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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