any given year. Moreover, retention of underrepresented faculty can be reduced by factors such as negative department climate (Jordan and Bilimoria, 2007; Xu, 2008). The current results demonstrate that faculty diversity initiatives such as the FRW can increase faculty members' approval of equitable search practices and intentions to enact them, two key ingredients in sustaining and normalizing the use of equitable search procedures that can ultimately lead to significant increases in faculty diversity (Stewart *et al.*, 2016).

The finding that endorsement of equitable search strategies was greater among faculty members when a greater proportion of their department colleagues had attended an FRW

offers the possibility that attending an evidence-based faculty recruiting workshop can lead to changes in institutional climate. When more of a department's members have learned about the social science findings presented in the workshop, this may provide a shared vocabulary and set of knowledge that changes the way they think about faculty diversity, such that the departmental culture becomes one of endorsing and supporting equitable searches. However, it is important to note in Study 2, the influence of one's own individual FRW attendance was stronger than departmental FRW attendance, perhaps because the proportions of department members who had attended an FRW were larger in Study 2 compared to Study 1. Other factors, such as unmeasured changes in departmental "politics" or leadership may have also played a role (Jordan and Bilimoria, 2007; Stewart *et al.*, 2016). In any case, it is an exciting possibility that the message promoting equitable search strategies can spread in some circumstances within an academic environment, even to those who have not directly received the message by attending the workshop themselves.

We predicted that exposure to a social science evidence-based workshop would increase endorsement of equitable search strategies because this exposure leads people to become more aware and convinced of the prevalence and impact of phenomena such as implicit bias, gender stereotyping and the accumulation of disadvantage. This mediation model was significant in analyses involving faculty members who had recently attended the FRW, suggesting that belief in these biases partially explain the immediate effects of the FRW. Moreover, the indirect effect was moderated by gender, such that men's endorsement changed due to changes in their awareness and belief in the social science principles more than women's endorsement did. This suggests the value of evidence-based initiatives to influence the most prevalent social identity group among faculty in many departments: men. Of importance, the mediation model was not significant in analyses including faculty who had attended the FRW longer ago. The indirect effect was marginally significant for long-term effects on attitudes toward search strategies, and significant in analyses examining separate pathways for disaggregated strategy types; however, the evidence is simply not as strong for long-term effects as they are for short-term effects. Nevertheless, the finding that having more recently attended the FRW had a stronger effect on outcomes supports a policy of receiving the training more than once, or being recertified at regular intervals. Having this "booster" training may foster more sustained change in attitudes and behavioral intentions.

Although the current studies show clear differences between those who had not attended an FRW and those who had, a strong causal explanation is not warranted due to lack of random assignment to groups, as faculty respondents were not randomly assigned to attend or not attend the FRW. However, it is important to note that faculty also did not necessarily "self-select" into groups because for the majority (65 percent in Study 1 and 68 percent in Study 2), attendance was a requirement of being able to serve on their department's search committee (and others were not required but likely strongly encouraged to attend). In addition, several key characteristics of the faculty respondents, including rank, race/ethnicity and whether they were in STEM or non-STEM departments could not be reliably analyzed due to small cell sizes in analyses including these factors. Future research should examine the potential role of these factors, in order to determine whether initiatives such as the FRW should be changed to be more effective for different types of audiences.

Given the importance of both attitudes and behavioral intentions for promoting intentional behavior (Ajzen, 1991), the present findings contribute to our understanding of how social science evidence-based FRWs can promote equitable searches. The more members of a department, organization, or institution have received an educational and persuasive message about the value of faculty diversity and how to reduce unintended evaluation bias in faculty searches, the closer they can come to achieving a more inclusive environment that fosters excellence in their constituencies.

Note

1. This rewording was intended to reduce socially desirable responding, i.e., claiming that one would refuse to discuss candidates' partners during applicant review, or object to non-diverse shortlists. See Appendix for both versions of the items.

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Appendix

Personal endorsement of equitable search practices (Study 1)

Instructions: please rate your perception of the following job search practices in terms of what you personally think is important to conduct an effective and successful job search.

Response scale: 1 "Not at all important" to 5 "Very important":

(1) Engage in active recruiting of specific individuals prior to the official opening of the search.

(2) Focus the search on narrow content areas rather than using a broad or "open search." (reverse scored)

(3) Be mindful of the composition of the search committee in terms of gender and race/ethnicity.

(4) Ensure that every candidate receives family friendly policy information.

(5) Ensure that every candidate receives dual career policy information.

(6) Decide and agree on specific applicant review criteria before the search begins.

(7) Use specific criteria (such as a candidate evaluation tool) in review of candidates.

(8) Take steps to reduce the influence of unconscious bias during applicant review.

(9) Avoid interviewing only one candidate from a particular social group (e.g. gender or race).

(10) During the visit, ensure that the candidate meets a wide variety of people from various social groups (e.g. gender or race).

(11) During the visit, show we are a "family friendly" department by asking job candidates about their children and families. (reverse scored)

(12) Avoid referring to a candidate in terms of his or her social group membership (e.g. as the woman or the minority candidate).

(13) Try to find out if the candidate has dual career issues by asking if he or she has a partner. (reverse scored)

Personal endorsement of equitable search practices (Study 2)

Instructions: please rate your perception of the following job search practices in terms of what you personally think is important to conduct an effective and successful job search.

Response scale: 1 "Not at all important" to 5 "Very important":

(1) Actively search for potential faculty recruits from institutions that train diverse students.

(2) In the job posting, state very specific areas of expertise as required for the position. (reverse scored)

(3) Systematically use defined criteria in evaluations (such as by relying on a candidate evaluation tool).

(4) Encourage search committee members to be vigilant about unconscious bias throughout the search.

(5) Make it a priority to bring in more than one female/racial-ethnic minority candidate for an interview.

(6) Take steps to ensure a diverse audience for the candidate's job talk.

(7) Try to find out whether candidates have a partner or children so that you can provide information about dual career services/family friendly policies to them. (reverse scored)

(8) Inform candidates that you are especially interested in them because of the diversity they will bring to your department. (reverse scored)

(9) Develop a rank order of candidates as early in the search process as possible. (reverse scored)

(10) Assign a faculty member to host the candidate's visit.

(11) Discourage speculation among search committee members of the likelihood that a candidate would accept the job if offered.

(12) Provide applicants with a checklist and clear instructions about the application process.

Behavioral intentions (Study 1)

Instructions: please indicate the likelihood of how you would respond to the following job search scenarios.

Response scale: 1 "Not at all likely" to 5 "Very likely":

(1) If a fellow search committee member were to speculate that a candidate is highly unlikely to leave his or her current institution for [our university], how likely are you to say that this type of speculation is not appropriate?

(2) If a fellow search committee member were to speculate that a candidate is highly unlikely to choose a Midwestern university such as [our university], how likely are you to say that this type of speculation is not appropriate?

(3) If a fellow search committee member were to bring up a candidate's partner during the review discussion, how likely are you to engage in the discussion of the partner? (reverse scored)

- If your search committee were to bring up a candidate's spouse or partner during the review discussion, how likely are you to say that spouses and partners should not be discussed until after an offer is made? (reworded version)

(4) If my search committee came up with a shortlist that did not include any women or underrepresented minorities, how likely are you to call attention to that fact?

- If, after a long review process, your search committee came up with a shortlist that did not include any women or underrepresented minorities, how likely are you to assert that the list is acceptable as it is? (reworded version)

Beliefs about bias (Study 2)

Instructions: please rate your agreement with the following statements.

Response scale: 1 "Strongly Disagree" to 5 "Strongly Agree":

(1) Although some people make assumptions about others' traits and abilities that are based on social group membership (such as gender or race-ethnicity), most people do not. (reverse scored)

(2) Our assumptions about a person's traits and abilities can subconsciously influence hiring decisions.

(3) Small instances of gender bias can accumulate to produce large disparities between men's and women's outcomes over time.

(4) Even though stereotypes exist about gender and race, women and racial-ethnic minorities are not affected by them. (reverse scored)

(5) Institutions often sacrifice quality in their efforts to increase diversity in hiring. (reverse scored)

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Examining models of departmental engagement for greater equity

A case study of two applications of the dual agenda approach

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Abstract

Purpose – The purpose of this paper is to examine two types of departmental interventions focused on creating healthier and more equitable academic departments as well as enhancing faculty members' capacity for collective dialogue, goals and work. Both interventions were informed by the "dual-agenda" approach and focused on targeted academic units over a prolonged period.

Design/methodology/approach – This paper uses a variety of qualitative and quantitative data (including National Science Foundation (NSF) ADVANCE indicator data) to assess the potential of dual-agenda informed interventions in reducing gendered structures and gendered dynamics.

Findings – The authors outline essential components of a dual-agenda model for maximizing success in creating more gender equitable work organizations and discuss why the authors are more optimistic about the dual-agenda approaches than many past researchers have been in terms of the potential of the dual-agenda model for promoting more equal opportunities in work organizations.

Originality/value – Most previous dual-agenda projects referenced in the literature have been carried out in non-academic contexts. The projects examined here, however, were administered in the context of multiple academic departments at two medium-sized, public US universities. Although other NSF ADVANCE institutional transformation institutions have included extensive department-focused transformation efforts (e.g. Brown University, Purdue University and Syracuse University), the long-term benefits of these efforts are not yet fully understood; nor have systematic comparisons been made across institutions.

Keywords Organizational culture, Sex and gender issues, Higher education

Paper type Research paper

Introduction

Institutions of higher education have commonly served as a context for implementing equal employment opportunity strategies in the USA. With a professed commitment to equal opportunity, preparing future leaders, and facilitating social innovation, colleges and universities provide a more solid foundation for change efforts than commonly exists in other types of organizations (Sturm, 2006, 2009). One of the key shifts in opportunity-enhancement strategies in recent decades has been a move away from person-centered approaches to more organization-centered models for change (Bird, 2011; Laursen and Austin, 2014; Bilimoria and Liang, 2012; Morimoto *et al.*, 2013; Roos and Gatta, 2009). Organization-centered change initiatives target the mechanisms built into organizations – organizational structures, cultures and practices – that enhance opportunities for some while creating barriers to success for

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others (Acker, 1990; Britton, 2000). Inherent in this approach is an assumption that equal employment opportunity laws and anti-discrimination training programs alone, when carried out in the context of work organizations, are insufficient for achieving equal opportunity goals (Bailyn, 2003; Kalev *et al.*, 2006).

Understanding the roles that equitable workplace structures, cultures and practices play in leveling the playing field for historically marginalized faculty groups (Tower and Dilks, 2015; Latimer *et al.*, 2014; Perlow and Kelly, 2014) is a necessary but insufficient first step toward creating more equitable workplaces. Two other steps are essential. First, effective department-level equity-enhancement strategies requires administrators and faculty throughout the university or college who are motivated to take the steps necessary to address potential inequities (Kezar, 2014). Second, effective department-level equity-enhancement strategies require efficient mechanisms for determining which "best practices" have the greatest potential for success in various types of work settings (Stewart *et al.*, 2016). Approaching organizational change with a "dual-agenda" framework is one method for taking each of these factors into account (Ely and Meyerson, 2000b). The dual-agenda framework assumes that to the extent that a group's and/or individual's instrumental goals can be advanced by creating more equal employment opportunities, organizational members will be more inclined to support organizational changes that enhance equal employment opportunity (Kolb and Merrill-Sands, 1999; Fletcher *et al.*, 2009; Meyerson and Kolb, 2000). Dual-agenda frameworks, by definition, are designed to meet multiple objectives. Ideally, these objectives constitute "win-win" outcomes: more equal opportunities and more successful work units/organizations. The likelihood for win–win outcomes is enhanced when organizational members have a vested interest in the processes in which they are being asked to engage. Dual-agenda frameworks enable organizational members to see equity work as both valuable and important while also motivating them to participate in and take ownership of the equity work (Ely and Meyerson, 2000a, b). Dual-agenda frameworks are pragmatic strategies for soliciting organizational members', or in this case, faculty members' support for change efforts (Ely and Meyerson, 2000a, b).

Most previous dual-agenda projects referenced in the literature have been carried out in non-academic contexts (e.g. Coleman and Rippin, 2000; Kolb and Merrill-Sands, 1999). The projects examined here, however, were administered in the context of multiple academic departments at two medium-sized, doctoral-granting land grant US universities – Iowa State University (ISU) and West Virginia University (WVU). Both institutions employ about 1,700 instructional faculty, are located in small rural cities and are primarily white with a majority male undergraduate population. These projects were implemented at two different points in time. Each was supported by National Science Foundation (NSF) ADVANCE institutional transformation (IT) grants for addressing barriers to the recruitment, retention and promotion of women and underrepresented minority faculty. Although other NSF ADVANCE institutions have included extensive department-focused transformation efforts (e.g. Brown University, Purdue University and Syracuse University), the long-term benefits of these efforts are not yet fully understood; nor have systematic comparisons been made across institutions.

In this paper, we examine two types of departmental interventions focused on creating healthier and more equitable academic departments as well as enhancing faculty members' capacity for collective dialogue, goals and work. Both interventions were informed by a "dual-agenda" framework and focused on targeted academic units over a prolonged period. The department-level interventions were implemented as part of a more comprehensive, multi-level and ADVANCE change initiative.

After brief discussion of relevant research and theory, we describe each departmental intervention and compare the two models. We then discuss lessons learned from our dual-agenda projects, summarizing how these university-based models differed from those

carried out in non-academic workplaces. Finally, we outline essential components of a dual-agenda framework for maximizing success in creating more gender equitable work organizations and discuss why we are more optimistic about dual-agenda approaches than many past researchers have been about the dual-agenda framework's potential for promoting more equal opportunities in work organizations (e.g. Kolb and Merrill-Sands, 1999; Acker, 2000; Hearn, 2000).

Theory

Dual-agenda frameworks for organizational change may be influenced by theories about how organizations emerge, operate, are managed and change. The theories that inform the dual-agenda frameworks discussed here overlap to some extent, but also differ. Each of the dual-agenda frameworks was informed by the gendered organizations theory (Acker, 1990; Britton, 2000; Kanter, 1977; Martin, 1996). Gendered organizations theory focuses on how organizations emerge, operate and are managed, but is not explicitly a theory of change. Gendered organizations theory suggests that when workplaces and paid labor are organized on the basis of gendered assumptions about what the ideal worker, work day, work practices, work policies and work cultures "look like," the result is the gendered organization of work or gendered organizations (Acker, 1990; Britton, 2000). Historically, each of these aspects of work and organizations has aligned mostly if not entirely with idealized masculinity and the norms of men's (especially white, able-bodied, heterosexual, native-born men's) lives. Gendered organizations research questions the acceptability of organizational structures, cultures and practices that inadvertently privilege people who are male (and/or otherwise historically advantaged) while also identifying aspects of the workplace that would need to be transformed to reduce institutionalized gender barriers to equal opportunity (Acker, 1990; Britton, 2000).

Although universities as academic workplaces often appear to be gender-neutral, their male-dominated histories have ensured that standards of academic performance, leadership styles, approaches to doing work, mentoring and promotion processes also align much better with norms of masculinity and men's lives than with norms of femininity or women's lives (Britton, 2017; Bystydzienski and Bird, 2006; Eveline, 2004; Krefting, 2003; Park, 1996). Altering these gendered structures, cultures and practices in academia is difficult because male and masculinity-centric standards have been constructed as neutral, objective and universal (DeWelde and Stepnick, 2015; Bird, 2011).

While gendered organizations theory is helpful in illuminating aspects of organizational structures, cultures and practice that undergird inequities, it is not a theory of change *per se*. Nor is gendered organizations a theory of leadership, management or group processes. Thus, while both dual-agenda approaches discussed here were influenced by gendered organizations theory, each was also informed by other theories. The dual-agenda approach implemented at ISU used gendered organizations theory to inform an "action research" model (Kolb and Merrill-Sands, 1999; Ely and Meyerson, 2000a, b; Kalev *et al.*, 2006; Meyerson and Tompkins, 2007) for department transformation, while the dual-agenda approach implemented at WVU used gendered organizations theory with social interdependence theory (Deutsch, 1949; Johnson, 2003) and a "unfreeze-change-refreeze" model (Lewin, 1947; Burnes, 2004, 2007). This combination is also action-oriented, for department transformation.

The action research model used at ISU involved social science research facilitators working directly with faculty to identify aspects of academic work units viewed as problematic in terms of hindrances to work productivity, hindrances to gender equity or to both productivity and equity. The term "action research" refers specifically to processes whereby the "subjects" of research act as participants in identifying "leverage points for change" as well as in processes for creating, designing and implementing change

"experiments" (Kolb and Merrill-Sands, 1999, p. 196; see also Coglan and Brannick, 2007). By engaging faculty in facilitated discussions (focus groups) about the structures, culture and practices of their immediate workplaces (departments), ISU's action research approach enabled the faculty to discover for themselves aspects of their immediate workplaces that were more supportive and empowering for some faculty than for others. The ISU dual-agenda approach was a very inductive one. Faculty in each department were assisted by researchers who helped them to uncover aspects of work structures, cultures and practices that posed barriers to productivity and/or equity. The social science researchers did not, however, set parameters on what the action plans for change in each department would include. ISU project leaders assumed, based on previous studies, that once departmental faculty had collectively identified problematic work structures, cultures or practices, they would be more likely to work together to change problematic aspects of the work environment (see Ely and Meyerson, 2000a). Then, by experimenting with new practices developed by faculty members themselves, faculty would feel ownership over the changes implemented (Coleman and Rippin, 2000; Ely and Meyerson, 2000a).

The "unfreeze-change-refreeze" (Lewin, 1947; Burnes, 2004, 2007) model used at WVU was influenced not only by gendered organizations theory but also social interdependence theory. Social interdependence theory focuses specifically on group processes and organizational goals that undermine democratic decision making. Thus, whereas ISU's inductive action research model allowed for a wide range of department change efforts (outlined in departmental action plans), WVU's approach to change focused more specifically on faculty group processes and ensuring democratic decision making. The WVU approach required setting these parameters, in part, because the WVU ADVANCE project had been designed to align with a new university strategic plan. Academic departments across campus would be required to develop unit-specific strategic plans in compliance with the university's new plan.

The WVU ADVANCE project also took into account emerging critiques of action research models which call for more nuanced and complex theories of change at the group and individual levels to ensure deeper ownership of change efforts (e.g. Benschop and Verloo, 2011). For the WVU approach effective organizational change is a process of disrupting or "unfreezing" and then changing problematic (and often, "gendered") aspects of organizational structures, cultures and practices. Once new, more democratic, structures, cultures and practices are in place, they must then be "refrozen" (Lewin, 1947). The WVU approach also drew faculty members' attention (from the beginning) to the need for new, more inclusive work routines that help to inspire collective efficacy. This approach enabled WVU's department change facilitators to focus faculty on tasks that would also lead to a specific outcome – i.e., the creation of a new department strategic plan.

The WVU approach was influenced by social interdependence theory, which assumes that the ways in which group and organizational goals are structured determines interaction patterns and outcomes (Deutsch, 1949; Johnson, 2003). Well-communicated organizational goals of cooperation are more likely than competition-based goals to promote trusting interpersonal relationships and the pooling of knowledge resources. Competition, however, is often the norm in academic departments, especially in science, technology, engineering and math (STEM) departments. Interdependence theory suggests that new understandings among department members about doing academic work, along with mechanisms of accountability for desired practices, help set a foundation for new collective work routines (Blair-Loy and Wharton, 2002). When groups experience "collective efficacy" in their pursuit of new modes of practice, these practices are more apt to be continued (Bandura, 1997). The new mode of practice that the WVU program sought to instill was inclusive group decision-making, which reduces the likelihood that women and other underrepresented faculty groups will be marginalized from career-relevant, informal decision-making processes that routinely and non-reflexively occur among men faculty.

Brief summary of the two dual-agenda approaches

Before comparing the two approaches, we note at the outset that these departmental interventions (as well as the overall IT projects within which the department work was embedded) were not designed nor initially assessed in conjunction with each other. However, members of the WVU ADVANCE team consulted with the ISU team (as well as with two other ADVANCE teams) about their departmental intervention to learn about their best practices, lessons learned, recommendations to improve the process, etc., and thus directly benefitted from ISU's experience. Regardless, two very different teams at two different points in time designed, implemented, modified and assessed the impact of multiple iterations of these interventions. The departmental data collected for the ISU project were more qualitative, involving extensive confidentiality issues that constrain how the data can be disseminated. The departmental data collected for the WVU project were, relatively speaking, more quantitative – and thus more conducive to statistical analyses. Additionally, because the requirements for receiving the grant awards changed over time, the WVU project involved a more extensive data collection process than the ISU project. The comparison of these projects occurs at a third point in time which also influences the manner in which we draw comparisons for this paper. Nonetheless, we note that data generated from each project provide valuable insights for theory building as well as for the evaluative purposes for which the data were originally collected.

The ISU "Department Enhancement" project

The ISU ADVANCE Department Enhancement Program (DEP), carried out as part of ISU ADVANCE (2006–2012), focused on engaging faculty in the process of illuminating taken-for-granted aspects of departmental work structures, practices and cultures so that they could identify and address potential barriers to faculty productivity and/or equity (Meyerson and Kolb, 2000). These productivity and equity goals were accomplished through a series of informational meetings with department chairs and focus groups and interviews with faculty designed to promote maximum participation. Meetings and focus groups were facilitated by faculty (external to the department) trained in action research facilitation methods. This action research approach assumes that by engaging faculty by rank in focus groups and/or interviews, and by providing department chairs/leaders with additional information about best practices for ensuring department productivity and equity (i.e. instrumental and equity components of the dual agenda), all department members will benefit from the resulting department enhancement reports action plans. This approach maximizes the likelihood that issues of concern about department efforts to ensure productivity and equity expressed by marginalized faculty will be identified and addressed as well as issues identified by less marginalized faculty (Bird *et al.*, 2010, 2011).

The ISU DEP was initially implemented in nine participating STEM departments (2007–2012) and in six more departments between 2013 and 2015, all of which were located across the three ISU colleges with the highest proportions of STEM faculty. After 2012, ISU opened DEP participation to departments of all academic disciplines to help ensure that the best practices generated from the DEP process would have the broadest reach possible.

The ISU DEP was facilitated by social science and humanities faculty who were either a part of the ISU ADVANCE leadership team or hired as consultants from outside the university. One facilitator per department was paired with a tenured faculty member in the department, referred to as "ADVANCE Professors" (APs). All APs and department Chairs received training in a 3–4 h ADVANCE workshop on issues of implicit gender and race bias, "gendered organizations," and best practices for ensuring that workplace climate is equally conducive to career success for all faculty.

The DEP process was implemented in four steps: providing information to department leaders about promoting productive and equitable workplaces; gathering and analyzing

information about department work processes (e.g. faculty hiring, mentoring and promotion and tenure); preparing and disseminating a department "DEP" report based on department-specific data; and using the DEP report as a springboard for making department-specific, work process changes (action plans). The department "DEP" reports were prepared collaboratively by the DEP facilitator, the department's AP and an additional two to four department faculty selected by the chair and AP. Each department report provided a summary of that which the faculty identified as most and least conducive to faculty success in core areas of their jobs as well as any issues found to be more or less salient for sub-groups among the faculty (e.g. by gender or rank). DEP reports also contained suggestions for best practices designed to address salient and problematic issues raised by faculty. Next, DEP reports were presented to the faculty, after which department chairs and their faculty developed action plans for addressing problematic aspects of department structures, cultures and practices (see Bird *et al.*, 2010, 2011 for extensive discussion of the process).

Faculty engagement throughout the DEP process was high. The average participation rate among the faculty across the initial nine DEP departments (comprising the data for this paper) was 74.3 percent (see Bird *et al.*, 2010, 2011). Department action plans focused on enhancing department work climate and reducing (as necessary) barriers to the recruitment, retention and promotion of diverse faculty. Examples of action plans included changing aspects of departmental "governance documents" to create greater transparency in department processes regarding tenure and promotion; creating department guidelines for faculty, including women and men, to modify teaching duties when the faculty member (or her/his spouse) gives birth or adopts; and realigning department staff to more equitable distribute support to faculty (Larson *et al.*, 2016; Bird *et al.*, 2011). Qualitative evaluation data indicate that the consistently high levels of faculty participation across departments helped to ensure collective ownership of change strategies while also promoting interpersonal accountability (Bird *et al.*, 2011).

ISU institutionalized the DEP after the NSF grant funding ended in 2012, using university resources in place of grant resources. Lessons learned from work with each cohort of departments are used on an ongoing basis by a Provost-level ADVANCE Faculty Fellow whose time is supported by the ISU Provost office to develop "best practices" for enhancing departmental workplaces. These best practices are shared with new cohorts of DEP departments but are also disseminated to department chairs via workshops.

Workplace climate survey data[1] based on faculty responses across campus and interviews conducted with DEP current and past department chairs and APs (Larson *et al.*, 2016) show that policy and practice changes (i.e. faculty governance guidelines and procedures) occurred in areas including faculty mentoring, work-life balance, faculty recruitment and hiring, faculty retention and promotion and in administrative leadership such that climate was viewed more positively while gender equity goals were also advanced (Bowen *et al.*, 2012; Harris *et al.*, 2009). Between 2005 and 2011, women's representation among all tenured and tenure-track STEM faculty rose from 18.9 to 20.9 percent. Institutional research data show that over the same time period, women in upper level administrative positions (i.e. VPs, Provost and Associate Provosts) rose from 16.7 to 62.5 percent. The percentage of female deans increased from 37.5 to 50 percent and the percentage of female associate/assistant deans increased from 24 to 33 percent. The percentage of females as department administrators increased from 11 to 20 percent. The percentage of female STEM faculty at the rank of Professor increased from 10.7 to 14.9 percent and from 32 to 35 percent for SBS full professors (see also Bowen *et al.*, 2012; Bowen and Debinski, 2013).

The WVU "Dialogues" project

The WVU ADVANCE Dialogues, carried out as part of the university's ADVANCE (2010–2017) Program, focused on changing the socially shared definitions of appropriate

group behavior so that inclusive decision-making processes become the norm for faculty meeting discussions and thus create a more positive and inclusive work environment. This gender equity goal was accomplished through a series of meetings grounded in inclusive strategies and practices and facilitated by faculty who ensured that the perspectives of all departmental members were included in the decision-making process. This approach assumes that while all faculty members will benefit from greater inclusivity, previously marginalized groups will benefit even more. The collective decision-making strategies and practices (gender equity goal) were used to create a product – a University required strategic plan (i.e. the instrumental agenda) with a strong diversity component and clear action items and goals.

Every STEM and SBS department in the two targeted colleges participated in the facilitation process. Each department's faculty participated in a 1-h introductory meeting with the University Provost (where she conveyed the importance of the Dialogues process), and an additional 7–8 h (spaced out over several months of meeting time) for the actual process. The neutral facilitators were WVU faculty from other units and were present to help ensure an inclusive process and departmental ownership over the final strategic plans (Nolan *et al.*, 2012; Latimer *et al.*, 2014).

"Dialogues" was implemented in four steps: identifying departmental foci for strategic planning, including diversity and inclusivity goals; envisioning the ideal department; raising to a level of greater awareness those practices faculty need to discontinue and those they would need to start in order to achieve their strategic goals, and then prioritizing those practices; and developing a list of concrete steps to be taken in order to fulfill the department's strategic plan. The departmental sub-groups prepared a draft outlining their part of the strategic plan. These documents were then reviewed by the Dialogues facilitators and the WVU ADVANCE Director. The groups' drafts were then forwarded to the department chair who used them to prepare a final strategic plan which they submitted to their dean (see Nolan *et al.*, 2012; Latimer *et al.*, 2014; Holmes *et al.*, 2016, for an extensive discussion of the process). Dialogues was implemented in 16 WVU STEM/SBS departments between 2011 and 2014. All of the units were successful in creating a strategic plan with a strong diversity/inclusivity component.

As summarized elsewhere (Holmes *et al.*, 2016; Latimer *et al.*, 2014) qualitative analysis of faculty assessments of the Dialogues process revealed that faculty participants responded quite positively to the Dialogues format and the faculty facilitators and a pre-test/post-test quantitative analyses of aggregate-level departmental patterns documented significant changes in existing gendered group processes (i.e. increases in the percentage of faculty assessing higher levels of cooperation among faculty members, more positive relationships and interactions with colleagues and greater shared belief that their departmental group could work together to meet gender equity goals).

Overall, data from climate surveys at this institution along with policy improvements in areas, including faculty mentoring and work-life integration, indicate clear improvements in NSF-specific indicators (i.e. data required in annual reports because they are identified as essential for understanding the status of women faculty at each academic institution) at WVU in hiring, retaining and promoting women faculty to the upper ranks and administration. Specifically, between 2009 and 2016, the percentage of female tenure-track STEM faculty increased from 14 to 22.4 percent; the percentage of female tenure-track SBS faculty increased from 46 to 49.2 percent. Women constituted 0.8 percent of STEM full professors in 2009 but 7.7 percent in 2016; for SBS full Professors the increase was from 21 to 47.4 percent. This significant increase of women at this rank is especially important given the on-campus preference for individuals to be fully promoted before serving in administrative positions. For associate professors, women STEM associate professors increased from 19.2 to 28.8 percent; the corresponding

change for SBS is 45.4–62.5 percent. In total, 50 percent of women had positive outcomes from the promotion and tenure process in 2009–2010 (pre-ADVANCE); 100 percent had positive outcomes between 2010 and 2016 (during ADVANCE) (Hougland and Darrah, 2017).

Comparing dual-agenda department-level approaches

The ISU and WVU dual-agenda models share important similarities and both improve upon previous implementations of this approach in non-academic work organizations (see Ely and Meyerson, 2000a, b). Both are process interventions designed to promote gender equity practices as well as the shared definitions of appropriate behaviors between and among academic colleagues.

Regarding similarities, each dual-agenda model was implemented in the context of a broader comprehensive "IT" program supported by a large grant from the NSF. Each of the institutions simultaneously promoted the use of "best practices" for reducing implicit bias in hiring and promotion processes, enhancing departmental work climate, and promoting better "work-life balance" among faculty. The broader "IT" programs were implemented under the leadership of top-level administrators and a diverse team of faculty whose professional research and experience were well suited for ensuring the effective implementation of intervention strategies. These leadership teams remained in place over the life of the grant (five to six years) at each institution.

Each institution's ADVANCE program ensured consistent and frequent communication across all levels of the university via an internal advisory group comprised of the university's top-level administrators (i.e. Provost and/or President), college deans and ADVANCE program leaders. Each university ensured the dissemination of information about the department-level interventions via annual reports, presentations to the university community about the department-level transformation successes and campus-wide surveys of departmental work climate (i.e. the Harvard COACHE survey). Faculty participation in targeted departments at each university was very high. Each unit was successful in translating the project ideas into various departmental products and practices. The commonalities between these approaches also are points of distinction between these efforts carried out in the context of universities with support from a national funding agency, and efforts previously deployed in the context of large private work organizations (Ely and Meyerson, 2000b; Meyerson and Kolb, 2000; Coleman and Rippin, 2000).

There are, however, at least five ways in which these dual-agenda approaches differ from each other. For example, at WVU all STEM and SBS departments were required to participate so that no department was singled out as a "problem unit." The process at ISU, however, involved inviting academic units to participate in the facilitation process to ensure that faculty and department leaders would view the process as one designed to achieve their goals, not goals imposed by upper administration. WVU primarily used internal facilitators for the process while ISU used a combination of external and internal faculty facilitators. WVU facilitations involved all the faculty from a unit at one time (like a regular faculty meeting) while ISU broke the facilitations into smaller focus groups organized by faculty rank (as a way to minimize power differentials). WVU's direct contact with departmental faculty occurred over the course of one semester while the ISU contact occurred over two semesters. The WVU process consisted of high, intense initial involvement with units and lower involvement after the facilitation was complete while ISU maintained highly involved departmental consultants consistently across the semesters. Thus, dual-agenda approaches to organizational change can vary in how they are operationalized but still can be successful as long as they are designed in ways that take the local culture and context into account.

Discussion

Overall assessment of the dual-agenda framework

We are more optimistic about the dual-agenda framework than many past researchers have been in terms of the potential of the dual-agenda to promote more equal opportunities in work organizations (e.g. Kolb and Merrill-Sands, 1999; Acker, 2000; Hearn, 2000). The dual-agenda approach which links gender equity goals with unit-specific instrumental goals (i.e. increasing the transparency of the promotion and tenure process will improve faculty retention and thus promote unit stability) was a successful strategy for maximizing participation at the time in which these IT grants were initiated at these specific institutions. Both programs have an ongoing financial investment on the part of the university's upper administration, colleges and academic departments. As such, prolonged attention and resources directed at these units have had an impact on the basic processes within these units and changed the overall diversity and inclusivity expectations for the rest of the campuses. The issue of continuity of change efforts and whether these efforts will be sustained at each institution, furthermore, is one that requires consideration of the extensive time and human resources that these efforts require. Costs associated with department interventions can be difficult for universities to cover, especially in an era of declining state budgets for higher education and concerns over tuition costs and rising student college loan debt. By taking a holistic approach to the issue of faculty recruitment, retention and promotion, however, the argument in favor of (or, possibly, against) department-level interventions that enhance department work culture and climate is not hard to make. If sustaining department-based intervention approaches keeps the costs of hiring faculty down by ensuring the retention of high quality faculty members and therefore less need for allocating new "start-up" packages (which in STEM are very high), the relative costs of department interventions are quite "low." If, however, department-based interventions are not necessary for retaining high quality faculty – either because department cultures and climates are already very good or faculty feel their employment alternatives are low – then the costs of department interventions are "high."

Addressing the challenges of the dual-agenda framework

These two implementations reveal the potential of dual-agenda approaches to transform work organizations in ways that reduce or eliminate gendered barriers to equal opportunities. Previous criticisms of dual-agenda approaches come from two main camps – researchers who have implemented such models themselves (e.g. Ely and Meyerson, 2000a, b; Meyerson and Kolb, 2000; Coleman and Rippin, 2000) and gendered organizations theorists who have conducted extensive research on changing gendered organizations but have not implemented these models personally (e.g. Acker, 2000; Hearn, 2000). Implementers of dual-agenda approaches identify the following challenges to ensuring the success of this model: establishing a solid foundation for the work, ensuring success during the implementation phase, and ensuring success once the primary intervention has been completed. Primary challenges associated with setting a solid foundation for the dual-agenda work, include ensuring that organizational leaders in key decision-making positions are involved at all organizational levels, and designing interventions in ways that enable even the lowest level organizational members to voice concerns and make suggestions about how to redesign work structures, practices and cultures (Ely and Meyerson, 2000a, b). Due partly to the fact that the NSF's ADVANCE IT grant program requires extensive top-level leadership buy-in as a stipulation for funding, both ISU and WVU programs readily met this challenge. Because both interventions also were specifically designed to enable department members of all ranks to provide input and participate in work-redesign efforts without fear of repercussions, those potential pitfalls were avoided as well.

Challenges associated with implementing dual-agenda change models include making sure that the interventions truly enable organizational members to "see" the many dimensions of "gendered organizations" and not allowing "gender" to be reduced to notions of personal gender identity alone (Ely and Meyerson, 2000b; Meyerson and Kolb, 2000). Research in non-academic settings shows that although training about the many ways in which gender shapes work organizations is commonly provided, those who attend such trainings are not always the same as the people who participate in subsequent work structure/culture/practice transformation exercises. This disconnect between the people who are trained, the people who are then asked to engage in the exercises for illuminating problematic aspects of the work environment, and the people who are tasked with implementing changes greatly diminishes the likelihood of success. Commitment and accountability to transformation goals requires that the organizational members who carry out plans for implementing changes understand the reason for the changes they are putting into place. Fortunately, both the ISU and WVU interventions were intentionally designed to maximize overlap between the organizational members who participated in "gendered organization"/subtle gender bias workshops and those who would then participate in work transformation exercises and execution of strategic/action plans. The WVU program, for example, engaged department leaders in training and then engaged department faculty (including department leaders) in the Dialogues process. During the Dialogues process, participating faculty completed exercises that enabled them to experiment directly with new (democratic) modes of communication and cooperation while also doing the work of strategic planning. The ISU program engaged department leaders, including the chair and a faculty point-person, in training, then engaged departmental faculty in the process of identifying aspects of their work processes that were ideal and those that needed improvement, and then engaged the faculty as a whole in the process of developing and implementing an action plan.

A related challenge associated with implementing dual-agenda models involves making explicit the connection between each type of intervention and the gendered issue or issues that it is designed to address. To explain this challenge more fully, we offer the following example. Consider a situation in which a manager implements a change in how a particular work task is carried out in her or his work unit, but does not fully understand why upper management has required this change. Let us assume that the initial reason for the change was that it would enable women workers to better fulfill primary childcare responsibilities (e.g. more flexibility in work schedules). If the manager does not truly understand the broader reasoning behind the change, she or he will not feel empowered to apply the principle behind the change to other work situations. The failure to apply the same logic to multiple situations thus minimizes the potential breadth of the transformation initiative. Inconsistent applications of logic may also undermine workers' job satisfaction and morale. As Ely and Meyerson (2000a, b, p. 605) explain, expert dual-agenda facilitators must work with organizational "partners to help them build narratives about their own gendered organizational experiences" and must make sure that organizational partners are able to apply knowledge about how gendered organizations operate to multiple situations and circumstances.

This complex challenge is one that the ISU and WVU dual-agenda approaches were only partly able to overcome. Faculty and administrators most closely involved in leading change efforts in the departments (and at other levels of the university) were most apt to understand and apply knowledge about gendered organizations broadly. Even so, there remain visible differences among faculty and administrators throughout each university in the extent to which they appear committed to and are able to maintain the "gender narrative." While the extensive efforts on the part of each university's ADVANCE program to train faculty and administrators about gendered organizations and their dual-agenda

department-level interventions set in motion many micro-initiatives that fed into and supported university-wide initiatives that have had and will have lasting positive effects, they did not fully "transform" these institutions in the short run. Though to be fair, we know of no successful efforts (with or without NSF funding) that have achieved a complete campus-wide transformation in a short amount of time (Stewart *et al.*, 2016). The dual-agenda models reviewed here clearly helped to enhance the success of other university-wide interventions, such as work-life balance policies and reducing subtle bias in faculty recruitment and hiring processes, but they have yet to fully transform university cultures, practices and structures. The dual-agenda interventions in academic departments in conjunction with each institution's overall ADVANCE program, nonetheless, helped to set each university on a new course.

Challenges associated with ensuring lasting success of transformation efforts additionally include committing organizational monetary and human resources for making and sustaining changes, appropriately rewarding organizational members who lead change efforts, and codifying changes in such a way that makes them difficult to "undo." Because the ISU and WVU ADVANCE programs each were funded, for the most part, by the NSF for approximately six years (including no-cost extensions), funding was not a challenge during the grant period. This is one of the obvious advantages of implementing a dual-agenda approach in the context of universities. Sustaining change in universities nonetheless requires that they commit resources after the grant funding expires. ISU met this challenge in three ways. First, the university continued to provide funding for the DEP process. Second, as part of ISU's early planning for the overall ADVANCE IT Program, the university established college level "Equity Advisors" in the three colleges where the DEP work was initially carried out. Equity Advisors were established in the dean's offices of each college to assist in the development and implementation of equity-enhancement efforts in areas including faculty recruitment and hiring, promotion and tenure processes, mentoring and work-life balance. After NSF ADVANCE funding expired, the three ISU colleges that had previously established the Equity Advisor position as well as the remaining colleges (except the Graduate College) appointed faculty members into these Equity Advisor positions and began using college funds to support them. Third, the university continued to fund a position in the Office of the Senior Vice President and Provost Office for a "Faculty Fellow" (filled by tenured faculty) to oversee and administer faculty enhancement programs in areas including mentoring, chair training and faculty recruitment and hiring, and by continuing the department-level program outlined above. WVU addresses this challenge through its Provost supported ADVANCE Center and Director, an expanding Advocates/Allies program (developed and disseminated by ADVANCE FORWARD at North Dakota State University as a network of male faculty working with other male faculty to promote and sustain a gender equitable University), and an entrepreneurial Dialogues program. Each institution has also codified many of the changes instigated by the department-level dual-agenda models. These changes include procedures for reducing implicit bias in recruitment and hiring practices, more extensive and utilized work-life balance policies and well-subscribed mentoring programs and workshops for associate as well as assistant professors.

Looking forward

Based on the comparison of the ISU and WVU projects for transforming academic workplaces and as facilitators who directly observed the significant shifts in faculty group dynamics, we conclude that dual-agenda approaches (in general and specifically those at ISU and WVU) hold great promise. Academic institutions intent on creating and sustaining a culture of inclusivity must engage faculty within the most basic units in which they spend their time. There must be some type of process intervention that simultaneously

acknowledges the needs of the individuals and the collective group because promoting a collective inclusive approach to change in the academy undermines and destabilizes the pervasive ideology of heroic individualism.

Although only time can determine whether these projects will have the lasting effect of creating organizational structures, cultures and practices that are equally conducive to the success of faculty of all backgrounds, the changes witnessed at these two institutions are very telling. Both institutions have seen improvements in terms of the numbers and percentages of women advancing through the tenure ranks and in administrative positions (ISU Office of Institutional Research; WVU Office of Institutional Research). Survey data also show that in departments where DEP and Dialogues interventions were carried out, positive perceptions of work climate increased (Latimer *et al.*, 2014). One of the reasons for our optimism about dual-agenda approaches are the advantages the university context provides over non-academic work organizations. Because universities are overtly committed to creating and enforcing policies that uphold equal opportunities and to a culture that encourages experimentation with new ideas, we believe that faculty and administrators at other institutions of higher education would be well-advised to use the lessons learned here in their own development of dual-agenda models for IT.

Note

1. Unless otherwise noted, statistics are from unpublished reports, available upon request.

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Is it always this cold? Chilly interpersonal climates as a barrier to the well-being of early-career women faculty in STEM

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Abstract

Purpose – The purpose of this project was to examine the extent to which early-career women faculty in science, technology, engineering and math (STEM) experience working in a chilly interpersonal climate (as indicated by experiences of ostracism and incivility) and how those experiences relate to work and non-work well-being outcomes.

Design/methodology/approach – Data came from a sample of 96 early-career STEM faculty (Study 1) and a sample of 68 early-career women STEM faculty (Study 2). Both samples completed online surveys assessing their experiences of working in a chilly interpersonal climate and well-being.

Findings – In Study 1, early-career women STEM faculty reported greater experiences of ostracism and incivility and more negative occupational well-being outcomes associated with these experiences compared to early-career men STEM faculty. In Study 2, early-career women STEM faculty reported more ostracism and incivility from their male colleagues than from their female colleagues. Experiences of ostracism (and, to a lesser extent, incivility) from male colleagues also related to negative occupational and psychological well-being outcomes.

Originality/value – This paper documents that exposure to a chilly interpersonal climate in the form of ostracism and incivility is a potential explanation for the lack and withdrawal of junior women faculty in STEM academic fields.

Keywords Well-being, Ostracism, STEM, Incivility, Chilly climate

Paper type Research paper

Decades of research document that women are less likely to enter and more likely to exit science, technology, engineering and math (STEM) fields compared to men (Hill *et al.*, 2010; Xie and Shauman, 2003), including academic faculty (Bilimoria and Liang, 2012; Demos *et al.*, 2014; Rosser, 2004; West and Curtis, 2006). For example, according the National Science Board (2016), women earn only 40 percent of STEM PhDs and account for only 46 percent of assistant professors, 38 percent of associate professors and 25 percent of full professors in STEM. Although researchers have been unable to identify a specific time point in which women leave STEM academic fields, the greatest losses appear to occur early with women becoming more and more underrepresented over time (Lichtenstein *et al.*, 2014). One explanation for the underrepresentation and departure of women from STEM academia is that it has a "chilly" climate for women.

Chilly climate refers to the differential maltreatment that women experience in academic settings. The term was introduced by Hall and Sandler (1982), who described it as the tendency for faculty, whether intended or not, to interact with women and men students differently in the classroom. More recent theoretical work has conceptualized chilly climates for women as encompassing not just inequitable interpersonal interactions in

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organizations, but also organizational structures and cultures including, for example, those related to work-life balance and the allocation of resources and rewards (Britton, 2017; Stewart *et al.*, 2007). However, we focus solely on the interpersonal aspect of chilly climates in the present research. Indeed, gender equity rests in part on micro-level relational processes making quality interpersonal interactions critical for women in STEM (Bilimoria *et al.*, 2006; Callister, 2006; Etzkowitz *et al.*, 2000; Latimer *et al.*, 2014; Morimoto and Zajicek, 2014; Roos and Gatta, 2009; Xu and Martin, 2011).

Research on the interpersonal aspect of chilly climates has documented the subtle mistreatment undergraduate women students experience in academic environments (e.g. Hall and Sandler, 1982; Morris and Daniel, 2008; Pyke and Janz, 2000). Research has also demonstrated the preponderance of chilly interpersonal climates for women academics (Blakemore *et al.*, 1997; Gersick *et al.*, 2000; Maranto and Griffin, 2011; Riger *et al.*, 1997), including in STEM fields (Carapinha *et al.*, 2017; Greene *et al.*, 2010; Settles *et al.*, 2006; Settles *et al.*, 2007; Wright *et al.*, 2003; Xie and Shauman, 2003; Xu, 2008). Findings have also documented that chilly climates relate to a host of negative occupational well-being outcomes for women faculty in STEM including lower job satisfaction and higher turnover intentions (e.g. Callister, 2006; Carapinha *et al.*, 2017; Riffle *et al.*, 2013; Settles *et al.*, 2006, 2007; Xu, 2008).

Although research has linked chilly interpersonal climates for women faculty in STEM to negative outcomes, a number of gaps in the literature remain. For example, little research has isolated the effects of working in a chilly interpersonal climate for STEM women academics early in their career, a time when they may be particularly vulnerable to leaving (Lichtenstein *et al.*, 2014). Further, it remains unclear the extent to which such experiences and their effects may differ from their early-career male STEM faculty counterparts. There is also a paucity of research examining how working in a chilly interpersonal climate affects non-work outcomes for women STEM faculty. Research has also not examined the extent to which the negative effects of chilly interpersonal climates differ depending on the gender of the instigator; that is, it remains unclear the extent to which women faculty in STEM are differentially harmed by chilly behavior from male and female colleagues.

The purpose of the present paper is to advance the literature on the underrepresentation of women faculty in STEM by examining the extent to which junior women in STEM experience working in a chilly interpersonal climate and how those experiences affect work and non-work well-being outcomes for these women. We do so in two studies by utilizing data from early-career faculty in STEM academia. In the first study, we assess gender differences in experiences of two indicators of an chilly interpersonal climate (ostracism and incivility) and the extent to which such experiences relate to two occupational well-being outcomes (turnover intentions and affective organizational commitment) in a sample of male and female junior academics in STEM at one university. We then extend these findings in the second study using data from a sample of junior women faculty in STEM from various universities by investigating the extent to which experiences of ostracism and incivility relate to two additional occupational well-being outcomes (academic self-efficacy and future career perceptions), as well as outcomes in two non-work domains: physical well-being (physical health ailments) and psychological well-being (psychological distress). In Study 2, we also examine the extent to which junior women STEM faculty differentially experience ostracism and incivility from their male and female colleagues and if those experiences differentially relate to outcomes.

Texas A&M University (TAMU) ADVANCE-IT

The data for the present studies originated from a National Science Foundation ADVANCE-IT grant awarded to TAMU in 2010. In 2006, findings from a faculty campus climate study showed that STEM women faculty perceived the workplace climate as much more negative

and discriminatory than did their men counterparts (TAMU ADVANCE Center, 2013). To help address this issue, the university submitted a proposal to the NSF ADVANCE program with the goal of transforming the workplace climate through numerous targeted initiatives aimed at improving recruitment, reducing attrition and promoting success of women faculty at all levels at TAMU. TAMU adapted and implemented the American Psychological Association's (APA) Psychologically Healthy Workplace (PHW; Grawitch and Ballard, 2016) framework as the foundation for the ADVANCE-IT to benefit women faculty at TAMU.

A PHW is characterized by "intentional, systematic, and collaborative efforts to maximize employee well-being and productivity by providing a supportive social-organizational environment, and accessible opportunities for career and work-life enhancement" (Wilson *et al.*, 2004). Empirical research has demonstrated that PHWs contain five areas with clear benefits for employees and the organizations within which they work. For example, people who work in PHWs have lower turnover rates, less stress, and higher satisfaction than the national average (Grawitch *et al.*, 2006; Grawitch *et al.*, 2007, 2009). PHWs are also better able to attract and retain top people (Grawitch *et al.*, 2007).

The present research focuses on one of the five areas of PHW: health and well-being. This component of PHW includes the health and well-being effects of workplace stressors for employees, such as those related to working in a chilly interpersonal climate. As part of the TAMU ADVANCE-IT social science research component, we developed surveys to assess the health and well-being effects of working in a chilly interpersonal climate for faculty in STEM to contribute to the literature on potential explanations for the underrepresentation of women faculty in STEM. We focus here on the data from STEM faculty early in their career trajectory that was collected as part of that effort.

Indicators of a chilly interpersonal climate: ostracism and incivility

We examine two indicators of a chilly interpersonal climate: ostracism and incivility. Ostracism is defined as being ignored and excluded by others (Williams, 2001). Examples include language exclusion, such as being ignored among people in a shared conversation (Hitlan *et al.*, 2006), information exclusion, or being "out-of-the-loop" (Jones *et al.*, 2009), and group exclusion, or marginalizing people from group activities (Williams and Carter-Sowell, 2009). Such behavior could result in junior women faculty receiving less information about resources, expectations for tenure and promotion, opportunities for career advancement, and developments in the field (Rose, 1985). Incivility, in contrast, is defined as rude and discourteous behavior that displays a lack of regard for others (Andersson and Pearson, 1999). Examples include condescension, being addressed inappropriately, and disparaging comments. Such behavior could lead junior women faculty to be taken less seriously and seen as less of an expert in her field. Both ostracism and incivility, because they entail exclusion and dismission, may be particularly harmful to the well-being and career trajectories of early-career women STEM faculty as they attempt to build their reputation, develop their expertise, and increase their visibility.

Both ostracism and incivility have been conceptualized as chronic stressors (Cortina *et al.*, 2001; Williams, 2007). Chronic stressors differ from acute stressors in that they occur over extended periods and have ambiguous onsets and offsets (Hepburn *et al.*, 1997). Lazarus and Folkman (1984) referred to such persistent stressors as "daily hassles." These daily stressors, while seemingly inconsequential in the short term, accumulate leading to well-being detriments for those who experience them. Research suggests they can be even more damaging to well-being than more dramatic life events because chronic stressors produce an additive "wear and tear" effect through repeated exposure (DeLongis *et al.*, 1982; Kanner *et al.*, 1981). Minority stress theory (Meyer, 1995) proposes that individuals in subordinate social groups (e.g. women) are especially likely to experience well-being detriments because of the persistent exposure to environments where they are a minority.

Empirical research on the effects of ostracism and incivility follow from theory. Experiences of ostracism have been linked with lowered organizational commitment (Hitlan *et al.*, 2006) and higher turnover intentions (Smith and Calasanti, 2005; Yin and Liu, 2013). In a sample of academic faculty, He *et al.* (under review) found that faculty experiences of ostracism related to lower job satisfaction, higher turnover intentions, and more job burnout. Pedersen and Minnotte (2017) reported that STEM faculty, particularly women, reported higher job burnout the more they experienced information exclusion. Research also shows that female faculty, compared to male faculty, reported greater incidences of ostracism and are commonly excluded from male networks and isolated from male colleagues (August and Waltman, 2004; Gersick *et al.*, 2000; Zimmerman *et al.*, 2016).

One of the most documented outcomes of incivility is decreased well-being (Schilpzand *et al.*, 2014). People who experience incivility at work also tend to be less motivated and committed, which eventually leads to withdrawal from work, higher turnover intentions, and organizational exit (Pearson and Porath, 2009). O'Brien *et al.* (2016) found that experiences of incivility related to stress which in turn predicted declines in physical health and objective performance for STEM academicians. Research also shows that women are especially likely to experience uncivil treatment at work (Cortina *et al.*, 2013; Settles and O'Connor, 2014; Zurbrügg and Miner, 2016) and report more work withdrawal (Loi *et al.*, 2015) and less job satisfaction (Zurbrügg and Miner, 2016) compared to men when they work in contexts tolerant of incivility.

Consistent with this research and theory, we propose that early-career women STEM faculty are more likely to experience ostracism and incivility at work compared to their male counterparts. We also posit that although both women and men report declines in occupational well-being with greater experiences of ostracism and incivility, such effects are especially pronounced for women:

H1. Early-career women STEM faculty report more experiences of ostracism and incivility than do early-career men STEM faculty.

H2. Greater experiences of ostracism and incivility are associated with greater negative occupational well-being outcomes (higher turnover intentions and lower affective organizational commitment) for early-career women and men STEM faculty.

H3. Although greater experiences of ostracism and incivility are associated with greater negative occupational well-being outcomes for both early-career women and men STEM faculty, the effects are stronger for women faculty.

Does sex of the instigator matter?

We also propose that men are more likely than women to instigate ostracism and incivility toward women academics in STEM and that the negative effects of ostracism and incivility are worse when men compared to women instigate such behavior. Theories of social power and dominance help explain gender differences in the instigation and impact of workplace mistreatment on outcomes. At the core of social power and dominance theories (Brauer and Bourhis, 2006; Fiske and Berdahl, 2007; Magee and Galinsky, 2008) is inequity between groups, which allows the more dominant social group to exert their control and influence over the subordinate group. To do so, the dominant group often engages in acts of aggression and mistreatment toward the subordinate group to maintain and promulgate their power in that context. Because power is often distributed based on ascribed status characteristics such as gender, men have historically been afforded more social power as the dominant social group, leaving women as the disadvantaged subordinate group. Such power differences extend to the workplace making women vulnerable to male-instigated maltreatment, especially in contexts where men numerically dominate (Acker, 1990, 2006).

Indeed, meta-analytic research suggests that men are more likely to engage in interpersonal workplace mistreatment than are women (Hershcovis *et al.*, 2007). Britton's (2017) findings support this notion specifically for women in STEM. She found that women faculty were especially likely to experience chilly "sexist or clueless" (pg. 22) interactions with male colleagues compared to female colleagues. As such, we propose that men (the dominant group) are more likely than women (the subordinate group) to engage in ostracizing and uncivil treatment toward junior women in STEM. Consistent with minority stress theory (Meyer, 1995), we further propose that ostracism and incivility instigated by male colleagues is more harmful for early-career women STEM faculty than when instigated by female colleagues because such experiences act as signals to early-career women of their minority status in STEM. We therefore predict the following:

H4. Male colleagues are more likely to instigate ostracism and incivility toward junior women faculty in STEM than are female colleagues.

H5. Greater experiences of ostracism and incivility (from both male and female colleagues) are associated with negative well-being outcomes (lower levels of academic self-efficacy and positive future career perceptions and greater physical health ailments and psychological distress).

H6. Although greater experiences of ostracism and incivility from both male and female colleagues are associated with negative well-being outcomes, the effects are stronger when instigated by male colleagues than when instigated by female colleagues.

Study 1

Method

Participants and procedure. Study 1 included data from 96 early-career STEM faculty at TAMU. The majority of participants were male ($n = 54$, 56 percent) and white ($n = 79$, 82 percent) with other ethnicities reported as Latinx or Hispanic ($n = 10$, 10 percent), Asian American/Asian ($n = 9$, 9 percent), Native American ($n = 3$, 3 percent) and black/African/African American ($n = 3$, 3 percent). Roughly 10 percent of the sample was composed of women of color ($n = 10$). Participants' ages ranged from 27 to 52 with an average age of 36.35, and they had been employed at the university an average of 3.64 years. In total, 69 percent ($n = 66$) of participants reported they were US citizens.

Potential participants were invited via e-mail by the Dean of Faculties to participate in an Institutional Review Board (IRB) approved "Faculty Campus Climate and Satisfaction" online survey in 2009–2010. The e-mail consisted of a description of the study, information about research participants' rights, and a link to the survey. Participants were told that their responses would be confidential and that completion of the survey served as their consent to participate. After the first e-mail invitation, three reminder e-mails were sent out roughly two weeks apart to encourage participation.

Measures. The survey assessed faculty perceptions of their department, attitudes about the university, and well-being. Demographic and work information were also collected. Survey construction focused on minimizing response bias and utilizing valid and reliable measures. For example, occupational well-being measures appeared prior to questions about ostracism and incivility to allow for an impartial assessment of well-being. All scale scores were computed by taking the mean of items, after reverse coding any necessary items. Thus, for final scale scores, higher values reflect higher levels of the underlying construct.

Ostracism. Ostracism was measured with three items in the survey deemed to tap into the workplace ostracism construct (i.e. being ignored or excluded). Two items came from the Workplace Incivility Scale (WIS; Cortina *et al.*, 2001, 2013) and the third item came from

the Uncivil Workplace Behavior Questionnaire (Martin and Hine, 2005). Respondents were asked if they had experienced any of the behaviors from someone in their department in the past year using a response scale from 1 (never) to 5 (very often). The items included "ignored or excluded you from professional camaraderie," "ignored you or failed to speak to you (e.g. gave you 'the silent treatment')" and "failed to inform you of a meeting you should have been informed about." Cronbach's α for our measure of ostracism was 0.80.

Incivility. Incivility was measured using nine items from the WIS (Cortina *et al.*, 2001, 2013) which assessed the degree to which participants had been the target of rude or disrespectful behavior at work. Respondents were asked if they had experienced any of the behaviors from someone in their department in the past year using a response scale from 1 (never) to 5 (very often). Example items include "put you down or was condescending to you" and "made jokes at your expense." Cronbach's α for this measure was 0.87.

Occupational well-being. Occupational well-being was assessed with measures of turnover intentions and affective organizational commitment. Turnover intentions were measured using Porter *et al.*'s (1976) three-item measure. The items included "I often think about quitting this job," "I am actively looking for another job," and "I will probably look for a new job during the next year," to which participants responded using a response scale from 1 (strongly disagree) to 5 (strongly agree). Affective organizational commitment was measured with Allen and Meyer's (1990) eight-item affective commitment scale. Respondents indicated how strongly they agreed with each item using a response scale from 1 (strongly disagree) to 5 (strongly agree). Example items include "[This university] has a great deal of personal meaning for me" and "I do not feel 'emotionally attached' to [this university]" (reverse-coded). Cronbach's α for these measures were 0.86 and 0.88, respectively.

Results

Means, standard deviations, and intercorrelations for all Study 1 variables are presented separately for women and men in Table I. Ostracism and incivility, as well as ostracism and turnover intentions and turnover intentions and affective organizational commitment, were correlated for both women and men. Incivility was correlated with turnover intentions and affective organizational commitment for women but not for men.

H1 predicted that early-career women STEM faculty would report more experiences of ostracism and incivility than early-career men STEM faculty. We conducted independent samples t-tests to examine this hypothesis. Results for ostracism showed a marginally significant difference in the frequency of ostracism experienced by women ($M = 1.85$, $SD = 0.88$) compared to men ($M = 1.54$, $SD = 0.74$), such that early-career women in STEM reported more ostracism than did early-career men in STEM, $t(78) = -1.82$, $p = 0.07$, Cohen's $d = 0.39$. Results for incivility showed that there was a significant difference in the frequency of experienced incivility by women ($M = 1.75$, $SD = 0.54$) compared to men ($M = 1.51$, $SD = 0.61$), such that early-career women in STEM reported significantly

Variable	*M*	SD	1	2	3	4
1. Ostracism	1.85 (1.54)	0.88 (0.74)	–	0.83***	0.36*	−0.34*
2. Incivility	1.75 (1.51)	0.54 (0.61)	0.83***	–	0.43**	−0.32*
3. Turnover intentions	2.69 (2.56)	1.06 (1.05)	0.28*	0.26	–	−0.33*
4. Org. commitment	2.69 (2.95)	0.83 (0.73)	−0.16	−0.08	−0.51***	–

Notes: $n = 42$ for women and $n = 56$ for men. Means and standard deviations for men are in parentheses. Intercorrelations for men are shown below the diagonal and intercorrelations for women are shown above the diagonal. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table I.
Means, standard deviations, and intercorrelations for all study 1 variables

more incivility than early-career men in STEM, $t(91) = -2.05$, $p = 0.04$, Cohen's $d = 0.42$. Taken together, these results provide support for *H1*, showing that junior women faculty in STEM report more frequent experiences of ostracism and incivility compared to their male counterparts.

H2 predicted that greater experiences of ostracism and incivility would be associated with greater negative well-being outcomes (higher turnover intentions and lower affective organizational commitment) for both early-career women and for early-career men STEM faculty. We further predicted in *H3* that the effects would be stronger for women than for men. Because ostracism and incivility were highly correlated suggesting the possibility of multicollinearity, we conducted separate multiple regression analyses for the predictors separately for women and men to test *H2* and *H3*; Table II displays the results for these analyses. Results revealed that experiences of both ostracism and incivility predicted higher turnover intentions and lower affective organizational commitment for early-career women in STEM. There was only one significant effect for early-career men in STEM: experiences of ostracism predicted higher turnover intentions. As such, *H2* was partially supported, and *H3* was fully supported.

Because research shows that declines in affective organizational commitment precede turnover intentions (Holtom *et al.*, 2008; Meyer *et al.*, 2002), we conducted additional analyses examining affective organizational commitment as a mediator of chilly climate experiences and turnover intentions for women and men faculty. We analyzed the data using the PROCESS macro for SPSS (Hayes, 2017) with 5,000 bootstrapped samples. Results showed that affective organizational commitment mediated the relationship between ostracism and turnover intentions for women faculty ($\beta = 0.14$, SE = 0.08, 95% CI [0.01, 0.31]) but not for men faculty ($\beta = 0.08$, SE = 0.08, 95% CI [−0.09, 0.23]). However, affective organizational commitment did not mediate the relationship between incivility and turnover intentions for women faculty ($\beta = 0.22$, SE = 0.11, 95% CI [−0.01, 0.45]) or for men faculty ($\beta = 0.05$, SE = 0.09, 95% CI [−0.10, 0.25]).

Discussion

Findings for Study 1 revealed that junior women faculty in STEM reported experiencing more ostracism and incivility and were more harmed by those experiences compared to their male counterparts. Results also showed that lowered affective organizational commitment undergirded the relationship between experiences of ostracism and turnover intentions for junior women. In Study 2, we extend these findings in a separate sample of early-career women faculty in STEM by investigating the extent to which experiences of ostracism and incivility relate to two additional occupational well-being outcomes (academic self-efficacy and positive future career perceptions), as well as outcomes in two non-work domains: physical well-being (physical health ailments) and psychological

Table II.
Study 1 multiple regression results for female and male target experiences of ostracism and incivility

	Ostracism		Incivility	
	Turnover intentions	Organizational commitment	Turnover intentions	Organizational commitment
Female targets	0.36*	−0.34*	0.43**	−0.32*
R^2	0.13	0.12	0.18	0.10
F	5.94*	5.15*	8.62**	4.40*
Male targets	0.28*	−0.16	0.26	−0.08
R^2	0.08	0.03	0.17	0.01
F	4.12*	1.28	3.66	0.32

Notes: βs are standardized. *$p < 0.05$; **$p < 0.01$

well-being (psychological distress). We also examine the extent to which junior women STEM faculty differentially experience ostracism and incivility from their male and female colleagues and if those experiences dissimilarly relate to outcomes.

Study 2

Method

Participants and procedure. The data utilized for Study 2 came from 68 early-career women in STEM academic positions who participated in an online survey study assessing "junior academics' career success." The majority of the respondents ($n = 53$, 78 percent) were participants in one of five ADVANCE-IT-funded workshops that were conducted from 2012 to 2016 aimed at increasing the success of junior faculty women in STEM; the remaining participants had been nominated by workshop participants to complete in survey. The most common ethnicity reported by the respondents was white ($n = 39$, 57 percent), followed by Asian American/Asian ($n = 6$, 9 percent), black/African/African American ($n = 4$, 6 percent), Latina or Hispanic ($n = 4$, 6 percent), and Native American ($n = 1$, 2 percent). The rest of the sample did not provide a response ($n = 12$, 18 percent). Participants' ages ranged from 24 to 40 with an average age of 32.43. Most of the sample consisted of assistant professors ($n = 62$, 91 percent) and the remainder were visiting professors. The majority of the participants ($n = 41$, 62 percent) were employed at the university conducting the workshops and accompanying survey study.

All potential participants ($N = 126$, for a 54 percent overall response rate) were contacted via e-mail by an ADVANCE-IT co-investigator and member of the social science research team and invited to participate in the three-wave longitudinal IRB-approved study. Before completing each survey, participants read consent information including the purpose of the study and research participant rights. To incentivize the participation of non-workshop participants, we offered nominees $20 for their participation at each wave. Consent was considered given if participants completed the survey. Because of high attrition numbers, only data from each participant's first survey were included in the present study. Thus, all participants completed the same survey but potentially in different years. In addition, if participants completed more than one survey (which was rare) over the three years for their cohort, we only included data from their first survey.

Measures. The survey contained scales assessing experiences of ostracism and incivility from male and female coworkers, attitudes, and health and well-being. Demographic and work information was also collected. Survey construction focused on minimizing response bias and utilizing valid and reliable measures such that outcome measures appeared prior to questions about ostracism and incivility to allow for an unbiased assessment of well-being. All scale scores were computed by taking the mean of items, after reverse coding any necessary items. Thus, for final scale scores, higher values reflect higher levels of the underlying construct. As mentioned above, data were collected in different waves, from 2012 to 2016, and individuals were asked to respond to three survey time points (the initial survey, and two subsequent years later). Thus, in order to compute scale scores, data from the first time an individual responded were used, which could have been in any year from 2012 to 2016. Thus, we have included the mean reliability over the five-year time period to give an estimate of the scale reliability.

Ostracism from male and female colleagues. Ostracism was measured using a modified version of Ferris *et al.*'s (2008) workplace ostracism scale. Respondents were presented with a series of six statements and asked if they experienced any of the behaviors from each of two sources (male colleagues and female colleagues) in their present job using a five-point response scale from 1 (never) to 5 (very often). Example statements include "Treat you as if you are invisible" and "Keep you out-of-the-loop on information that

is important." The mean reliability for the ostracism from male colleagues scale across years was 0.93, and the mean reliability for the ostracism from female colleagues scale across years was 0.94.

Incivility from male and female colleagues. Incivility was measured using the seven-item version of the WIS (Cortina *et al.*, 2001). Respondents were asked to report the extent to which they had experienced any of the behaviors from each of two sources (male colleagues and female colleagues) in their present job using a five-point response scale from 1 (never) and 5 (very often). The mean reliability for the incivility from male colleagues scale across years was 0.91, and the mean reliability for the incivility from female colleagues across years was 0.90.

Well-being outcomes. Well-being was assessed with measures of academic self-efficacy and future career perceptions (occupational well-being), physical health ailments (physical well-being) and psychological distress (psychological well-being).

Academic self-efficacy was measured using a series of nine statements created for the present study. Respondents were asked to rate their confidence in their ability to perform routine academic duties related to research, teaching, and mentoring using a response scale from 1 (not confident at all) to 5 (very confident). Example items include "present your research ideas orally or in written form to your colleagues," "effectively prepare a teaching lesson/lecture," and "mentor undergraduate students." The mean reliability of academic self-efficacy scale across years was 0.81.

Future career perceptions were measured using a series of 20 statements from Lyness and Thompson's (2000) Perceived Barriers and Facilitators to Advancement Scale. Respondents were asked to rate the perceived likelihood of 6 "barriers" and 14 "facilitators" of a future career in their discipline for someone of their gender using a response scale from 1 (extremely unlikely) to 5 (extremely likely). Example items include "Getting access to opportunities," "Receiving enough meaningful feedback about your strengths and weaknesses," and "Feeling like you are held to a higher standard than others" (reverse-coded). The mean reliability for this measure across years was 0.91.

Physical health ailments were measured with seven items from the Physical Symptom Inventory (Spector and Jex, 1998) which assesses physical, somatic health symptoms. Respondents were asked to indicate the extent to which they experienced the ailments (e.g. "headache," "an upset stomach or nausea," "trouble sleeping") in the previous year using a 1 (never) to 5 (once a week or more) response scale. The mean reliability for this measure across years was 0.74.

Psychological distress was assessed with nine items from the Brief Symptoms Inventory (Derogatis and Spencer, 1983) which includes three subscales (anxiety, hostility, and depression). Respondents were asked how much in the past week, symptoms such as "nervousness or shakiness inside," "feeling easily annoyed or irritated," and "feeling blue" had bothered them using a response scale that ranged from 1 (not at all) to 5 (extremely). The mean reliability for psychological distress scale across years was 0.85.

Results

Means, standard deviations and intercorrelations for all Study 2 variables are presented in Table III. Ostracism and incivility from male colleagues were correlated with all of the well-being outcome measures with one exception: incivility from males was not related to physical health ailments. Ostracism and incivility from female colleagues were both correlated with psychological distress; ostracism from females was also related to lower academic self-efficacy and less positive future career perceptions. The well-being outcomes were all significantly correlated.

H4 predicted that male colleagues would be more likely to instigate ostracism and incivility toward junior women faculty in STEM than female colleagues. To test this hypothesis, paired samples *t*-tests were run comparing experiences of ostracism and incivility from male and female colleagues. Results for ostracism showed that there was a significant difference in the frequency of ostracism experienced from male ($M = 1.97$, $SD = 0.99$) and female ($M = 1.61$, $SD = 0.79$) colleagues, such that respondents reported significantly more ostracism from male colleagues than from female colleagues, $t(62) = 3.11$, $p = 0.003$, Cohen's $d = 0.39$. Results for incivility showed that there was also a significant difference in the frequency of experienced incivility from male ($M = 1.93$, $SD = 1.01$) and female ($M = 1.63$, $SD = 0.67$) colleagues such that respondents reported significantly more incivility from male colleagues than from female colleagues, $t(62) = 2.21$, $p = 0.03$, Cohen's $d = 0.28$. These results provide support for *H4*, showing that junior women faculty in STEM report more frequent experiences of ostracism and incivility from their male colleagues than their female colleagues.

H5 predicted that greater experiences of ostracism and incivility (from both male and female colleagues) would be associated with negative well-being outcomes (lower levels of academic self-efficacy and positive future career perceptions and greater physical health ailments and psychological distress). We conducted a series of multiple regression analyses to test *H5* with all mistreatment variables being entered simultaneously; Table IV displays the findings. Results revealed that ostracism from male colleagues predicted lower academic self-efficacy, less positive future career perceptions, and heightened psychological distress. Ostracism from male colleagues was not related to physical health ailments. Incivility from male colleagues was also related to lower academic self-efficacy and less positive future career perceptions. In contrast, ostracism and incivility from female colleagues did not predict any of the outcome variables. Thus, *H5* was only partially supported as subtle interpersonal mistreatment from female colleagues did not predict negative well-being.

Variable	*M*	SD	1	2	3	4	5	6	7
1. Ostracism from males	1.90	0.98							
2. Incivility from males	1.93	1.35	0.57***						
3. Ostracism from females	1.60	0.74	0.49***	0.56***					
4. Incivility from females	1.65	0.73	0.28*	0.22	0.54***				
5. Academic self-efficacy	3.78	1.11	−0.59**	−0.57***	−0.27*	−0.14			
6. Future career perceptions	3.18	0.83	−0.70***	−0.58***	−0.26*	−0.19	0.83***		
7. Physical health ailments	3.15	0.83	0.29*	0.16	0.16	0.12	−0.36**	−0.34**	
8. Psychological distress	2.09	0.94	0.55***	0.42**	0.39**	0.29*	−0.69***	−0.64***	−0.48***

Notes: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table III.
Means, standard deviations, and intercorrelations for all study 2 variables

	Academic self-efficacy	Future career expectations	Physical health ailments	Psychological distress
Ostracism from males	−0.45**	−0.61***	0.28	0.42**
Incivility from males	−0.41**	−0.36**	−0.03	0.11
Ostracism from females	−0.09	0.24****	−0.06	0.14
Incivility from females	0.18	−0.01	−0.04	−0.03
Total *R*	0.69	0.76	0.29	0.57
Total R^2	0.47	0.57	0.08	0.32
F	12.48***	18.83***	1.29	6.59***

Notes: βs are standardized. **$p < 0.01$; ***$p < 0.001$

Table IV.
Study 2 multiple regression results for ostracism and incivility from male and female instigators

Finally, *H6* predicted that the negative effects of ostracism and incivility would be stronger when instigated by male colleagues than when instigated by female colleagues. As shown in Table IV and described above, there were no significant effects of ostracism or incivility from female colleagues on well-being. As such, *H6* was fully supported.

Based on the literature on academic self-efficacy and STEM career attainment for women (Buse *et al.*, 2013; Jaeger *et al.*, 2017), we also conducted several follow-up analyses examining academic self-efficacy as a mediator of the relationship between working in a chilly interpersonal climate and well-being outcomes. We analyzed the data using the PROCESS macro for SPSS (Hayes, 2017) with 5,000 bootstrapped samples. Results showed that academic self-efficacy mediated the relationship between ostracism from male colleagues and lowered positive future career perceptions ($\beta = -0.35$, SE = 0.08, 95% CI [−0.50, −0.17]) and ostracism from male colleagues and psychological distress ($\beta = 0.31$, SE = 0.12, 95% CI [0.09, 0.55]). Academic self-efficacy also mediated the relationship between incivility from male colleagues and future career perceptions ($\beta = 0.35$, SE = 0.10, 95% CI [0.12, 0.51]).

Discussion

Findings for Study 2 revealed that junior women faculty in STEM reported experiencing significantly more ostracism and incivility instigated by their male colleagues than by their female colleagues. Findings also showed that ostracism instigated by male (but not female) colleagues (and to a lesser extent incivility instigated by male but not female colleagues) was the best predictor of negative well-being outcomes (lowered academic self-efficacy and positive future career perceptions and heightened psychological distress) for junior women faculty in STEM. Academic self-efficacy also mediated several of the relationships between chilly interpersonal experiences with male colleagues and well-being.

General discussion

Research shows that women are less likely to enter and more likely to exit academic STEM positions compared to men (Bilimoria and Liang, 2012; Demos *et al.*, 2014; Rosser, 2004; West and Curtis, 2006) and that the greatest losses occur early in the career trajectory (Lichtenstein *et al.*, 2014). The purpose of the present research was to investigate chilly interpersonal climates as a possible explanation for this discrepancy. In Study 1, we examined gender differences in experiences of working in chilly climate – as indicated by experiences of ostracism and incivility – for junior women and men faculty in STEM; we also examined how those experiences related to two occupational well-being outcomes. In Study 2, we built on these findings by investigating the extent to which junior women faculty in STEM differentially experience ostracism and incivility from their male and female colleagues and how those experiences affected not only occupational well-being outcomes but physical and psychological well-being as well. Both studies utilized data collected as part of the social science research component of TAMU's ADVANCE-IT grant.

We tested three hypotheses in Study 1: early-career women STEM faculty report more experiences of ostracism and incivility than early-career men STEM faculty; greater experiences of ostracism and incivility are associated with greater negative occupational well-being outcomes (higher turnover intentions and lower affective organizational commitment); and the effects of ostracism and incivility on outcomes are stronger for junior women faculty than for junior men faculty. Largely consistent with our hypotheses, junior women faculty in STEM reported more frequent experiences of ostracism and incivility compared to their male counterparts. Moreover, whereas men reported greater turnover intentions with higher levels of ostracism, both ostracism and incivility predicted both greater turnover intentions and lowered affective organizational commitment for women.

Thus, early-career women in STEM not only experienced their workplace as interpersonally chillier than early-career men in STEM, but they were also more harmed by it.

We extended these findings in Study 2 by testing three additional hypotheses: junior women faculty in STEM report more ostracism and incivility instigated by their male colleagues compared to their female colleagues; greater experiences of ostracism and incivility are associated with negative well-being outcomes (lowered academic self-efficacy and positive future career perceptions and greater physical health ailments and psychological distress); and the effects of ostracism and incivility on outcomes are stronger when instigated by male colleagues compared to female colleagues. These hypotheses were also largely supported; participants reported experiencing an interpersonally chiller climate from their male colleagues than from their female colleagues and were more negatively affected by it when they did. Specifically, participants reported more ostracism and incivility from their male colleagues than from their female colleagues. They also reported lower academic self-efficacy and positive future career perceptions the more they experienced ostracism and incivility instigated by their male colleagues; greater experiences of ostracism instigated by male colleagues was also associated with more psychological distress. Experiencing mistreatment from male colleagues was not related to physical health ailments. Finally, none of the well-being outcomes were related to experiences of ostracism or incivility instigated by female colleagues.

Advancing past research on chilly climates for women in STEM, our findings suggest that junior women faculty in STEM experience an interpersonally chillier climate compared to junior men faculty in STEM and that working in a such a climate has important implications for junior women's occupational and psychological well-being, especially when they have chilly interpersonal experiences with male colleagues. These findings offer a potential explanation for the underrepresentation of women academics in STEM and why women STEM faculty may leave at an earlier and more consistent rate than men. These finding are also wholly consistent with theories of chronic stressors (Lazarus and Folkman, 1984), minority stress (Meyer, 1995), and social power and dominance (Brauer and Bourhis, 2006; Fiske and Berdahl, 2007; Magee and Galinsky, 2008). For example, the findings that women faculty experienced more ostracism and incivility than men faculty and reported more ostracism and incivility instigated by male compared to female colleagues lends support to the theoretical proposition that women, because of their subordinate status in society, are particularly likely to experience maltreatment, especially from men who hold dominant status in society (Brauer and Bourhis, 2006; Fiske and Berdahl, 2007; Magee and Galinsky, 2008). That women faculty were also more negatively affected than men faculty when they were targets of such behavior and more harmed when they were targeted by male colleagues than female colleagues suggests that women's minority status in society makes them vulnerable to the chronic wear and tear associated with mistreatment, particularly in contexts where they are underrepresented (Lazarus and Folkman, 1984; Meyer, 1995). Finally, our findings also contribute to research on APA's PHW (Grawitch and Ballard, 2016), the framework used as the foundation for the ADVANCE-IT awarded to TAMU where the research was conducted, by documenting the important role interpersonal workplace relationships have on the health and well-being of employees.

Practical implications

Results from the present research showed that chilly interpersonal experiences with colleagues (particularly male colleagues) were associated with negative occupational and psychological well-being outcomes for junior women in STEM. Like other ADVANCE-related efforts, the present research documents that subtle gender biases in interactions are critical to the recruitment, promotion, and retention of women faculty in STEM academia.

The ADVANCE community of scholars has investigated and identified a number of potential interventions that may be helpful for addressing and lessening the chilly interpersonal treatment experienced by early-career women in STEM. Indeed, research shows that efforts aimed at making interpersonal interactions less gendered is one of the most common interventions ADVANCE institutions have instituted to address gender equity in STEM (e.g. Morimoto *et al.*, 2013). We review several of these interventions here. First, universities might institute workshops that specifically address subtle negative interpersonal behavior and how such interactions are often gendered. Bird (2011) reported findings from an ADVANCE-related intervention strategy to raise awareness among faculty and administrators about subtle interpersonal gender barriers to women's advancement in academe. The intervention used a case-study approach where participants discussed situations (e.g. a junior female faculty member being excluded from male colleagues' information networks about tenure and promotion) involving STEM academicians that had unanticipated gender effects favoring men and problem solved how the rectify them. She reported that most men in the workshop initially did not perceive the situations as gendered but through discussion became committed to understanding and learning more about the issues and the larger transformation effort. Moreover, the participants engaged in practices after the workshop demonstrating this commitment. A case-study workshop approach could also be used to address other aspects of chilly interpersonal climates for women faculty in STEM (e.g. being disparaged) and how they affect junior women's well-being.

Second, universities might provide opportunities for junior women faculty in STEM to build their interpersonal relationships with colleagues. Such opportunities could be explicit or part of a larger initiative. For example, Smith *et al.* (2017) described a grant-writing "bootcamp" that focused in part on building meaningful connections with others that was created as part of their university's ADVANCE. The bootcamp was specifically developed to engage and fulfill three critical psychological needs – autonomy, competence and relatedness – as proposed by self-determination theory (Deci and Ryan, 2000). Most relevant here, relatedness refers to the experience of connection, caring, and involvement with other people (Deci and Ryan, 2012). They addressed the relatedness component by creating small groups of faculty to work together on a common-interest grant proposal; group members included both junior faculty and faculty who had an established and successful record of securing funding. Not only did the bootcamp participants receive more grant funding compared to a sample of matched faculty, but they also reported that the bootcamp supported and fostered feelings of relatedness. Universities could implement similar common-goal interventions to build interpersonal connections and relationships among STEM faculty members.

ADVANCE institutions have also implemented relationship-building interventions such as workshops to promote collegiality through a departmental Dialogues process (Holmes *et al.*, 2016; Latimer *et al.*, 2014), develop networks to challenge existing policies and practices that limit women (Rankin *et al.*, 2007), increase the number of professional connections untenured women have with distinguished scholars outside the institution (Dyer and Montelone, 2007) and develop interconnections across multiple levels of the university (Realff *et al.*, 2007). Laursen and Austin (2014) summarize numerous other interventions aimed at developing faculty interpersonal connections and creating climates that are more hospitable for women in STEM. Together, these efforts have proved helpful in addressing the negative differential interpersonal treatment women faculty experience in STEM contexts.

Limitations and future directions

The present research has a number of limitations that offer directions for future research. For example, the cross-sectional nature of the data renders causal inferences about the relationships among variables tentative until they can be replicated using longitudinal or experimental designs. That is, we cannot say definitively that working in chilly climate

causes declines in occupational and psychological well-being for early-career STEM women faculty. It may be, for example, that having greater turnover intentions causes women to perceive their workplace climate as particularly chilly. Note, however, that we based our hypotheses on theoretical work (Grawitch and Ballard, 2016; Lazarus and Folkman, 1984; Meyer, 1995) suggesting the proposed causal order of the variables. Even so, it would be fruitful for future research to track chilly climate experiences and related outcomes for tenure-track STEM faculty over time or to experimentally manipulate chilly workplace interactions to make more definitive conclusions about how cold interpersonal environments affect early-career women in STEM.

The data were also single-source and self-reported, and are therefore susceptible to perceptual biases. Thus, we cannot know conclusively if junior women in STEM actually experienced a chillier workplace climate compared to junior men in STEM or that junior women in STEM actually had chillier workplace interactions with male colleagues compared to female colleagues. Nevertheless, we maintain that perceptions are necessary to understanding individual outcomes, because it is individuals' perceptions of their environment that determine how they are affected by and respond to it. Perceptions also need not agree with others' perceptions in the same environment to be meaningful because each individual's environment may be distinct and not necessarily shared with others. It would be fruitful, however, for future research to examine bystander (e.g. colleagues) reports of ostracism and incivility toward junior women STEM faculty to help address some of the problems inherent in single-source self-report assessments.

Our findings were also primarily based on the experiences of faculty at a predominantly White research-intensive public university in the southern USA. Thus, concerns may arise about the generalizability of results to other academic STEM contexts. Moreover, our samples included faculty who were currently employed at the university and does not represent the experiences of those who may have left for industry or other academic positions, perhaps because of their chilly interpersonal climate experiences. Indeed, faculty who may have encountered the most ostracism and incivility may have left the university, or academia altogether, before the data were collected. Future research should investigate experiences of working in chilly interpersonal climates for early-career STEM faculty in other academic settings such as those that are teaching intensive, private, in other regions of the USA, and more diverse. It would also be worthwhile to sample faculty who had left the university for other opportunities perhaps through exit interviews or online surveys about the extent to which working in a chilly climate was a factor in their departure.

Finally, because of our small sample sizes, we were unable to examine the intersection of gender with other identities such as race, ethnicity, or nationality. Given that women of color are particularly underrepresented in STEM faculty positions a focus on intersectionality is critical for understanding how STEM women faculty of color may be differentially targeted and affected by working in chilly interpersonal climates (Smith and Calasanti, 2005). As such, we encourage future research to investigate the interpersonal experiences of women of color in STEM academic contexts. Examinations of how gender intersects with sexual orientation, ability, social class, parenting status, and other dimensions of inequality to affect chilly climate experiences for STEM women faculty would also be beneficial (Acker, 2006; Armstrong and Jovanovic, 2015; Hunt *et al.*, 2012; Morimoto and Zajicek, 2014).

Conclusion

The present research was conducted as part of the social science research component of an NSF ADVANCE-IT grant awarded to TAMU in 2010. The purpose of this specific project was to examine the extent to which early-career women STEM faculty experience working

in an interpersonally chilly climate (as indicated by experiences of ostracism and incivility) and how those chilly experiences relate to a host of work and non-work well-being outcomes. In the first study, we found that junior women STEM faculty reported greater experiences of ostracism and incivility compared to junior men STEM faculty and that these experiences related to more negative occupational well-being outcomes (heightened turnover intentions and lowered affective organizational commitment) for women. In the second study, we found that early-career women in STEM experienced more ostracism and incivility from their male colleagues than from their female colleagues. Results also revealed that experiences of ostracism (and to a lesser extent, incivility) from male colleagues related to more negative occupational (lowered academic self-efficacy and positive future career perceptions) and psychological (greater psychological distress) well-being outcomes. Together, our findings suggest that junior women faculty in STEM experience an interpersonally chillier climate compared to junior men faculty in STEM and that working in such a climate has consequences for junior women's well-being especially when they have chilly interpersonal experiences with male colleagues. These findings suggest that exposure to a chilly climate and its effects may be an important explanation for the lack and withdrawal of women in STEM academic fields. They also point to the importance of organizational interventions focused on developing STEM faculty interpersonal relationships and connections as a means to address such interactions.

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Unclogging the pipeline: advancement to full professor in academic STEM

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Abstract

Purpose – Women remain underrepresented in academic STEM, especially at the highest ranks. While much attention has focused on early-career attrition, mid-career advancement is still largely understudied and undocumented. The purpose of this paper is to analyze gender differences in advancement to full professor within academic STEM at a mid-size public doctoral university in the western USA, before and after the National Science Foundation (NSF)-ADVANCE Program (2003–2008).

Design/methodology/approach – Using faculty demographics and promotion data between 2008 and 2014, combined with faculty responses to two waves of a climate survey, the magnitude and longevity of the impact of ADVANCE on mid-career faculty advancement across gender is evaluated.

Findings – This study documents increased representation of women in all ranks within the STEM colleges, including that of full professor due to ADVANCE efforts. It also demonstrates the role of greater gender awareness and formalization of procedures in reducing the variability in the time as associate professor until promotion to full professor for all faculty members, while also shrinking gender disparities in career attainment. As a result of the codification of the post-tenure review timeline toward promotion, more recently hired faculty are promoted more swiftly and consistently, irrespective of gender. Post-ADVANCE, both male and female faculty members express a greater understanding of and confidence in the promotion process and no longer see it as either a hurdle or source of gender inequality in upward career mobility.

Research limitations/implications – While data were collected at a single university, demographics and career experiences by women mirror those at other research universities. This study shows that within a given institution-specific governance structure, long-lasting effects on faculty career trajectories can be achieved, by focusing efforts on creating greater transparency in expectations and necessary steps toward promotion, by reducing barriers to information flown, by standardizing and codifying the promotion process, and by actively engaging administrators as collaborators and change agents in the transformation process.

The initial data collection was funded through the NSF-ADVANCE program (NSF No. SBE-0244922). Funding for the 2016 faculty survey was provided by the USU Center for Women and Gender, the College of Science and the Department of Sociology, Social Work and Anthropology at Utah State University. The authors give many thanks to Paul Jacobs and Ace Beorchia for their assistance with the administration and analysis of the survey.

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Originality/value – This study addresses mid-career dynamics and potential mechanisms that explain gender gaps in the promotion to full professor, a largely understudied aspect of gender disparities in career attainment within STEM. It shows how institutional policy changes, intended to alleviate gender disparities, can benefit the career trajectories of all faculty members. Specifically, this study highlights the crucial role of codifying procedures and responsibilities in neutralizing subjectivity and inconsistencies in promotion outcomes due to varying departmental climates.

Keywords Academia, Policy, Promotion, STEM, Glass ceilings, Gender inequality

Paper type Research paper

Introduction

Women have been entering academic STEM disciplines in increasing numbers since the 1980s (Burelli, 2008), yet they remain underrepresented at the senior ranks (Long and Fox, 1995; Valian, 1999; Mason *et al.*, 2013). The National Science Foundation (NSF) ADVANCE program was initiated in 2001 with the specific goal of developing strategies to increase the representation and advancement of women in science and engineering disciplines at institutions of higher education (IHE) in the USA. This paper analyzes gender differences in the rate of advancement to full professor within academic STEM at a mid-size public doctoral university in the western USA, before and after participation in the NSF-ADVANCE Program (2003–2008). Using quantitative personnel data augmented with findings from two waves of a faculty climate survey, we investigate the magnitude and longevity of the impact of ADVANCE on mid-career faculty advancement across gender.

The pattern of declining representation of women up the academic STEM ladder is frequently compared to a "leaky pipeline" (Goulden *et al.*, 2011). Some scholars attribute this progressive filtering of women scientists out of academic STEM solely to supply side factors, such as early self-selection into/out of science, individual career choices away from academia, lack of motivation or lower success by women (Ceci and Williams, 2011; Ceci *et al.*, 2014). An alternative metaphor, that of the "clogged pipeline," might be more apt in describing the slower upward mobility of mid-career women. Due to structural barriers or institutional practices that create chilly working conditions or put women at an evaluative disadvantage, women's advancement into these higher ranks is slowed or stalled, causing some to leave academia before reaching the full professor rank (Cech and Blair-Loy, 2010; Goulden *et al.*, 2011). If significant gender gaps in mid-career advancement indeed exist, they are particularly puzzling since women scientists possess the human capital to be hired (Glass and Minnotte, 2010; Williams and Ceci, 2015) and have successfully navigated the tenure process – the first critical gatekeeping event where significant faculty attrition takes place (Ceci *et al.*, 2014).

Creating a balanced gender representation at all levels in STEM is important as it contributes to the diversity of thinking and innovation in the sciences (Rosser, 2004). Women's advancement also maintains our scientific competitiveness worldwide by providing role models that entice young talent, especially underrepresented groups, to become part of the domestic, highly trained, scientific labor force (Rosser, 2004; Goulden *et al.*, 2011). Within academia, career support for women faculty at all ranks also serves as an important mechanism for achieving gender equity in leadership and administrative positions as administrators are drawn from among tenure-track faculty ranks. This in turn engenders diversity in thinking and management style, instrumental in the recruitment and retention of a diverse faculty corps.

With a few exceptions (e.g. Sabatier *et al.*, 2006; van den Brink and Benschop, 2011; Britton, 2017), the majority of studies on gender gaps in career attainment within academic STEM have focused on early career, particularly personal challenges and institutional barriers to women faculty's success in attaining tenure (e.g. Goulden *et al.*, 2011). There has been much less focus on mid-career dynamics and potential gender gaps in the promotion to full professor, especially for the USA (Britton, 2010, 2017). The objective of this paper is to

fill this knowledge gap by conducting a quantitative analysis of gender differences in the average time to promotion from associate to full professor at a single doctoral research university in the western USA before and after the implementation of the NSF-funded ADVANCE project. This university is representative of many IHE with a strong research emphasis and where research productivity plays a key role in the promotion process. It was also one the early participants in the ADVANCE program, allowing us a longer retrospective timeframe to evaluate the program's impact. We were particularly interested to determine the existence and size of the gender gap in career advancement prior to ADVANCE and whether there was a lasting post-ADVANCE impact on mid-career mobility for women. Our analysis provides valuable insights into which institutional practices are effective in mitigating gender differences in career attainment among STEM faculty. Our findings also identify practices that yield positive outcomes that are sustainable in the long term even in the more competitive environment associated with research universities, where gender disparities at the highest ranks appear more acute (West and Curtis, 2006; Bakian and Sullivan, 2010; Britton, 2017). Thus, our findings can provide guidance to other universities that face similar challenges.

The underrepresentation of women across ranks in academic STEM is undisputed, but potential causes for this phenomenon or the best approach to normalize women's movement up the academic ladder are still the subject of considerable debate. One viewpoint, framed around the belief in academia as an objective gender-blind meritocracy, focuses on innate individual traits or personal choices and decisions (e.g. family formation) to explain divergent career outcomes, without considering the institutional context that may influence these choices and career trajectories (e.g. Ceci *et al.*, 2014). Scientific achievement, the cornerstone of academic success, according to this point of view, is judged against objective criteria and with quantitative metrics, irrespective of gender. If some women are less successful it is because they are simply less productive, divert their attentions elsewhere or choose to not fully commit to their careers (Ceci *et al.*, 2014). And, after controlling for productivity and personal or family characteristics, there is no evidence of gender bias in academic career attainment (Ceci *et al.*, 2014). Thus, according to this "women as deficient" model, to fix the problem we need to fix the women (Rosser, 2004).

Of course, meritocracy as a concept in itself is vulnerable to critique as the reliance on seemingly "objective" criteria in the evaluations of a scientist's cumulative accomplishments does not automatically translate into gender-neutral decisions (Acker, 2006; O'Connor and O'Hagan, 2016). Universities are gendered organizations in that judgments on what constitutes scientific quality or what activities are deemed valuable often reflect implicit bias along gender lines (van den Brink and Benschop, 2011). The image of the ideal scientist continues to be framed around largely masculine characteristics, such as competitiveness and complete dedication to the job, yet are presented as gender-neutral (Acker, 1990; Cech and Blair-Loy, 2010). This puts women at an evaluative disadvantage as lacking competence or commitment. Evaluation criteria are often unevenly applied in academia (O'Connor and O'Hagan, 2016), and according to Foschi (1996, 2006), assessments of ability are often influenced by the social status of the performer, leading to double standards in performance evaluations. Because men enjoy a higher social status than women, this tendency leads to the systemic downplaying of the accomplishments or competence of women even if there is no objective or measurable difference in ability between men and women. Numerous studies have demonstrated how gender bias in evaluation influences hiring and advancement decisions that lead to divergent career outcomes for men and women scientists. This dynamic has been observed at all career stages, from the hiring of lab managers with undergraduate degrees (Moss-Racusin *et al.*, 2012) to the recruitment and promotion of associate and full professors (van den Brink and Benschop, 2011; Nielsen 2016). It also has been reported in teaching evaluations of academics (MacNell *et al.*, 2015),

for invites to prestigious colloquia at top universities (Nittouer *et al.*, 2018) and other forms of recognition that contribute to the construction of excellence (van den Brink and Benschop, 2011; O'Connor and O'Hagan, 2016).

It is not uncommon to find statements in the STEM literature regarding the lower productivity of women (see citations in Leahey, 2007 and Ceci *et al.*, 2014) – a contention that is not entirely undisputed (Cameron *et al.*, 2016) – that are then invoked as a supply side explanation for slower advancement (Ceci *et al.*, 2014). Such claims often lack the further exploration of structural or institutional conditions that may have caused differences in productivity between men and women faculty, such as academic division of labor and high demands for non-research activities, exclusion from information and collaboration networks or limited mobility due to family obligations (Rosser, 2004). However, parallel studies in the USA and Europe, using an array of productivity metrics of early-career (Weisshaar, 2017) and mid-career academics (van den Besselaar and Sandström, 2016), concluded that differences between men and women's career advancement are often not explicable on the basis of differences in productivity, but are due to other factors, including gender bias in the hiring and promotion process of academic staff.

In recent years, significant evidence supports the conclusion that institutional barriers have prevented women from having a level-playing field, and that the scarcity of women in the upper levels of academia is less than the result of their individual failure than a consequence of systemic barriers present within academic settings (Rosser, 2004). The NSF-ADVANCE Program, which supported research into the recruitment, retention and advancement of women in STEM, reflects this sea change in perspective at the national level. The program was initiated in 2001 specifically to clarify structural barriers and seek institutional solutions to the underrepresentation of women in the STEM disciplines (Stewart *et al.*, 2007).

The ADVANCE program

Our university was part of the second wave of NSF Transformational Grants funding and shares many of the programmatic components and study approaches with other early ADVANCE projects (Stewart *et al.*, 2007). Among the various goals of the NSF-ADVANCE project at this university (2003–2008), three aspects were particularly pertinent to the mid-career advancement issue: data transparency, i.e., the development of a demographic database to provide an objective and tractable record of the gender distribution among faculty ranks over time; awareness and intervention through workshops, panel discussions and departmental meetings sanctioned by the university administration and intended to provide information to all faculty on the promotion process; and policy changes such as clarifying post-tenure review in the faculty policy, which at this university contains a detailed delineation of all policies and procedures specifically related to faculty.

The ADVANCE team began tracking faculty data in 2002 and was instrumental in compiling and digitizing the initial faculty database in 2007 for STEM, as no centralized accessible digital database of university personnel was available prior to this date. Maintenance and annual update of this university-wide database has been institutionalized since then and is now under the purview of the Office of Analysis, Assessment and Accreditation (AAA). The centralized collection, maintenance and annual update of this database has enabled the objective reporting of the proportion of women (and racial/ethnic minorities) in various tenure and non-tenure track faculty and leadership positions, and has allowed us to quantify longitudinal changes in faculty composition. Data tracking has been identified by other institutional analyses as one of the key mechanisms supporting institutional transformation as data transparency allows the identification of the problems related to gender representation and provides indicators by which to monitor progress toward institutional goals and effectiveness of interventions (Rosser and Chameau, 2006; Frehill, 2007; Stewart *et al.*, 2007; Correll, 2017).

A second component of this ADVANCE project focused on improving tenure and promotion processes by creating greater transparency in institutional practices. Secrecy or ambiguity surrounding performance expectations, lack of clear guidelines and misinformation with regards to promotion decisions has emerged as a common theme in numerous other ADVANCE studies (Sturm, 2006; Frehill, 2007; Stewart *et al.*, 2007; Banerjee and Pawley, 2013). Codified university policies related to faculty at this university, hereafter referred to as "Faculty Policy," describe the composition and authority of the faculty (including definitions of categories, academic units and department heads); define the Faculty Senate and purview of its committees; define tenure, eligibility, the probationary period for tenure; and faculty search procedures as well as due process and complaint procedures. While Faculty Policy clearly outlined processes and procedures for tenure, processes related to promotion from associate to full professor were less clear. Information on the steps toward promotion to full professor were generally less formalized and were conveyed mostly informally through (largely male) social networks, rather than transparently and systematically to all faculty through codification in Faculty Policy.

The ADVANCE team identified five departments (at least one from each of the four STEM colleges) that were willing to work with ADVANCE to reflect on and improve gendered interactions. An outside organizational consultant who had previously worked with business organizations on gender issues, and one ADVANCE team member first interviewed the majority of faculty in each department. The ADVANCE team identified promotion as a significant problem through interviews with STEM women who expressed frustration about the opaqueness of the promotion process, exemplified by statements such as "This University/College/Department does a good job of mentoring faculty through tenure […]. After tenure no one talks to you again." Such statements were often followed by comments about not knowing how to decide when to go forward for promotion.

In addition, ADVANCE conducted department climate surveys to further identify perceived barriers to faculty, especially women's success and to quantify metrics of departmental climate quality. Hiring rates of women vs men over the previous five years were also tracked and presented within the context of national graduation rates of PhDs within each department's discipline. ADVANCE worked to modify the academic culture by working with search committees to improve gender balance in the candidate pools and decrease bias in candidate selection. Departmental and university-wide workshops and panel discussions were held to provide information to all faculty members on expectations and actual steps in the promotion process, thus creating much-needed transparency especially with respect to the promotion to full professor. In addition to increasing the transparency of the promotion process, the USU ADVANCE Program provided small grants to faculty members preparing for promotion to full professor. These were not continued beyond the award period.

In response to faculty feedback regarding missing guidelines on promotion review initiation, ADVANCE drafted and guided policy changes through the Faculty Senate approval process. Faculty Policy changes were implemented in 2005 that more clearly codified the post-tenure review procedures. Specifically, the Faculty Policy now stipulates that no later than three years after tenure (or earlier at the request of the tenured faculty member), a post-tenure review committee must be assigned to each faculty member. This committee must meet with associate professors at least once within the first three years after tenure to "provide guidance to the faculty member relative to the criteria for promotion to professor." This formalization of the post-tenure review timeline ensures that accomplishments of all tenured faculty members are reviewed in a timely manner and that evaluations of faculty portfolios are framed within the context of potential promotion.

During the ADVANCE program, the university administration was characterized by high turnover, with nine individuals serving in the three upper administrative positions closely collaborating with the ADVANCE program (president, provost and vice provost for

faculty and academic affairs) and ten individuals serving as deans in the four STEM colleges. Administrators varied in their support of the ADVANCE Program and frequent turnover of positions made it difficult for the program to find consistent support. The economic recession severely disrupted university operations and occupied the time and effort of administrators in 2007 and 2008. Consequently, implementation of this post-tenure review policy was sometimes inconsistent during leadership transitions, but more recent provosts have shown a commitment to working with departments to ensure the consistent implementation of this policy.

Methods

This study used secondary faculty data (AAA census data) for 2008 and 2014, including college, gender, date and rank at hire and dates of promotion. During the ADVANCE project, promotion rates prior to 2008 were extracted from personnel files. The proportional representation of women in assistant, associate and full professor rank was compared to the NSF data on the gender composition of PhD recipients in 2009–2013, 2004 and 1999, respectively. In addition, the provost office provided an anonymized list of promotions to full professor by college between 2008 and 2015, which also included gender, date and rank at hire, and year of tenure. The 2008 census data were used retrospectively and examined the past career trajectory of those faculty who were listed as full professors in the 2008 census. It could not, by its very nature (static snapshot), provide any information on the promotion dynamics of faculty who had left the university prior to 2008. Those faculty members who were full professors in the 2008 census are considered to have been promoted using the pre-ADVANCE institutional practices in faculty promotions. The 2014 census and the 2008–2015 promotion data were used to reflect post-ADVANCE institutional practices as they pertained to the promotion to full professor.

Because data on entire faculty populations (census data) were used, rather than samples, averages were calculated by gender and reported at face value, rather than being analyzed statistically. Furthermore, variability (range) in the data on time in associate rank until promotion to full professor was in itself pertinent to illustrate the level of consistency in the promotion process and changes over time. All data were analyzed using SPSS (Version 21).

In fall 2016, an online Qualtrics survey was distributed to faculty in the colleges of Science, Natural Resources and Engineering that included demographic information and core work climate-related questions from the previous ADVANCE surveys (2003 and 2011). In addition, tenured faculty members were queried on their perceptions of the promotion process to full professor. The survey response rate was 32 percent. This response rate is consistent with response rates from comparable published studies based on survey research. A meta-analysis of survey research found that individual and organizational-based survey response rates average 36–53 percent with a standard deviation of around 20 percent (Baruch and Holtom, 2008). Our survey population was comprised of 19 percent non-tenure track faculty, 25 percent untenured faculty, 17 percent associate professors and 39 percent full professor, capturing around 28 percent of the tenured faculty in the three colleges. Men and women respondents were represented in a 2:1 ratio overall and in all ranks, except for non-tenure track faculty, which were more evenly distributed by gender.

Results

Status of women

The first wave of women hires within STEM colleges at this institution took place between 1988 and 1995. In the 2008 census, there were a total 264 male and 62 female tenure track and tenured faculty (TT&T) in STEM. Women represented less than 20 percent of TT&T faculty in the STEM colleges at the university, with only 3 percent of STEM women faculty holding the rank of full professor. In 2008, the ratio of men over women in this rank was 12 to 1 (Figure 1). By 2014, the total number of women STEM faculty had increased to 75

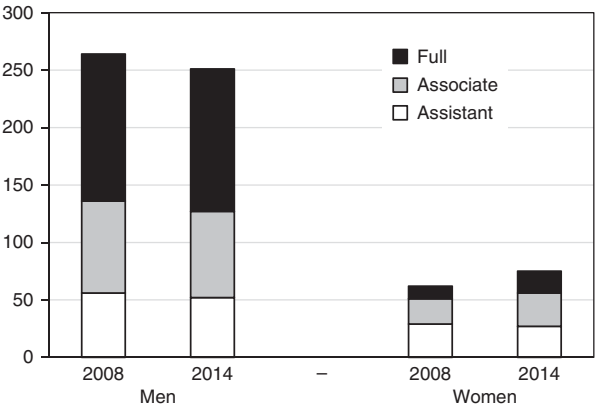


Figure 1.
Distribution of STEM faculty by rank and gender in 2008 (first census) and 2014

(vs 251 men), representing 23 percent of all STEM TT&T faculty. Increases were most noticeable in the higher ranks with the number of women associate professors increasing from 22 in 2008 (22 percent of all associate professors) to 29 in 2014 (28 percent of all associate professors), while the number of women full professor increased from 11 in 2008 to 19 in 2014, representing 8–13 percent of all faculty in that rank, respectively.

Time as associate until promotion to full professor

Retrospective analysis of the 2008 census data indicated inconsistent mid-career trajectories for all STEM faculty, and a large gender gap in the time as associate professor until promotion to full professor. While it took men on average 6.5 years as associate professor to be promoted to full professor (range 1–22 years), women took on average more than two years longer (mean 8.75 years, range 4–12 years). Cumulative distributions of time in associate professor rank by gender (Figure 2) show that 41 percent of male associate professors were promoted to full professor within five years of being tenured, while only 25 percent of the female associate professors attained the rank of full professor by that time. The majority (81 percent) of men but only a little over one-third (37 percent for) of women had been promoted after 8 years in the associate professor rank. Characteristic of the pre-ADVANCE cohort was the large variability in time to promotion for both men and women, suggesting a highly inconsistent promotion process.

One possible mechanism that may have contributed to this variability within and between gender groups is the rank at hire and associated employment-related negotiations. Indeed, faculty who started their university appointment as associate professors took significantly less

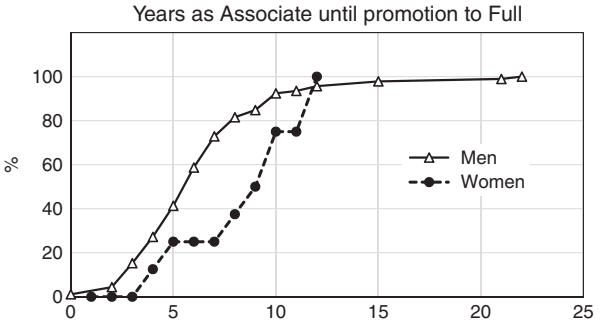
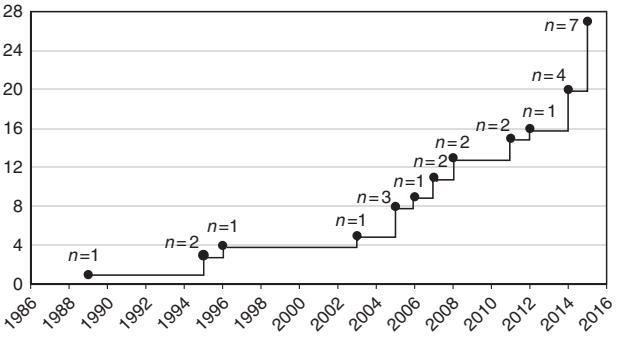


Figure 2.
Cumulative distribution of number of years in associate professor rank prior to promotion for men and women in STEM who were full professors in 2008

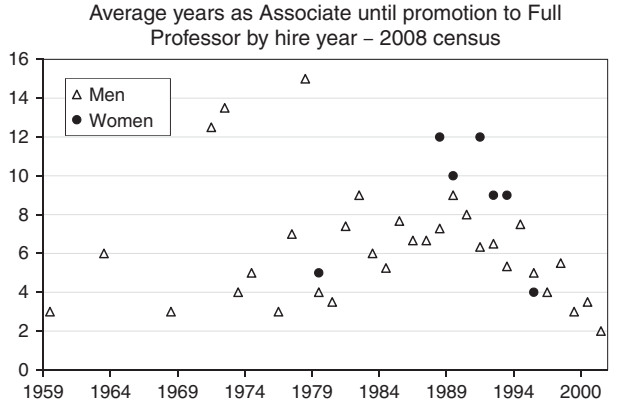
time until promotion to full (mean = 5 years, median = 4 years when hired as an associate professor vs mean = 7 years, median = 6 years for those hired as an assistant professor; Kruskall–Wallis non-parametric test at $p < 0.05$). The 2008 census data revealed that all but two women faculty (who were originally hired in administrative ranks) had started their appointment as assistant professors, while hiring rank was more variable among male STEM faculty. Consequently, rank at hire constituted an indirect gender effect on career advancement.

Few women were promoted to full professor prior to 2003 (Figure 3). Between 2001 and 2005, only four women were promoted, representing 11 percent of the cohort of faculty promoted to full professor in that timeframe. This partly reflected the relative scarcity of eligible women faculty hired before the late 1980s. However, there were at least six faculty women who had been hired prior to 1991, and should have been under consideration for promotion (assuming "normal" six years pre-tenure and six years as associate professor (Britton, 2010)). It is noteworthy that by 2008 these women had still not reached the full professor rank, despite faculty appointments spanning 17–30 years. Because the full professor population in 2008 likely reflected past legacies and potential variability in procedures over time, a direct gender comparison was made by year of hire (Figure 4). Once again, this comparison revealed high variability in faculty promotion outcomes, both for women and men. The data also showed that within the same hire cohort, the average time from associate to full professor was always longer for women compared to men.



Note: Two women promoted to full in 1995 had left university prior to 2008 census

Figure 3.
Number of women in STEM promoted to full professor between 1988 and 2015



Note: $n = 1$ for women except in 1993 hire year, where $n = 2$

Figure 4.
Average time (in years) in associate professor rank until promotion by year appointment at university for men and women who were full professor in 2008

Promotions of women to full professor started to occur more frequently and at higher rates with the onset of the ADVANCE project, and this trend has continued through the present (Figure 3). At the same time, the relative proportion of women among those promoted also increased from 28 percent in the period 2006–2010 to nearly one-third in the most recent five-year period (2011–2015). Since 2008, men and women have been promoted in roughly a 2:1 ratio (33 men vs 16 women). There has also been a decline in variability in career outcomes for all faculty members and a closing of the gender gap (Figure 5), especially for the more recent hires. For those promoted since 2008, the average time as an associate professor was just under nine years for both men and women (median seven years for men; eight years for women). After removing the 25 percent that were hired prior to 1996 – considered pre-ADVANCE legacies given the time since hire was greater than 12 years and they should reasonably have been considered for promotion – patterns were even more favorable. The average time as associate until promotion to full professor was 13 years from women (range: 10–18 years) and 15 years for men (range 11–25 years) in the legacy group. The more recent hires (i.e. those hired since 1996) have been moving through the process more swiftly and consistently (on average in seven years) and any gender gap has disappeared for these cohorts (median seven years for women, range 5–9 years; median six years for men, range 3–14 years) (Figure 5). The changes in promotion dynamics between 2008 and 2014 resulted a doubling of the number of female full professors in STEM (from 3 to 6 percent of TT&T faculty), such that the ratio of male to female full professors is now 6.5:1 (Figure 1).

Past legacies and changes in promotion dynamics are further illustrated in overall time to promotion (years in assistant and associate professor rank combined) before, during and after the ADVANCE program. The period prior to 2003 (before ADVANCE) reflects a male-dominated legacy, with more than two-thirds of the (male) faculty promoted to full professor within 12 years of being hired, and only 31 percent of the men taking longer to achieve that rank. During and following ADVANCE, promotion standards were raised and portfolios were scrutinized more systematically. This resulted in some men moving through the process more slowly, illustrated by the equal proportion of men take both longer and less than 12 years at the university before promotion to full professor. On the other hand, only one-quarter of women achieving full professor rank have done so within 12 years of being hired (22 percent: 2003–2008; 29 percent after 2008).

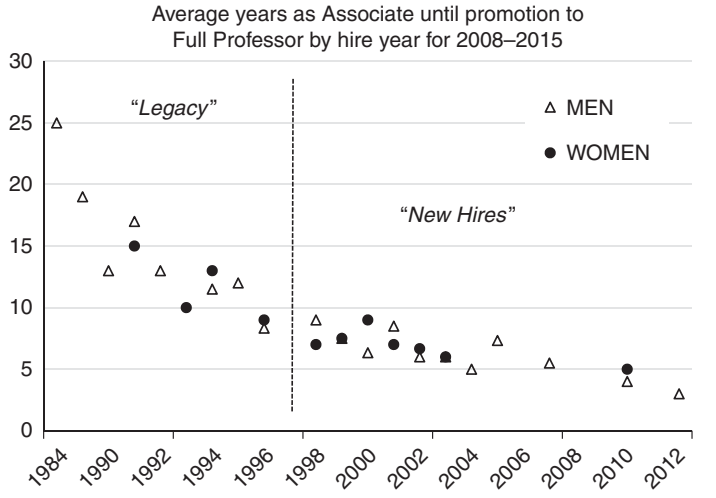


Figure 5.
Average time (in years) in associate professor rank until promotion by year appointment at university for men and women promoted between 2008 and 2015

Women's perception of the institutional climate

The 2016 survey indicated significant improvement in faculty attitude *vis-à-vis* the climate at the university compared to similar surveys conducted at the onset (2003) or immediately after (2011) the ADVANCE project (Figure 6). Survey results for both men and women faculty were similar between 2003 and 2011, with women generally expressing lower job satisfaction than men. The improvement in faculty morale observed in 2016 was most pronounced for women. In 2016, the majority of the women expressed job satisfaction (87 percent) and indicated that they felt valued (74 percent), fit in their respective departments (65 percent) and felt they regularly received all important information needed to conduct their work. This represented a 20 percent increase in positive responses compared to the pre-ADVANCE survey. Fewer women reported being excluded from informal networks (44 percent in 2003 vs 26 percent in 2016). In addition, metrics signifying distrust or disappointment with the university, such a frustration over their treatment, anger or feelings that promises had not been kept, simultaneously declined and virtually disappeared (< 5 percent of women respondents).

Faculty perception of the promotion process

In 2016, almost a decade after the ADVANCE project came to an end, the majority of all tenured faculty (64 percent) agreed that guidelines, criteria and expectations related to the promotion process had generally been communicated clearly to them. There was no significant difference in response by rank ($\chi^2 = 0.443$, $p = 0.382$) or gender ($\chi^2 = 0.000$, $p = 0.647$). Furthermore, over 80 percent of the male faculty indicated that guidelines to promotion, committee formation, standards of excellence and portfolio preparation were clearly communicated by their respective departments. The proportion of women responding positively to these questions (i.e. selecting "extremely clearly" and "somewhat clearly") were lower compared to men, but gender differences were not statistically significant (promotion guidelines: 82 percent for men vs 64 percent for women, $\chi^2 = 1.725$, $p = 0.631$; committee formation: 90 vs 57 percent, $\chi^2 = 5.475$, $p = 0.140$; standards of excellence: 82 vs 79 percent, $\chi^2 = 4.136$, $p = 0.388$; binder preparation: 79 vs 71 percent, $\chi^2 = 1.343$, $p = 0.719$). There were statistically significant differences in response distribution between associate and full professors, with the latter more frequently selecting "extremely clearly," whereas associate professors were slightly more judicious in their responses, selecting "somewhat clearly," 45–55 percent of the time (promotion guidelines: $\chi^2 = 13.548$, $p = 0.004$; committee formation: $\chi^2 = 13.548$, $p = 0.004$; standards of excellence: $\chi^2 = 8.141$, $p = 0.087$; dossier preparation: $\chi^2 = 2.036$, $p = 0.565$). Nevertheless, almost all associate professors in the survey (87 percent of

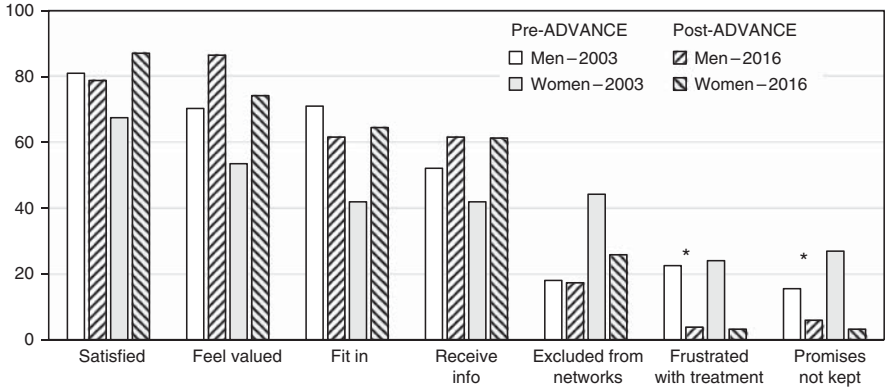


Figure 6.
Percentage of male and female faculty who agreed with the statements (selected "strongly agree" or "agree") in the 2003 (Pre-ADVANCE) and 2016 (Post-ADVANCE) faculty climate survey

Note: *For the two last categories comparison between 2011 and 2016 survey

men and 80 percent of women) indicated intent to go up for promotion and a similar proportion (71 percent of men and 75 percent of women) expressed confidence in a successful outcome, with women actually expressing greater confidence (75 percent of women selected "very confident" vs 27 percent of the men). None of the patterns were significantly influenced by gender of the faculty.

Discussion

The initial climate survey conducted in 2003 by the ADVANCE team into the perceived barriers to career attainment among STEM faculty revealed the mediating effect of departmental climate on lower job satisfaction of women faculty (Callister, 2006). Confusion about promotion criteria and process (Fox and Colatrella, 2006) or lack of access to information (Hult *et al.*, 2006) have been documented as causes for lower job satisfaction and career attainment for women faculty in STEM. This study shows significant post-ADVANCE improvement in women's perception of the academic climate for advancement and provides evidence of positive feelings toward and confidence in the promotion process by the majority of tenured faculty, irrespective of gender. The differences in pre-ADVANCE job satisfaction between men and women, and the overall improvement in faculty morale post-ADVANCE, especially for women, are consistent with findings from a similar longitudinal ADVANCE study at Ohio State University (Bystydzienski *et al.*, 2017). The slightly more positive responses of full compared to associate professors likely reflect situational differences in perception between those who have successfully navigated the process and those still facing the promotion decision.

The institutional practices prior to 2008 led to inconsistent outcomes for both men and women, as indicated by the large variability in time to promotion to full professor. It also clearly disadvantaged women faculty, as it took longer for them to be considered for promotion. The first women moving through the ranks were largely in token positions within their respective departments, which is often associated with hyperscrutiny and negative evaluation bias (Kanter, 1977) such that women have to work harder and accomplish more in order to be recognized compared to similarly positioned male colleagues (Rosser, 2004). Exclusion from critical information networks and the lack of senior role models further contributes to women being overlooked as potential candidates for promotion in the absence of clear guidance on process and timeline (Rosser, 2004). An empirical study combining personnel data with faculty interviews by Roos and Gatta (2009), reported similar large inequities and subtle gender discrimination in the promotion process, as (some) men but not women were encouraged to seek early promotion. This dynamic is suggested in our study by the observation that the majority of men promoted to full professor prior to 2003 did so in less than 12 years after being hired. A study in France further showed that being overlooked and lingering in rank tends to reduce one's chances of future promotion to professor (Sabatier *et al.*, 2006). The initial focus of the ADVANCE project was to move some of these legacies through the process.

The impact of gender differences in the rank at hire on subsequent career trajectories has also been documented in other universities (Roos and Gatta, 2009) and research institutions (Sabatier *et al.*, 2006). Merton (1973) refers to this dynamic as the "Matthew effect," the self-reinforcing process that increases inequality when higher-status individuals (generally men) are given the benefit of the doubt and accrue more recognition for their scientific contributions than lower status individuals. Conversely, similarly situated women, according to Valian (1999), tend to accumulate disadvantage. These tendencies underscore the crucial role of early-career recognition (and decision at hire point) to a scientist's future success via the positive feedback between status, resource access and subsequent productivity (DiPrete and Eirich, 2006). Several empirical studies in STEM have documented that men often have greater access to institutional resources and support

(Rosser, 2004; Duch *et al.*, 2012; Ceci *et al.*, 2014) and such differences in resource allocation can present indirectly as gender differences in career trajectory (Roos and Gatta, 2009). When there is a high level of ambiguity during pre-hire negotiations, gender gaps in outcomes tend to be more pronounced (Bowles *et al.*, 2005). Women often find themselves at a disadvantage when they cannot negotiate their start-up packages with the same vigor as their male counterpart without being perceived negatively (Williams and Dempsey, 2014). Double standards in portfolio evaluations downplaying the accomplishments of women may also contribute to gendered hiring practices (Foschi, 1996, 2006; O'Connor and O'Hagan, 2016).

The ADVANCE project had a positive effect on the number of women hired within STEM (Hult *et al.*, 2008). By 2014, the relative proportion of women in STEM departments was consistent with the gender composition of the employment pool for associate professors (percent women PhD recipients in 2004) and was at or above availability for assistant professors (average percent of women PhD recipients for period 2009–2013) (Burelli, 2008; Van Miegroet, 2018). This had a twofold positive effect on the mid-career dynamics for women: women were no longer in token positions; and the pool of women eligible for promotion increased gradually over time. Importantly, however, increased representation of numerical minorities is necessary but insufficient to transform the organization (Acker, 1990). Thus, additional efforts by the ADVANCE team in transforming institutional climate were critical.

The presence of ADVANCE on campus made the issue of gender inequality more visible by collecting and making transparent demographic and promotion data. The latter has been an essential project component of all ADVANCE initiatives, both as a diagnostic tool and means of assessing progress toward institutional gender equity goals and intervention effectiveness (Sturm, 2006; various chapters in Stewart *et al.*, 2007). Data are now updated annually and the process of data collection and visualization has become institutionalized. The 2003 climate survey revealed the critical role of departmental climate on job satisfaction, especially among women in STEM (Callister, 2006). Specifically, women faculty cited a lack of access to information as one cause for lower job satisfaction (Hult *et al.*, 2006), a complaint commonly expressed by faculty at other ADVANCE institutions (Sturm, 2006; Frehill, 2007; Stewart *et al.*, 2007; Banerjee and Pawley, 2013). The workshops and dialogues on campus transformed the process of informal and inconsistent information transfer to the privileged network-connected and those "in the know" into a more objective and egalitarian information flow. These efforts also created greater transparency in expectations and promotion procedures that seemed to have had an overall positive influence on the promotion trajectories both in terms of overall reduction in the length of time until promotion to full for all STEM faculty members and in reducing differences in career attainment between male and female STEM faculty members. These workshops have become institutionalized and are still ongoing, albeit at lower intensity and frequency than during ADVANCE, and are largely organized by the provost's office.

While these information transfer sessions were instrumental in alleviating faculty anxiety and improving morale, enduring changes in promotion dynamics were achieved through Faculty Policy language in 2005 that systematized the process of post-tenure review and clarified the faculty's right to such review. After an initial transition period during which STEM college administrators were held accountable through queries by ADVANCE team members about the relative compliance with the requirement of post-tenure review within three years, this codified procedure is now routinely implemented across colleges. Consistent with the literature (Reskin, 2000; Fox and Colatrella, 2006), this study indicates that greater transparency, accountability and formalization in the post-tenure review process initiated by ADVANCE improved the promotion outcomes for both men and women and also significantly reduced the gender gap. In other words, the

codification of procedures and responsibilities neutralized the subjectivity stemming from variable departmental climates. Analysis of the 2016 faculty survey seems to confirm greater overall job satisfaction of women and a positive attitude toward the promotion process among all tenured STEM faculty members.

Another key element in the sustainable success of the ADVANCE program lies in the requirement by NSF to include high-level university administrators as project collaborators and in the role of change actors (Sturm, 2006). The provost office was represented on the ADVANCE team by an associate vice provost, who had specific role responsibilities related to gender equity and who oversaw many of the activities initiated by ADVANCE. Between 2004 and 2005, one of the co-PIs on the project had a dual leadership role as dean of one of the STEM colleges and as vice provost for women's issues. Her successor, who served as vice provost for development and diversity between 2006 and 2010 was instrumental in the organization of many of the provost-sponsored activities, and in 2010 became the director of the newly established Center for Women and Gender. Correll (2017) argues that change initiatives within organizations are most effective when leadership is involved in shaping the process. Indeed, the involvement of upper-level administrators lends legitimacy to the institutional intervention because they have the credibility and influence within the organization, possess the power to facilitate policy changes and have the authority to require adherence to these policy changes by all members of the institution (Sturm, 2006).

This study demonstrates that marked improvements in the upward mobility of women in STEM were achieved by ADVANCE through a combination of several factors: greater transparency in the institutional expectations and necessary steps toward promotion; reduced barriers to information flow; standardization and codification of the promotion process; and inclusion of university leadership as change actors. Yet despite the positive effect of the intervention strategies from ADVANCE, including increased recruitment of women faculty in STEM and accelerated promotion rates of women associate professors, demographic modeling by Bakian and Sullivan (2010) suggests that the ratio of men to women in the full professor ranks is not likely to reach the composition of the employment pool in the foreseeable future at this institution. While the proportional representation of women has improved following ADVANCE in some faculty ranks, the current (skewed) faculty population structure, with men dominating the full professor rank, is likely to persist for several decades through demographic inertia. In order to completely overcome demographic inertia (i.e. break the entrenched population structure), two crucial conditions are necessary (Bakian and Sullivan, 2010). First, positive efforts toward increased recruitment and promotion rates of women initiated through ADVANCE must be sustained in order to avoid a deceleration in the current positive trajectory toward greater women's representation in the faculty ranks. Second, a change in hiring practices, particularly increased recruitment of women at the associate and full professor level, is necessary to achieve greater gender balance in the highest faculty ranks at this institution (Bakian and Sullivan, 2010).

Conclusions and implications

On the basis of faculty census and promotion data between 2008 and 2014, and multiple waves of climate surveys, this study was able to demonstrate the impact of the ADVANCE project on the mid-career upward mobility of women faculty in STEM at a single doctoral research university where research productivity rather than teaching, advising, mentoring or service is prioritized in faculty evaluations for promotion. The relative proportion of women faculty in the associate professor rank increased from 22 percent in 2008 to 28 percent in 2014, with corresponding increase from 8 to 13 percent for full professors. There was a noticeable upswing in the number of women promoted full professor post-ADVANCE, such that nearly one-third of those promoted to full professor now

are women. A more equitable working environment for women was achieved through a combination of data collection to highlight problem areas and provide indicators of progress toward gender representation targets; systematic and deliberate disseminations of crucial information to all faculty to counteract the impact of informal networks and dispel myths and misinformation; formalization and codification of post-tenure procedures to counteract ambiguity in decision making; and the active engagement of university leadership in the transformation of institutional practices toward greater transparency, consistency and accountability. Our findings suggest that the variability in promotion outcomes was not a gender issue *per se*, and that a program aimed at improving the working environment for women faculty members in fact benefited all faculty members irrespective of their gender. This was borne out both by actual promotion data and by faculty survey responses that signaled a noticeable improvement in faculty morale, irrespective of gender.

ADVANCE efforts had a transformative and lasting influence on institutional practices. As institutional climate matters to job satisfaction (Callister, 2006) and career outcomes for women in STEM (Valian, 1999; Rosser, 2004), the critical question becomes "How can lasting changes in academic climate be achieved?" The effectiveness and sustainability of this ADVANCE project was in part achieved by adhering to many of the recommendations summarized in the ADVANCE synthesis by Stewart *et al.* (2007) and by following the sequence of steps outlined in the "small wins model" for institutional change outlined by Correll (2017). Throughout the program, university administrators at various levels were engaged as collaborators and change actors. While the program at large endeavored to change institutional practices that benefited faculty, change could not be achieved without making leadership aware of the uneven gender representation within STEM and its potential causes (education, diagnosis) and making them active participants in the design and implementation of the change process. For example, institutionalization of many of the project activities (e.g. data collection, information dissemination through documents and workshops) was possible only through the commitment by the provost's office to allocate resources to safeguard their continuity. Because department climates and practices vary, oversight from college and/or university-level administrators is necessary to guarantee systemic change and consistency in implementation of procedural changes. This finding is consistent with research by Goodwin *et al.* (1998) demonstrating that decision-makers are less likely to show cognitive bias when they have a stake in the outcome or are held accountable for their decisions and decision criteria, especially to those in power. High turnover in leadership and university administration during the ADVANCE period somewhat hampered consistent and uniform implementation of the post-tenure review policy, but more recent provosts have shown greater commitment to adherence to Faculty Policy. As a result, standardization of policy and practice is being implemented across the university including in non-STEM departments and colleges.

The sustainability of the program rests on two essential components: it created greater awareness of actual gender gaps (by collecting quantitative data) and clarified expectations of promotion (through information workshops); and it put in place policies that translated these findings into objective and enforceable action items. While the first step was essential in making problems visible and creating greater institutional attentiveness to gender equity at the departmental, college, and university levels (at least temporarily) (Sturm, 2006), this in itself can prove ineffective in achieving gender equity if not associated with structural (i.e. policy) changes (Kalev *et al.*, 2006). Furthermore, a faculty population structure characterized by dominance of men in the highest ranks cannot be alleviated in the short term. Fundamental faculty composition changes overcoming this demographic inertia are possible over longer time periods only and require that gender-balanced recruitment and promotion efforts initiated during ADVANCE be maintained, and that recruitment of women also includes hiring at associate and full ranks (Bakian and Sullivan, 2010).

This ADVANCE project had a systematic and sustainable influence on the institutional promotion practices despite the modest funding size of the promotion to full program, by responding to institution-specific conditions and tailoring interventions to the institution's culture (as per Sturm, 2006). While previous research has shown that gender bias permeates the evaluation of academic performance, this study suggests that deliberate changes in institutional practices can indeed limit the impact of gender bias on career outcomes. To achieve institutional gender equity goals, the project first identified the specific obstacles to the career success of women within the context of the institution and then worked to remove the sources of inequality appropriate for the institution. In this case, change occurred through modification of the Faculty Policy, the locus of all personnel procedures at this particular university. For example, the ADVANCE team changed faculty policy to expand a smaller program and create a university-wide promotion and tenure ombudsperson program. This requires one trained faculty member, who is not on the promotion and tenure committee, to be present as an observer tenure meetings to ensure that all committees follow policy and with the power to stop the meeting if the committee violates policy. Furthermore, the ADVANCE team changed university policy to create a standing Faculty Senate committee charged with focusing on gender and ethnic equity and diversity. This committee is charged with retrieving university data and presenting an annual update to the Senate on how each college is preforming on several gender and minority metrics.

Our findings suggest that other similar doctoral research universities can reduce gender disparities in the advancement to full professor by increasing the visibility of gender disparities, pursuing transparency in the promotion process and standardizing policy and practice-related to promotion for all faculty members. However, the NSF-ADVANCE program aimed to increase the representation and advancement of women faculty members in STEM across all institutional types, not just at large research universities. According to the aims of the program, "ADVANCE is interested in supporting a range of non-profit academic institution types" including but not limited to community colleges, minority-serving institutions and primarily undergraduate institutions. Though women at different types of institutions may face variable challenges, Rosser (2004) found that irrespective of institutional variability, women faculty members in STEM are consistent in their response about barriers and challenges to their respective academic career. Britton (2010) further argues that organizational demographics inherent to the STEM disciplines, with men numerically dominating most decision points, is likely to impact the promotion dynamics for women at most IHEs. Therefore, we think that our findings are relevant to the women's experiences at other IHEs in that promoting standardization and transparency in the promotion process can reduce evaluation bias and increase the representation of women in STEM.

Fully interrogating the various mechanisms through which other types of institutions can facilitate the advancement of women into the full professor ranks requires further research. Gender inequality is seldom experienced by women in STEM as a uniform oppressive climate according to Britton (2017). Rather, it is contextual and emerges through interactions, organizational structures and workplace culture. Thus, efforts to foster gender equity are most effective when placed within a specific organizational context (Sturm, 2006; Britton, 2017). However, our study provides some insights into the general path that other institutions might follow. Most institutions have criteria and guidelines that govern promotion for faculty. Thus, focusing efforts on clarifying those criteria and standardizing the guidelines are vital for reducing gender disparities in advancement. First, stakeholder and change agents can begin by identifying aspects of the promotion process that are subjective, opaque or non-standardized. For example, identifying gender differences in the time to promotion, in the likelihood of pursuing promotion and in differences in rank at hire can illuminate where in the process bias might occur. Is post-tenure review automatic or

institutionalized for all faculty or can faculty opt for a review? If the latter, then it is likely that departmental climates vary in their support of women's advancement, with some privileging men faculty in formal or informal ways that may be alleviated by implementing a mandatory automatic review for all faculty. Second, stakeholders can build administrative buy-in by making gender disparities at any point in the process visible and transparent. Data collection and dissemination, sanctioned by university leadership, play a key role in identifying gendered promotion dynamics and in facilitating institutional change. This is because data transparency can serve as a mechanism of accountability and "nudge" decision-makers to adopt fairer and more equitable practices. Administrative allies, including institution-specific governance structures such as faculty senate, can assist in implementing policies in a systemic way (Sturm, 2006).

Finally, stakeholders can pursue sustainable change by modifying existing policies where they exist or introducing new policies and procedures where they are needed.

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Hidden patterns

Using social network analysis to track career trajectories of women STEM faculty

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Abstract

Purpose – The purpose of this paper is to describe how one group of ADVANCE Project researchers investigated faculty co-authorship networks to identify relationships between women's positions in these networks, their research productivity and their advancement at the university – and to make those relationships transparent.

Design/methodology/approach – Multiple methods for capturing faculty network data were evaluated, including collecting self-reported data and mining bibliometric data from various web-based sources. Faculty co-authorship networks were subsequently analyzed using several methodologies including social network analysis (SNA), network visualizations and the Kaplan–Meier product limit estimator.

Findings – Results suggest that co-authorship provides an important way for faculty to signal the value of their work, meaning that co-authoring with many others may be beneficial to productivity and promotion. However, patterns of homophily indicate that male faculty tend to collaborate more with other men, reducing signaling opportunities for women. Visualizing these networks can assist faculty in finding and connecting with new collaborators and can provide administrators with unique views of the interactions within their organizations. Finally, Kaplan–Meier survival studies showed longitudinal differences in the retention and advancement of faculty based on gender.

Originality/value – Together, these findings begin to shed light on subtle differences that, over time, may account for the significant gender disparities at STEM institutions, patterns which should be investigated and addressed by administrators. Lessons learned, as well as the novel use of SNA and Kaplan–Meier in investigating gender differences in STEM faculty, provide important findings for other researchers seeking to conduct similar studies at their own institutions.

Keywords Gender, Academic staff, Sex and gender issues, Women workers, Higher education

Paper type Research paper

Introduction

During the second phase of a National Science Foundation (NSF) Institutional Transformation grant (2006–2013), the ADVANCE Project at the New Jersey Institute of Technology (NJIT) implemented a novel strategy: applying social network analysis (SNA) to faculty co-authorship data in order to better understand and address the factors that affect the careers of women faculty in science, technology, engineering and math (STEM). This paper describes the methodological challenges involved in studying the networks of STEM faculty – and the opportunities that SNA affords to both individuals and institutions by making hidden relational patterns more visible.

The university's 2005 Status of Women Faculty Report indicated that at NJIT, as at other similar institutions, women faculty felt isolated and outside the information loop (e.g. August and Waltman, 2004). The NJIT–ADVANCE Institutional Transformation grant was designed to address these concerns. In its initial phase (2006–2010), the project targeted

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isolation by stimulating research collaborations among faculty through activities such as seed money and travel grants for woman-led research project teams; interdisciplinary knowledge exchanges; cross-sector research showcases; and an informal Research Café. Simultaneously, the project studied the existing patterns of collaboration through networks of faculty co-authorship. The goal was to determine whether increased research collaboration was advantageous for women. In this earlier study, statistically significant correlations between collaboration (calculated using network centrality measures) and career advancement suggested that it was. In its second phase (2010–2013), NJIT–ADVANCE built on that work, moving from concept to deeper analysis and sustainable application. The project's primary research goal was to demonstrate that SNA and mapping (network visualization) could be used at NJIT and elsewhere to support more efficient faculty career management, including mentoring – and to visualize subtle institutional changes occurring over time.

From the beginning, NJIT–ADVANCE was distinctive in its focus on the intersection of research collaboration and academic advancement (promotion in rank). In order to design career interventions effectively and assess their actual impact, NJIT–ADVANCE researchers needed to collect baseline network, productivity and promotion and tenure (P&T) data on all STEM faculty and find sustainable (scalable) means of analyzing changes in that data over time. In recent years, a growing number of studies have investigated the correlation between network structure (as measured by various social network centrality measures) and productivity (as measured by publication or citations counts), e.g. Abbasi and Altmann (2011). However, there have been remarkably few US studies that look at network structure and promotion, despite the fact that promotion is the clear measure of career success in academia. This study was therefore informed by a central research question:

RQ1. What is the relationship among collaboration (network structure), productivity and advancement in rank?

Background

Numerous studies have found that women and under-represented minority (URM) faculty in STEM feel that they are more isolated than their peers (e.g. August and Waltman, 2004; Belle *et al.*, 2014; Xie and Shauman, 2003) and have less influence in their departments (Carr *et al.*, 2003; Niemeier and Gonzalez, 2004). Such feelings, in turn, are linked to lower job satisfaction, reduced career success and higher turnover rate (Hart, 2016; Shore *et al.*, 2011).

Early approaches to addressing these issues focused on an "add-women-and-stir approach" (Etzkowitz *et al.*, 2000). However, when NSF replaced POWRE with the ADVANCE Program, it shifted the foundation's focus from individual empowerment to institutional transformation. The NJIT–ADVANCE project mirrored this shift in focus, proposing a novel method of investigating gender differences within STEM institutions using the power of social networks as "transformational engines" (Ibarra *et al.*, 2005) while addressing their paradoxical invisibility (O'Reilly, 1991). The NJIT–ADVANCE strategy had two goals: to develop techniques, tools and practices that could provide potential faculty outsiders – especially women – with inside knowledge of network pathways, and simultaneously give university administrators a more subtle means of identifying potentially problematic characteristics of the units they manage (Basole, 2016). In this effort, NJIT–ADVANCE was guided by the core belief that data transparency is not only the key to measuring change, but also it is the key to motivating change.

The project sought to actualize Christakis and Fowler's (2009) observation that, "To know who we are, we must understand how we are connected" by making hidden organizational network structures visible to the faculty embedded in them (Niehaus and O'Meara, 2015; O'Reilly, 1991; Tichy *et al.*, 1979). To accomplish this goal, NJIT–ADVANCE researchers selected SNA, a methodology rooted in "sociometry" (Moreno, 1934; Scott, 1988), to explore networks of faculty collaboration through co-authorship. In SNA, ego networks

provide a "Ptolemaic" view of an actor and those with whom he or she has direct and indirect ties; however, they do not provide information about the organization in which the ego is embedded (Steffen-Fluhr and Plummer, 2008). To get a more "Copernican" view, researchers must "consider both the occurrence and non-occurrence of relations among all members of a [bounded] population" (Garton *et al.*, 1997). However, the actual power of SNA is limited by a tension between the need to collect complete, high-quality data and the burden of collecting complete, high-quality data. For this reason, project researchers chose to explore co-authorship ties as a proxy for collaboration.

Co-authorship has been identified as one of the most tangible and well-documented forms of collaboration among scholars (Cugmas *et al.*, 2017; Kumar, 2015; Melin and Persson, 1996) because it generally requires a working interpersonal relationship. Co-authorship networks provide a lens through which collaborative networks can be extensively analyzed and assessed for trends or changes over time. This approach is well-established, going back to early author co-citation analyses by McCain (1986) and others (e.g. Eklund and Nelhans, 2017; Goodrum *et al.*, 2001), demonstrating that representations of the intellectual structure of a field generated by bibliometric data correlate strongly with the judgments of experts in the field. Moreover, bibliometric data are public, objective and can be scraped directly from the internet, suggesting a scalable and sustainable approach to data collection.

NJIT–ADVANCE aimed to acquire a three-dimensional understanding of the university's co-authorship network structures and their relationship to key variables, including promotion and productivity, by combining key dimensions of social network theory (Burt, 1998; Granovetter, 1973), including homophily (the tendency of people to associate with others they perceive to be similar to themselves) (Belle *et al.*, 2014; McPherson *et al.*, 2001), with gender schema theory (Valian, 1997). Project researchers also hypothesized that because organizational networks enable individuals to convert human capital into status (Brink and Benschop, 2014; Ibarra *et al.*, 2005), conscious awareness of network structure is potentially empowering (Krackhardt, 1990; Leonardi, 2015). In fact, prior research has shown the importance of visualizing social networks, not only for researchers seeking to understand the interactions between actors but also for those immersed in the network to gain insights from their positions and the positions of others (Collins and Gruzd, 2017; McAuley and Lewis, 2016; Viegas and Donath, 2004).

The subsequent sections of this paper describe in detail the methods tested for collecting network data, the application of SNA and data visualization techniques to faculty co-authorship networks to investigate relationships between network centralities, faculty productivity and their advancement at the university. The authors describe specific analytic and mapping tools, discuss the benefits of network visualizations and explain significant findings from the study. The concluding sections discuss the implications of this work and make recommendations for future studies.

Collecting self-reported data

Capturing faculty CVs

Initially, NJIT–ADVANCE planned to extract baseline collaboration data from faculty CVs using resume "ripper" software. Complete data were required, however, and some faculty would not submit their CVs, arguing that they were proprietary intellectual property. NJIT–ADVANCE researchers also considered collecting data from the university's annual summary software system (Digital Measures' "Activity Insight"); however, during the initial grant phase, faculty response rate was typically below 30 percent.

Surveying

NJIT–ADVANCE researchers next attempted to collect network data through one-on-one interviews and in small groups using an instrument developed from established network

data collection protocols (Wellman, 1997). Unfortunately, the paper-based instrument required an hour or more with each subject, an unsustainable effort given the nearly 300 potential subjects. The Wellman questions subsequently formed the basis for a shorter survey instrument that NJIT–ADVANCE researchers designed for online distribution.

The survey consisted of four sections including one about NJIT Friends. Some faculty in the pre-test sample differed in their ideas about what constituted "a friend," however, while other faculty were reluctant to respond. This reluctance to name friends increased faculty reluctance to complete the network survey as a whole. The research team subsequently abandoned the survey approach and focused on mining objective bibliometric data from online sources – with one important exception: the "Department X" study.

Interviewing (Department X)

In parallel with bibliometric data collection, two NJIT–ADVANCE researchers conducted a network study of tenure-track faculty in one STEM department (Department X). The study had two goals: to collect self-reported data about many forms of collegial interaction (e.g. advice and collaboration) in order to create multi-modal ego networks representing different types of faculty connections (modes), and to collect faculty perceptions about research collaborations between all members of their department.

The researchers conducted a sequence of 1 h interviews with 12 of the 15 tenured/tenure-track Department X faculty. They first provided the subjects with the names of all faculty employed at the university between 2000 and 2010, arranged in alphabetical order by department, and asked the subjects to indicate which of those individuals they knew.

During phase 2, for each person selected in the "first pass," the subject was asked to specify the nature of the interaction as one or more of the following: co-author, collaborate, serve on committees, discuss research, give advice, receive advice and socialize. These two phases provided input for the multi-modal ego networks of each of the 12 faculty respondents.

In the third and final phase, the researchers employed a network visualization tool called VennMaker (Kronenwett and Schonhuth, 2011) to display nodes representing all 15 faculty members in Department X. The researchers asked the subjects to draw connections between nodes based on their perception of which Department X faculty were engaged in intra-departmental research collaborations (Figure 1).

The primary aim of the study was to compare faculty self-reported networks (and the effort required to collect them) to networks generated from mined bibliometric data, testing the project's hypothesis that the latter were a valid proxy for the former – and thus that data mining, a sustainable and scalable process, produced salient network maps. To assess the

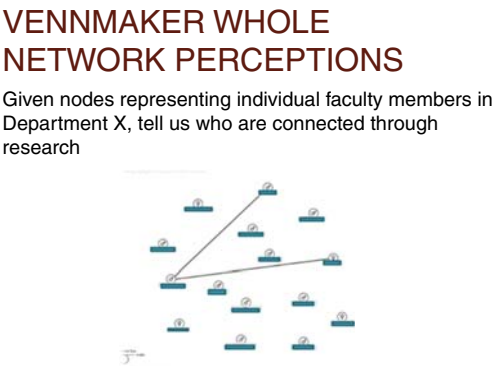

Figure 1.
One faculty member's perception of within-department collaboration

accuracy of the Department X data, NJIT–ADVANCE researchers first calculated reciprocity measures (Calloway *et al.*, 1993) within the department, indicating how many of the ties provided by the reporting faculty member were reciprocated by the reported faculty member. The results, shown in Table I, suggest that, in general, the more verifiable the connection (i.e. co-authorship and committee membership as opposed to socializing), the higher the reciprocity.

The results of the VennMaker whole network perception study indicated that the faculty members of Department X did not have an accurate understanding of the research collaborations occurring within their department. Correlations between each faculty member's perceived network and the bibliometric co-authorship network revealed that only three (out of 12) faculty members' perceptions of their departmental connections were strongly correlated with the objective bibliometric data ($r > 0.600, p = 0.000$). Based on the low reciprocities in the self-reported data, the overall low correlations between faculty perceptions and objective realities, and the time and effort involved in collecting this data, project researchers concluded that co-authorship networks were a valid proxy for faculty collaboration (Ductor, 2015; Gonzalez-Brambila *et al.*, 2008, 2013) and that mining bibliometric data was a more reliable, sustainable and scalable approach than collecting self-reported data.

Mining databases

Searching (and cleaning)

NJIT–ADVANCE researchers next developed an interactive database of publications produced by NJIT STEM faculty using a simple affiliation search strategy to extract scholarly publications from databases for which the NJIT library had licenses. The team focused first on validating the data for a subset of tenured/tenured-track STEM faculty members who had been employed full-time for all or part of the period 2000–2008, plus a small group of non-tenure-track "research professors" supported by grant funds.

A review of the results of the affiliation search identified a number of significant issues that required laborious hand-cleaning of the data: the "common name problem" (i.e. the need to disambiguate publications by NJIT faculty from publications by non-NJIT faculty and NJIT graduate students who have the exact same name); incorrect affiliation tags (e.g. listing "IEEE" as a professor's university affiliation rather than "NJIT"); gaps in coverage (e.g. Scopus does not index many small but prestigious international conference proceedings); and duplicate entries for a single publication, often resulting from slight variations in the way the article title was recorded (e.g. using the word "beta" as opposed to the symbol "β"). Queries were used to remove most of the duplicates from the database, but common name problems required manual correction. Hand-cleaning not only corrected many errors but also inadvertently introduced new ones, raising concerns about the quality of the data. Moreover, the initial affiliation search was not automated and therefore not readily sustainable or scalable. In consequence, during the second phase of the project, the team fundamentally restructured the co-authorship database, expanding its coverage to 2010 and using fully automated data mining techniques.

Connection type	Reciprocity
Co-author papers	0.667
Committee membership	0.311
Discuss research	0.217
Socialize	0.222
Collaborate on research	0.115

Table I.
Reciprocity measures for self-reported data

Mining google scholar

NJIT–ADVANCE data miners tested several different approaches before settling on a mash-up that sent each faculty name to Google Scholar's author search function. A parser program for Google Scholar was then used to process each paper in the search results. Predictably, the raw data contained a significant number of common names, duplicates, etc. This time, however, cleaning the data was more systematic, producing much more complete and reliable results.

However, despite the higher quality data, this method was deemed not sustainable because it required a two-stage crawl: first Google Scholar, then the source databases feeding Google Scholar. Unfortunately, the information display patterns were unique to each source database and changed periodically, meaning that researchers using this approach would need to create – and update – hundreds (perhaps thousands) of separate parser programs.

Mining scopus

As a result, the team decided to apply its data mining approach to a single large source database (Elsevier's Scopus) using a more efficient, one-layer crawling method. Results were merged with the data already collected, creating a unified database containing 8,395 NJIT faculty publications, 3,608 of which were co-authored by NJIT faculty during the period 2000–2010. (These co-authored publications constituted the core NJIT–ADVANCE "co-authorship network" on which all subsequent analyses were performed.) Researchers were also able to identify a subset of publications in which at least one of the collaborators was a faculty member from another university and another subset in which NJIT graduate students were one or more of the co-authors.

A test comparison against six faculty members' CVs indicated that the accuracy of the NJIT–ADVANCE co-authorship database approached 100 percent. Nevertheless, sustainability remained a concern. In consequence, for the final phase of the project and beyond, NJIT–ADVANCE researchers adopted a new approach for updating the faculty publication database: building a web service to extract bibliographic data from the Digital Measures' Activity Insight faculty reporting system. The fact that the annual report requirement was now linked to teaching load and merit pay seemed to guarantee that self-reported bibliographic data would continue to be added to Activity Insight – and that data cleaning would be institutionalized as well.

Building networks

The initial data collected for analysis included publications by all STEM tenured/tenure-track faculty as well as research professors and faculty from non-STEM departments. From the data, a matrix was created in which rows and columns were faculty members' names, and cells indicated the number of co-authored papers. Thus, cells with 0 values indicated that those faculty members had not co-authored a paper, and any value other than 0 indicated the number of papers those two faculty members had co-authored during the study period (2000–2010). The resulting network was symmetric: if Faculty_A co-authored a paper with Faculty_B, then by necessity Faculty_B must have a co-authorship tie with Faculty_A. Values on the diagonal of the matrix were 0 and were ignored in subsequent analysis (i.e. self-reflective ties were ignored). A sample matrix is illustrated below.

The entire faculty matrix was imported into the SNA tool ORA: organizational risk analyzer (Carley, 2010). As illustrated in the sample network in Figure 2, faculty members became nodes in the network, while co-authored publications were weighted edge lists connecting co-authors. The matrix in Table II would generate the network visualized in Figure 2.

Network attributes

Faculty attributes from a number of sources were also imported into ORA. Human resources provided information on rank, tenure status, hire date, date of promotion(s) and termination date (if applicable). To reflect the longitudinal nature of the study, rank progressions were coded into a single rank variable indicating all ranks held during the study period, and a rank change value was assigned to indicate the number of ranks held. The full list of ranks and rank change values is shown in Table III.

Publication data were also calculated for each faculty member, providing productivity attributes including yearly and total publication counts, counts of co-authored publications, counts of papers co-authored with graduate students and counts of papers co-authored with external co-authors. Each value was also normalized (divided by the number of years the faculty member was in the study) to allow a comparison of productivity over time, adjusting for differences between faculty who were at the institution during the entire study period and those who joined or left at some point during that period.

Finally, data on major committee membership and service obligations were obtained from the Office of the Provost. Because committee service was typically for a specific period of time, these values were not normalized; however, the committee service burden attribute was calculated to weight those committees that were known to meet frequently.

	Faculty_A	Faculty_B	Faculty_C	Faculty_D
Faculty_A	0	0	2	0
Faculty_B	0	0	1	4
Faculty_C	2	1	0	1
Faculty_D	0	4	1	0

Table II.
Sample co-authorship matrix

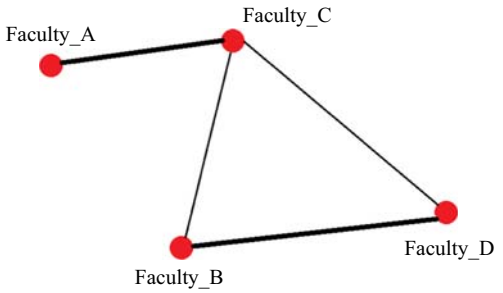

Figure 2.
Sample weighted co-authorship network

Rank	Rank change value
Asst_Prof	0
Asst_Assoc	1
Asst_Assoc_Prof	2
Assoc_Prof	0
Assoc_to_Prof	1
Assoc_Prof_Dist	2
Prof	0
Prof_Dist	1
Dist_Prof	0

Table III.
Ranks and rank change values

Social network centrality measures

All of these attributes were imported into ORA. Then, using ORA's measure calculator, four node-level centrality measures were calculated and added to the attribute file. These measures, listed below, assess different types of co-authorship relationships and provide insights into how faculty members were connected within the university:

- Total degree centrality measures a node's overall level of connectedness in the network by counting the number of ties that exist and dividing that value by the number of ties the node could have.
- Bonacich centrality is similar to total degree centrality in that it measures the total connectedness of a node – how well connected a node is compared to how well connected it could be. Bonacich centrality, however, accounts for the connectedness of a node's neighbors as well; thus, a high Bonacich centrality indicates a node that is connected to many nodes that are also well-connected.
- Eigenvector centrality measures a node's connectedness to well-connected others. This differs from Bonacich centrality in that eigenvector centrality does not take into account the connectedness of the node itself but only the connectedness of its neighbors.
- Betweenness centrality identifies nodes that are gatekeepers or bridges joining two or more groups of nodes. A high betweenness centrality indicates a node that is on many of the shortest paths between the other nodes around it.

For each node (faculty member) in the network, ORA calculated a value for the above centrality measures. Once these centrality measures were added as attributes, research faculty and non-STEM faculty were removed from the data set. This approach ensured that faculty members' centrality measures reflected all of their collaborations with other faculty at the university, but that faculty comparisons described later in this paper explored only STEM tenured/tenure-track faculty. Faculty hired prior to 1980 were also removed. (P&T requirements changed significantly circa 1986.) This cohort of STEM tenured/tenure-track faculty, labeled Cohort 1, enabled the exploration of the interconnectedness of a broad sample of early, mid and late-career faculty at the university ($N = 286$). To gain deeper insights into early-career STEM faculty in particular, another cohort (Cohort 2) was extracted from the data set: STEM faculty who had been hired as assistant professors between 1998 and 2006 ($N = 78$). Researchers were able to obtain promotion data for this cohort up to 2013 to ensure that all individuals in the cohort had the opportunity to be promoted to associate professor with tenure.

With all the attributes (including centrality measures) generated and the two cohorts defined and visualized in ORA, the data were exported for analysis in UCINET 6, a social network analytical package (Borgatti *et al.*, 2002). UCINET performs node-level analysis (*t*-tests and ANOVA) using a permutation test to generate the significance level, so that standard assumptions on independence and random sampling are not required. Using ORA and UCINET to analyze these two cohorts, NJIT–ADVANCE researchers began to track changes in network maps (data visualizations) over time and perform statistical analyses to establish the significance of these changes, uncovering hidden patterns buried in the mass of data. Some interesting results emerged and discussed in the sections below.

Results

Participants

The cohorts examined in this study consisted of STEM faculty in engineering (biomedical, chemical, civil, electrical/computer, industrial and mechanical), life sciences (biology, chemistry, mathematics and physics), computer science, information systems, information

technology and engineering technology. As Table IV clearly indicates, there was a significant gender disparity in both cohorts, with female faculty comprising only 13 percent of the total populations in Cohort 1 and Cohort 2. This reflects the significant gender disparity within the NJIT faculty as a whole, causing concern during gender-based analyses because differences would have to be extreme to be detected using normal statistical tests and statistical results for women could be more sensitive to outliers.

To address the gender disparity, researchers used tools and methodologies discussed previously that apply permutation tests or methods not assuming normally distributed data.

Relationship between productivity and centrality measures

Social network centrality measures do not necessarily equate to productivity: some faculty are very successful publishing alone, with students or with external co-authors. In this study, centrality measures reflect only a faculty member's connectedness with other university faculty. Therefore, researchers explored the relationship between the four centrality measures (Betweenness, Bonacich, eigenvector and total degree centrality) and faculty members' productivity as measured by co-authorship rate and total publication rate.

Table V shows the Spearman correlations (calculated in UCINET 6) for the ORA centrality measures and the two productivity rates: co-authorship publication rate and total publication rate. Spearman's ρ was used because network data violate the assumption of normality (Abbasi *et al.*, 2011).

For Cohort 1, all four of the centrality measures showed a statistically significant positive correlation with both co-authorship rate and total publication rate, with Bonacich centrality and total degree centrality having the strongest correlations with both productivity measures. This suggests that co-authoring with multiple faculty has a positive relationship with overall productivity. Betweenness centrality had the weakest relationship with co-authorship publication rate, and was the only centrality measure for which the relationship with overall publication rate was somewhat stronger than the relationship with co-authorship publication rate, suggesting that a bridging position between groups may lead to fewer collaborations with other university faculty. Together, these results suggest that co-authoring with many other faculty members (having many direct ties) has the

	Total *n*	Men	Women
Cohort 1 – all STEM T/TT faculty 2000–2010	268	232 (87%)	36 (13%)
Cohort 2 – STEM T/TT assistant professors hired 1998–2006	78	68 (87%)	10 (13%)

Table IV. Participants

	Co-authorship publication rate	Publication rate
Cohort 1 – all STEM T/TT faculty (2000–2010) (N = 268)		
Betweenness centrality	0.370*	0.439**
Bonacich centrality	0.805**	0.625**
Eigenvector centrality	0.542**	0.367*
Total degree centrality	0.852**	0.684**
Cohort 2 – STEM T/TT assistant professors (1998 and 2006) (N= 78)		
Betweenness centrality	0.268*	0.416**
Bonacich centrality	0.730**	0.625**
Eigenvector centrality	Not significant	Not significant
Total degree centrality	0.821**	0.741**

Notes: *$p < 0.05$; **$p < 0.01$

Table V. Productivity and centrality

strongest positive relationship to a faculty member's publishing productivity. A similar pattern is seen for Cohort 2, except that eigenvector centrality was not correlated with either co-authorship publication rate or overall publication rate. These results suggest that, even in their early careers, faculty should seek opportunities to work with various faculty members rather than repeatedly publishing with the same one or two co-authors.

Relationship between productivity, centrality measures and advancement in rank

Table VI shows the correlations between productivity (publication) rates, social network centrality measures and rank change value which indicate advancement in rank during the study period.

For Cohort 1, all of the centrality and productivity measures were positively correlated with faculty's number of rank changes during the study period, with the strongest correlation being the relationship between rank changes and total degree centrality. This again suggests that the number of direct ties (co-authors) a faculty member has is positively related to promotion (advancement in rank). Although several of these relationships were not significant for Cohort 2, the strength of the correlation between total degree centrality and advancement in rank suggests that, even for junior faculty, co-authoring with multiple faculty members has a positive relationship with promotion.

Gender differences

In response to self-reported perceptions of isolation among women faculty, all of the attributes were evaluated for gender differences. For Cohort 1, none of the attributes exhibited statistically significant differences between men and women in the *t*-tests conducted in UCINET 6. However, in Cohort 2, several attributes showed statistically significant differences between genders (Table VII).

These results suggest that, for assistant professors hired between 1998 and 2006, female faculty, while being promoted at the same rate as men, performed more committee service than their male counterparts and also brought in more grants.

	Rank change value
Cohort 1 – all STEM T/TT faculty 2000–2010 (N = 268)	
Betweenness centrality	0.201*
Bonacich centrality	0.277**
Eigenvector centrality	0.157*
Total degree centrality	0.300**
Co-authorship rate	0.214**
External co-authorship rate	0.171*
Student co-authorship rate	0.151*
Total publication rate	0.279**
Cohort 2 – STEM T/TT assistant professors hired between 1998 and 2006 (N = 78)	
Betweenness centrality	Not significant
Bonacich centrality	0.240*
Eigenvector centrality	Not significant
Total degree centrality	0.293**
Co-authorship rate	Not significant
External co-authorship rate	0.243*
Student co-authorship rate	0.193*
Total publication rate	0.265**

Notes: *$p < 0.05$; **$p < 0.01$

Table VI.
Productivity, centrality and promotion

Homophily

Analysis of faculty co-authorship ties enabled researchers to better understand the impact of homophily within the university. UCINET calculates homophily using an E-I index, where the number of internal or within-group connections (e.g. male faculty co-authoring with other males and female faculty with other females) is subtracted from the number of external (between-group) connections (e.g. male faculty co-authoring with female faculty or vice versa). The E-I index is calculated for each node and then averaged for all nodes, providing a value ranging from −1 (indicating only within-group collaborations) to +1 (indicating only between-group collaborations).

The E-I index for all faculty in Cohort 1 was calculated. (Note that the sample size in this calculation is 187 for the entire group of STEM T/TT faculty because not all of the 268 faculty members in the study collaborated with other faculty at the university.) After calculating the overall E-I index, nodes were separated by gender, so that gender-specific E-I indices could be calculated. Results are shown in Table VIII.

These results suggest that, for all faculty, there was a tendency to co-author with other faculty of the same gender. When separated by gender, however, the results suggest that female faculty co-authored papers with their male counterparts more frequently, while male faculty were much more likely to co-author with other male faculty.

Longitudinal gender differences in retention and promotion

To evaluate promotion data longitudinally, several Kaplan–Meier survival studies were conducted. The Kaplan and Meier (1958) estimator is used in medical research to estimate the number of patients who will survive for a certain period after treatment. In sociological research, the Kaminski and Geisler (2012) estimator has been applied to estimate the overall "survival time" (retention) of tenured male and female faculty. Kaplan–Meier has also been used to explore differences in promotion rates; in this case, being promoted is considered the end of the faculty member's "life" at the previous rank (Ries *et al.*, 2012).

The plot below tracks NJIT STEM faculty retention over 60 years. For the first 10 years, there was no significant difference between female and male retention patterns. At the 10-year mark, however, female survival dropped off steeply. Given the disparity in the population sizes, it is typically difficult to detect subtle gender differences; however, here the effect is visible. Even the best case for female faculty was worse than the worst case for male faculty. These findings are not definitive, given the small number of women in the study. However, they suggest disturbing gender patterns that were previously invisible and difficult to quantify (Figure 3).

Cohort 2 – STEM T/TT assistant professors (1998–2006) ($N = 78$)			
	Men ($n = 68$)	Women ($n = 10$)	Difference
Committee number	0.60	1.30	0.70*
Committee service	1.31	3.00	1.69*
Grants awarded	0.97	3.40	2.43**

Notes: *$p < 0.05$; **$p < 0.01$

Table VII.
Gender differences

Cohort 1 – all STEM T/TT faculty (2000–2010)	
All co-authors ($n = 187$)	−0.56
Male faculty ($n = 160$)	−0.75
Female faculty ($n = 27$)	0.59

Table VIII.
Homophily

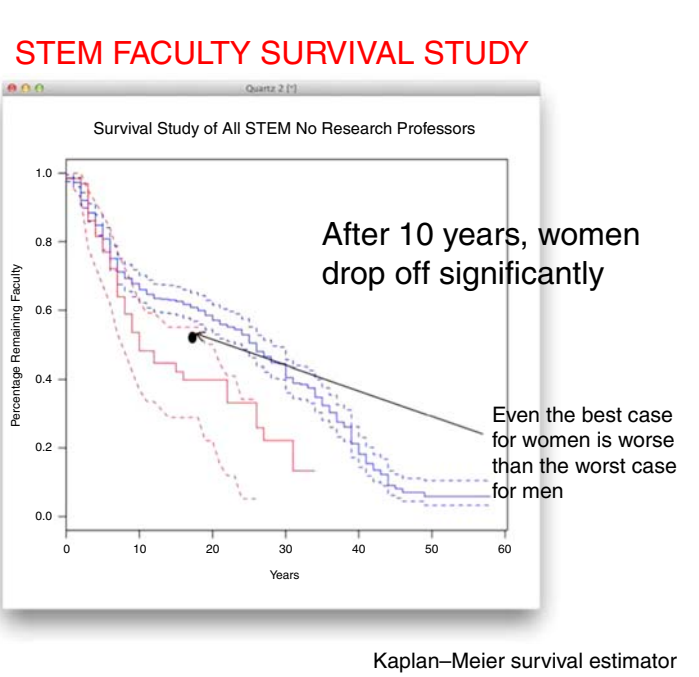

Figure 3.
Kaplan–Meier retention

The Kaplan–Meier survival estimator was also used to investigate possible gender differences among NJIT STEM faculty in promotion from associate professor to professor. Once again, there was a noticeable difference in career trajectories over time. Initially, male and female faculty had approximately the same chance to be promoted. At the seven-year mark, however, the pattern changed. Female faculty not promoted to professor during the first 10 years of their "life" as an associate professor were unlikely to ever be promoted. In contrast, male faculty continued to be promoted up to 23 years after becoming associate professors (Figure 4).

Network visualizations

Having built the co-authorship networks, NJIT–ADVANCE researchers used network visualizations to track these networks as they developed over time. The visualizations in Figure 5 show the growth of the co-authorship networks of female STEM faculty from 2000 to 2010 (female faculty nodes are circled). Through such visualizations, NJIT–ADVANCE researchers were able to identify female faculty for further investigation, such as those whose networks grew significantly and those who remained isolates, even after 10 years.

Because network visualizations provide salient information to those embedded in them, the NJIT–ADVANCE team also developed a data visualization tool: ResearchMap. This tool generates network maps based on either co-authorship connections or similar research interests, allowing faculty to identify potential research collaborators or assess their own positions in the university's co-authorship networks. (In fact, ResearchMap was used to identify mentors for new faculty during the study period by facilitating the identification of other faculty with similar or complementary research interests.) More importantly, ResearchMap visualizes collaborative pathways among researchers, allowing a faculty user to identify colleagues who can broker introductions to other faculty in the network. In addition, the system gives academic administrators an aerial view of collaborative interactions within and among departments, allowing them to track information flow across the university and to quickly identify disconnected individuals and dysfunctional structures (Figure 6).

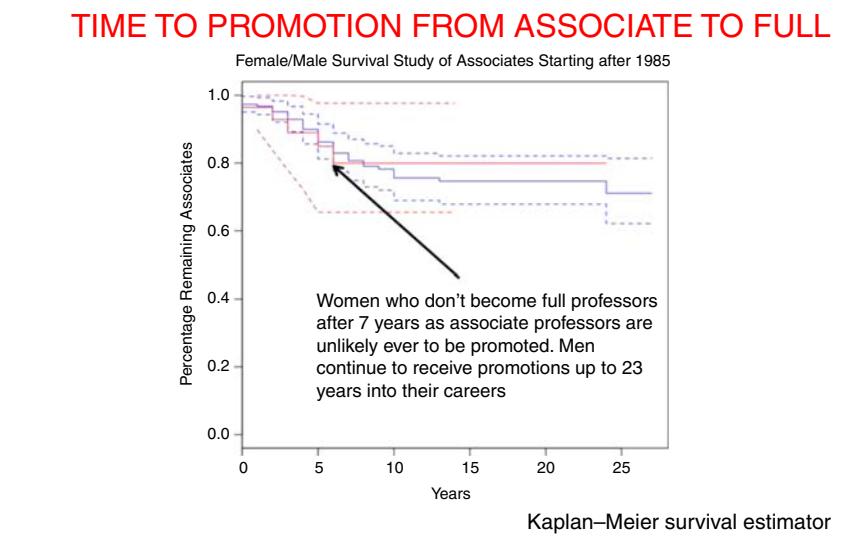

Figure 4.
Kaplan–Meier promotion

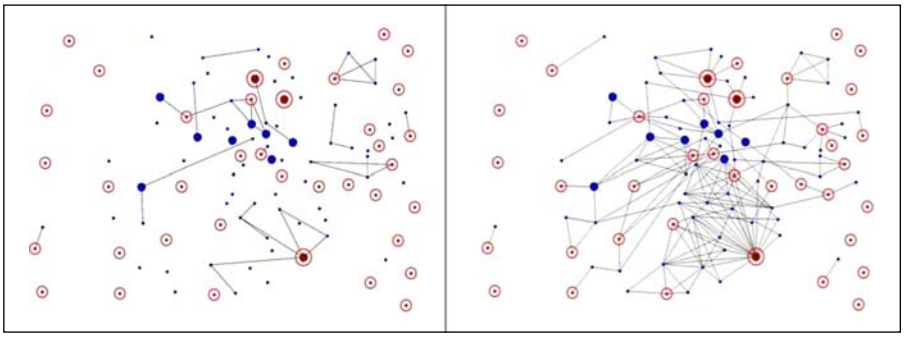

Figure 5.
Female faculty co-authorship networks 2000 to 2010

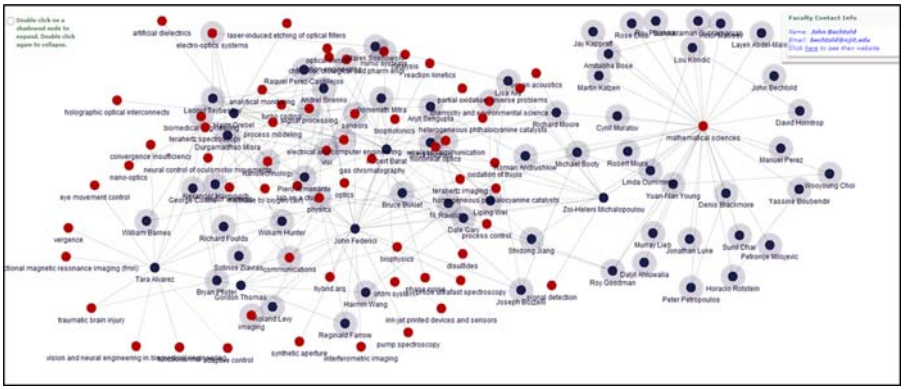

Figure 6.
Faculty connections shown in ResearchMap

Discussion

The NJIT–ADVANCE project utilized SNA to explore faculty co-authorship networks, looking for hidden patterns. First and foremost, the project achieved its primary goal of showing that there is a strong, positive relationship between collaboration (as measured through co-authorship network centrality measures), productivity and promotion. Analysis of the longitudinal data suggests that, while all the centrality measures were positively correlated with productivity and promotion, total degree centrality was the most strongly correlated with both productivity (co-authorship rate and total publication rate) and promotion (number of rank changes) for both cohorts. Thus, in general, faculty seem to benefit from co-authoring with a variety of faculty members rather than repeatedly publishing papers with the same co-authors. This may suggest that co-authorship represents an opportunity for a faculty member to signal her or his value to others, and that signaling value to many others has a positive effect on promotion.

The results of the homophily analysis, combined with the findings discussed above, suggest a potential negative feedback loop for women, however. If co-authorship is a powerful method for faculty members to signal their value to others, and if male faculty co-author more with other male faculty, it is more difficult for women faculty to show their value to their male colleagues. It is important to note that E-I indices do not account for the gender disparity at the university; male faculty may collaborate more with other male faculty simply because there are more male faculty available. However, the indices calculated for each gender group reflect an overall tendency for men to collaborate more often with men and for women to also collaborate more frequently with men. Regardless of the motivation for these tendencies, the fact that male faculty collaborate infrequently with female faculty is potentially problematic for the advancement of women in STEM.

Although none of the faculty attributes showed statistically significant gender differences for Cohort 1, this could be the result of the disparate sizes of the two groups. Additional analyses are being conducted using non-parametric tests to identify subtle gender differences. In Cohort 2, however, there were statistically significant differences between male and female assistant professors, with female faculty serving on more committees and bringing in more funded grants. This suggests that, for the same result (promotion to associate professor), women actually did more than their male counterparts.

Finally, in the application of the Kaplan–Meier survival analysis to retention and promotion, female faculty fared far worse than their male counterparts. These findings reveal patterns that would be otherwise difficult to identify, raising important questions about retention and promotion of women faculty that must be addressed by the university's senior leadership.

Methodological implications

The results of this study provide several methodological implications. First, researchers seeking to investigate faculty collaboration are justified in using bibliometric co-authorship data as a valid proxy for other types of connections that are more difficult to capture and verify (e.g. friendship or advice). However, researchers must carefully consider the boundaries of the whole network they intend to study. It was only through the investigation of outlier data that researchers identified the change in promotion patterns that occurred in 1986. Had the network included all faculty still at the university at some point between 2000 and 2010 (not just those hired 1980 and later), results would have been skewed, particularly in any analysis of number of years spent at a particular rank.

Similarly, the decision to investigate assistant professors hired from 1998 to 2006 was based upon informed decisions that placed the starting year at a time that would allow the first of the assistant professors sufficient time to advance to associate professor and potentially even to professor during the study period. The last year included in Cohort 2 was

determined by the last year for which P&T data were available during the grant period (2013), giving all assistant professors sufficient time to be promoted with tenure (or not).

This study also identifies the strengths and weaknesses of various data collection methods for capturing bibliometric data. Although Scopus and other databases are easily mined, many of the problems that bedeviled ADVANCE researchers persist even today. Self-reported data are more reliable, particularly if vetted by the university for merit or P&T purposes, but can be difficult to collect. However, new faculty reporting tools provide a means of automating the collection of faculty self-reported data and may also enable collection of multi-modal data, allowing researchers to explore not only co-authorship but also other forms of faculty collaboration (e.g. grants and committees) as they emerge.

Practical implications

This study has several practical implications. First, the fact that network structure is correlated with productivity and advancement in rank suggests the importance of programs such as faculty mentoring to ensure women and URM faculty are well integrated into the university population. Faculty are more productive and are more successful in attaining promotions when they collaborate with many others. To be successful, therefore, women and URM faculty may need assistance from academic administrators to find opportunities to collaborate with other faculty.

One way to identify faculty in need of intervention, and to evaluate the efficacy of interventions, is through the development and use of interactive network mapping tools such as ResearchMap. Such tools can provide critical feedback to faculty, administrators and funding programs such as NSF Advance through visualizations of network changes over time. For individuals, network mapping can function as a "GPS system for career navigation," showing faculty members their network positions as well as those of their peers, making otherwise hidden power structures visible. The ability to see peers and their connections also has the potential of reducing the "transaction costs" of identifying and gaining introductions to potential collaborators.

For administrators, network mapping provides a Copernican view of their organization and the interactions occurring within it. Because faculty success (i.e. rank) is by definition affected by the power structures in an organization through the P&T process, network visualization tools can enable academic administrators to identify faculty members who are relegated to the periphery and who would benefit from some forms of intervention. Preferential patterns of collaboration such as homophily are also evident in network visualizations, providing opportunities to investigate and address such inequalities. As an added benefit, interactive faculty mapping provides a graphical tool for universities to brand their research strengths by publicizing networks based on faculty research interests.

Limitations and future work

This study has several limitations that may affect its generalizability. First, it was conducted at a single, STEM-focused research university in an urban setting in the northeastern USA. Similar studies at other institutions may generate different results. The statistical difficulties arising from the disparate sizes of the gender groups might also be alleviated at other universities that have a more gender-balanced faculty population; and yet gender balance is rare at STEM institutions. (In other words, ironically, the very problem that ADVANCE seeks to address – the paucity of women in STEM – confounds the effort to study it.) In addition, although the longitudinal nature of the study was designed to provide a large enough sample size to reduce the effect of yearly fluctuations, the researchers are aware that, during at least part of the study period, the university hired fewer new faculty than previously, or subsequently. Thus, future studies may generate different results.

Future studies should explore alternate methodologies for collecting co-authorship data; NJIT–ADVANCE researchers tested several alternatives, but with constant improvements in search engines, databases and other technologies (including the new ORCID author identifiers), more accurate methods may emerge. Other connections (e.g. serving together on committees, working in the same research lab) could also be integrated into future studies, creating multi-modal networks reflecting different types of organizational interactions that may provide deeper insights into faculty members' embeddedness. NJIT–ADVANCE researchers are also continuing their analysis on the two cohorts discussed in this paper, conducting non-parametric statistical analyses of faculty attributes for deeper understanding and qualitative analysis of faculty networks through comparisons of network growth over time.

Finally, researchers performing similar studies may benefit from sharing their data to facilitate inter-institutional comparisons. Such data sharing could provide a truly Copernican view of the status of women and URM faculty across STEM institutions, giving institutional administrators and government policymakers critical information to guide future efforts to increase diversity in STEM.

Conclusions

Despite recent efforts of universities and organizations such as the NSF to increase the population of females and under-represented minorities in STEM academia, gender imbalances continue to exist. A major goal of this study was to understand whether encouraging collaboration – a frequent intervention suggested by many NSF Advance projects – is actually beneficial to women faculty. Using a novel approach that captured bibliometric data to create social networks representing faculty and their co-authored papers, this study found that faculty network centrality measures were correlated with both productivity and promotion, suggesting that collaboration is indeed one powerful tool for faculty to signal their value to others. Furthermore, network visualizations can give administrators a bird's eye view of the academic work environment they manage, enabling them to address isolation in their organizations, while at the same time providing faculty with a sort of GPS that makes apparent their own positions (and the positions of their peers) in such collaborative networks. Particularly for women and URM faculty, such knowledge can be empowering, giving them visual cues that can guide proactive efforts to seek out new opportunities for collaboration. Together, the methods and findings of this research lay the foundation for the use of SNA as a powerful tool that enables the exploration of many types of faculty interactions for hidden patterns of embeddedness and isolation, and the assessment of the efficacy of institutional interventions in achieving positive structural change in faculty networks.

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