International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

Professional Development Programs for Women in Academic Science, Technology, Engineering, and Math (STEM) Fields: Enhancing Retention and Promotion

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ABSTRACT

Under-representation of women in academic Science, Technology, Engineering, and Math (STEM) requires multi-faceted solutions focused on retention along with recruitment. This study evaluates programs developed to provide mentorship, work-life balance support, and leadership training, all aimed at ensuring retention. Perceived benefits and objective productivity markers were investigated, relying on quantitative and qualitative data. High levels of satisfaction were reported for career-advancement initiatives, with the program providing support during periods of personal challenges rated somewhat higher. Together, programs resulted in productivity gains, including more publications, conference presentations, and promotions post-participation, although grant submissions were not affected. This study provides preliminary support for multi-faceted career development efforts, spanning scholarship and work-life balance, and targeting STEM women academic staff across the career trajectory. Similar efforts are likely to be effective in other higher education settings, in the United States (U.S.) and elsewhere, providing career support and development opportunities for women in STEM. "Best practices" resulting from this program implementation are currently being disseminated regionally in the U.S. through the Pacific Northwest Partnership effort funded by the National Science Foundation (HRD–1936019) and await broader applications.

KEYWORDS

career development, academic staff, women in STEM, program evaluation, academic administrators

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The phenomenon wherein women do not progress as far as men in Science, Technology, Engineering, and Math (STEM) is widespread around the globe (World Economic Forum; 2017). According to the National Science Foundation (NSF) in the United States (U.S.), women in academia face inequities in salary, grant acquisitions, and recognition (NSF, 2018). Gender representation progress in academic STEM has not been stagnant in multiple estimations (Beeler et al., 2019; Gordon, 2014; NSF, 2018). Women remain underrepresented in undergraduate and graduate degree STEM programs, are more likely than men to change majors to non-STEM disciplines, are less likely than men to pursue postdoctoral and tenure track positions and are underrepresented at the highest ranks as professors and leaders in the field (NSF, 2018; Van Miegroet et al., 2019; Xu, 2016). In the U.S., where the present effort is focused, women received approximately 25% of all doctoral degrees in STEM fields in 2014/2015, held 28% of STEM occupations overall, 24% of full-time professor positions at four-year universities and colleges, 15% of full-time professorships in engineering, and were overrepresented at 'less prestigious' institutions (NSF, 2018). By some estimates assuming current rate of grown, no gender inequality, constant faculty size, and one-to-one replacement of permanent academic staff, it would take at least 50 years for women to achieve parity in terms of numbers employed in the highest academic ranks (Valentine, 2017).

Perhaps most importantly, gender inequity in STEM could have detrimental effects on the quality of work produced in related fields. Without a diversity of perspectives, scientific efforts on grand challenges facing the world can be stymied and the number of solutions limited (Schueller-Weidekamm & Kautzky-Willer, 2012). Moreover, any group without adequate representation in disciplinary leadership is less likely to benefit from initiatives targeting their concerns (McLaren, 1991). When women in STEM fields are few, they can be singled out for their gender as opposed to their contributions as scientists (Kanter, 1993; Sonnert & Holton, 1996). If STEM (as a set of fields) and academia (as a place to work) are not viewed as viable options for women, the best and brightest will pursue other professions and fields (Golde & Dore, 2001; Sallee, 2011). Women are globally under-represented in STEM fields, both with respect to the number of graduates (especially doctorate degrees) and participation in occupations (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2017). It should also be noted that social and financial inequities are closely linked. Overall, STEM professions tend to pay higher salaries than non-STEM fields (Bureau of Labor Statistics [BLS], 2019). Moreover, dismissing the talent of half the population is not acceptable, as for example in the U.S., in less than 10 years 1.7 million more engineers and computing professionals will be required (American Association of University Women, 2020). Remedying the gender imbalance in STEM, especially at the highest levels of the academic hierarchy, will not only improve these fields, but will have greater societal implications in terms of achieving gender equality.

The underrepresentation of women in academic science careers is at odds with the widespread objective of fostering scientific innovation through an inclusive, diverse workforce (American Association for the Advancement of Science, 2010; Morimoto & Zajicek, 2012; National Research Council, 2010; NSF Science & Engineering Indicators, 2014). Two competing theories attempt to explain low numbers of women in STEM academic fields (Ulriksen et al., 2010). The 'pipeline' theory suggests that women are lost to academia, and STEM fields in particular, due to hiring discrimination and/or mid-career dropout. The reasons for this attrition are largely attributed to individual and personal choices such as work-life imbalances and family issues (Goulden et al., 2009; Xie et al, 2015). However, family responsibility does not always interfere with work performance (Jean et al., 2015), and married female professors were shown to have higher productivity- including teaching (e.g., number of classes taught) and research (e.g., number of refereed articles, funded scholarly activity, etc.), than those who reported being single (Kelly & Grant 2012). A second explanation for the low numbers of female professors in STEM disciplines has been coined the 'deficit' theory. This theory focuses on the idea that career outcomes of female academic staff are linked to obstacles that result in an accumulation of disadvantages. Small differences in access to 'scientific goods' such as resources, mentoring, or public visibility spiral over time, leading to significant divergence in achievement over the career course (DiPrete & Eirich, 2006). Notably, postdoctoral level women mentored by high-profile, prestigious scientists were more likely to be successful themselves (in terms of grants awarded, numbers of publications, and prestige) than those without mentorship advantage (Sheltzer & Smith, 2014). These results were interpreted as supporting the 'deficit' theory, as the resolution of deficits (i.e., access to high-profile, prestigious scientist mentors) led to considerable achievements and career advancement for women involved.

Regardless of the best explanation for the limited representation of women in STEM, it is clear that transitional career points are critical moments for women in academia (Mason et al., 2013). Most programs for women in academic STEM fields focus on early career academic staff. Yet, women represent only 29% of all full professors across STEM fields in the U.S. (Kena et al., 2015) and in some fields considerably less (e.g., 6.3% of full professors in engineering). Moreover, midcareer academic staff experience post-tenure blues, a slump, or a let-down (Austin, 2010; Mathews, 2014; Trower, 2011). Harvard Collaborative on Academic Careers in Higher Education surveys found that midcareer professors experienced lower levels of satisfaction across all 20 of their project themes (e.g., shared governance, leadership, collaboration, retention, and recognition), with increased dissatisfaction correlating to the length of time midcareer academic staff remain without further promotion or career advancement (Harvard Collaborative on Academic Careers in Higher Education, 2014). This mid-career slump, disparity at the full professor rank, and evidence for attrition at each stage of the 'pipeline' (Van Miegroet et al., 2019; NSF, 2018), makes it imperative to focus systemic and evidence-based efforts on supporting women in academic STEM across their career trajectories. The trend of underrepresentation is also prominent in administrative leadership roles in STEM fields, and academia more broadly, as comparatively few

women are included in the academic organizational hierarchy, especially in research universities. For example, women comprise 25% of mathematics department chairs, 29% of chemistry department chairs, and 10% of physics department chairs in the U.S. (McCullough, 2019). This underrepresentation of women at the highest ranks of professoriate and senior levels of academic leadership likely reflects cumulative effects of barriers at different junctures of their careers, consistent with the 'deficit' model (DiPrete & Eirich, 2006; McCullough, 2019).

A MULTI-FACETED APPROACH TO ENHANCING RETENTION AND PROMOTION

Washington State University (WSU) is a large doctorate degree granting institution that also includes a veterinary medicine program and the Elson L. Floyd College of Medicine. ADVANCE at WSU represents a set of programs that were initiated with an Institutional Transformation (IT) grant from NSF (HRD-0810927), with key initiatives sustained by the Provost's office, designed to address barriers faced by women on the way to higher ranks and leaderships positions in STEM fields. Specifically, the following programs addressed herein represent the cornerstone of ADVANCE at WSU academic staff support: External Mentor (and External Mentor-Pilot Extension), Transitions Grant, and Leadership Award, targeting women in STEM disciplines at all ranks, with the goal of promoting career development, elevating scholarship, and enhancing leadership engagement. Together, these programs were designed to support retention and promotion across the career trajectory, including beginning and mid-career women academic staff.

The External Mentor program aims to foster career development and scholarship advancement by supporting the development of mentoring relationships with off-campus leaders. These mentors provide training and guidance, facilitate collaborative research efforts, and provide examples of strong, senior role models. This program is based on a sizable literature demonstrating that mentoring by successful, dynamic individuals with large professional networks significantly influences career outcomes for women, especially in STEM (e.g., DeCastro et al., 2013; Gorman et al., 2010; Heilbronner, 2012). Moreover, mentoring is a transformative mechanism for increasing the representation of women at more senior levels of academic STEM (Ben-Shachar, 2014). External mentors confer several advantages, including shared scientific interests and perspectives not conflicted by organizational connections (Law et al., 2014). The External Mentor-Pilot Extension program represents a continuation of the External Mentor experience, providing an opportunity for data collection with the mentor and developing an external funding agency application on the basis of this collaborative effort. The External Mentor program provides funding for: 1) a mentor visit to WSU to meet with the mentee and engage in an activity that would be helpful to the mentee (e.g., view labs, review data or writing); (2) a research seminar by the mentor to the individual's department (or broader if desired); (3) regularly scheduled time designated for the mentor to spend with the mentee (either at WSU, on their own campus, or via electronic communication [e.g., monthly Skype meetings]); (4) a mentee visit to the mentor's lab or other professional site to further engage in activity that would be helpful to the mentee (e.g., lab visit, training in instrumentation or laboratory technique, campus networking). Each

mentee selected a mentor – a senior professor from another institution deemed expert in theirs, or a closely related field. The cost of this program ranged from $2,000 to $5,000, largely as a function of travel expenses. External Mentor-Pilot Extension opportunity is available after successful completion of the External Mentor program, providing support to obtain preliminary data required for external funding applications for larger-scale research with mentors ($5,000 to $10,000 awards).

The Transitions Grant program provides institutional support to maintain a healthy work-life balance during personally challenging periods. This program provides short-term assistance, such as instruction-related support (funding for someone to take over teaching responsibilities), and research assistance (lab supervisor, postdoctoral fellow or graduate student funding) in the midst of major life transitions (e.g., personal medical issues, significant family disruptions). There is a strong theoretical foundation for this program, as it is intended to overcome barriers described in the 'pipeline' model (e.g., challenges associated with attempts to balance family and work commitments) that disproportionally affect female academic staff (Goulden et al., 2009; Xie et al., 2015). This program is also in line with the 'deficit model' explanation for under-representation of women in academic STEM, intended to provide access to 'scientific goods' despite personal challenges (DiPrete & Eirich, 2006). The Transitions program was also developed in light of mounting evidence that support for work-life balance is often limited or lacking all together, disproportionately impacting women who typically face greater family responsibilities (Strong et al., 2013). Thus, the Transitions Grant provides support for academic staff required to fulfill their teaching and/or research obligations during challenging periods in their career, with costs ranging from $10,000 to $20,000.

The Leadership Award is an initiative for supporting participation in leadership training and other opportunities, with the primary aim of fostering career development. The initiative is intended to help female professors in STEM through the promotion process, also encouraging them to seek administrative responsibilities, taking on department, college, and university leadership roles. This program enables participation in experiences structured to support both leader (intrapersonal) and leadership (interpersonal) development (Day et al., 2014). The long-term objective is to overcome the severe under-representation of women in leadership roles within STEM disciplines and administration of STEM academic units (McCullough, 2019). The Leadership Award funding supports trainings and opportunities that require registration fees and/or other expenses, with awards ranging from $2,000 to $5,000. Applicants must demonstrate potential for career advancement and assistance in reducing barriers (e.g., with respect to pursuing administrative/leadership roles in STEM academic units).

This investigation was focused on female academic staff in STEM who took advantage of the ADVANCE at WSU External Mentor/External Mentor-Pilot Extension, Transitions Grant, or the Leadership Award programs - specifically, their program satisfaction, objective markers of career and scholarship advancement that could be attributed to program participation, and themes emerging in

qualitative narratives provided in response to the open-ended questions outlined below. This program evaluation effort was intended to support dissemination of "best practices" across the U.S. and internationally, as gender equity in STEM represents a world-wide concern (UNESCO, 2017). The goal of the program evaluation was three-fold: (1) to examine survey data from participants addressing their satisfaction/perceived impact on productivity; (2) to analyze objective productivity markers (e.g., number of promotions, publications, and grants) pre- and post- program participation; and (3) to summarize qualitative data obtained from participants regarding program acceptability/satisfaction, potential benefits, and recommendations for improvement. Thus, primary research questions listed below involved satisfaction with each of the programs, overall participation effects with respect to objective performance indicators, as well as perceptions of those taking part provided in narrative responses to open-ended questions.

To what extent did taking part in External Mentor/External Mentor-Pilot Extension, Transitions, or the Leadership Award program result in participant satisfaction?

How did participation in ADVANCE at WSU programs aimed at retention/promotion of women academic staff in STEM (i.e., External Mentor/External Mentor-Pilot Extension, Transitions, and the Leadership Award program) affect objective performance markers (e.g., number of publications/presentations, external grants)?

What impressions/themes regarding program participation highlighting potential benefits (or lack thereof) could be discerned by asking open-ended questions:

1. If you were a recipient of the External Mentor award, to what extent was the professional benefit you experienced worth the time and effort you put into obtaining the grant and working with your mentor?
2. If you were a recipient of the External Mentor-Pilot Extension award, were you able to successfully collect data with the assistance of your external mentor?
3. Have your students benefited as a result of your relationship with your mentor, knowledge you gained from interactions with him/her, or if you are the recipient of the External Mentor-Pilot Extension award, the data collection project?
4. Overall, how would you describe the professional benefit you experienced as a result of events or activities supported completely or in part by the Transitions grant?
5. Have you conducted research that would not have been possible (or would have been unlikely) without the Transitions grant?
6. Have you submitted or published any papers that would not have been possible (or would have been unlikely) without the events or activities you participated in as result of the Leadership Award program?
7. Overall, to what extent was the professional benefit you experienced worth the time and effort you put into obtaining the grant and pursuing Leadership Award opportunity?

METHOD

All participants were women (N=42) and academic staff in STEM disciplines (Table 1) who took part in ADVANCE at WSU programs between 2014 and 2018 and provided survey data in 2018: External Mentor (n=22), External Mentor-Pilot Extension (n=6), Transitions Grant (n=5), Leadership Award (n=8). Institutional data documenting external grant applications/awards and promotions were also collected at that time, with program evaluation narratives obtained in 2019. Participants were all permanent academic staff, representing different points along the career trajectory (i.e., pre- and post-tenure): assistant professor (n=29); associate professor (n=9); professor (n=3). The response rate was 98.6% for the online survey, with the follow-up short-answer narratives returned at the rate of 55.56%.

Table 1. Science, Technology, Engineering, Math (STEM) academic units.

- Animal Sciences
- Anthropology
- Biological Systems Engineering
- Chemical Engineering and Bioengineering
- Chemistry
- Civil and Environmental Engineering
- Crop and Soil Sciences
- Economic Sciences
- Engineering and Computer Science
- Entomology
- Food Science
- Global Animal Health
- Horticulture
- Human Development
- Institute of Biological Chemistry
- Integrative Physiology and Neuroscience
- Mathematics
- Mechanical and Materials Engineering
- Physics/Astronomy
- Plant Pathology
- Political Science
- Psychology
- School of Biological Sciences
- School the Environment
- School of Molecular Biosciences
- Sociology
- Veterinary Microbiology & Pathology

Evaluation efforts included anonymous online surveys obtained from participants by the WSU Social and Economic Sciences Research Center (SESRC). The majority of survey questions were tailored to each of the programs because of their individual

objectives (e.g., relationship building for External Mentor and preliminary data collection for External Mentor-Pilot Extension), with the exception of four satisfaction items considered herein for comparative purposes.

Institutional data maintained by the WSU Office of Research provided information concerning the number of external grants for which participants had applied, before and after taking part in the programs, and the grants they were able to obtain. Institutional research data also served as the source of promotion-related information. Additional productivity data pertaining to the number of publications, conference presentations, honors received, and leadership positions held, was gleaned from current participants' curriculum vitae (CVs), typically updated by Information Technology support staff and publicly available online. All productivity indicators — Promotions, Leadership, Journal Publications, Honors, Conference Presentations, and Grants (number applied and awarded) — were considered up to 3 years prior to ADVANCE at WSU program participation and up to 3 years after. Promotions included tenure (i.e., progressing from assistant to associate professor rank), and earning the designation of full professor. Leadership indicators included all internal and discipline leadership roles: departmental, college, university, state, and national-level positions. Publication counts were based on refereed journal entrees only; books, book chapters, and published abstracts were excluded. For Honors, all recognition (internal and discipline-specific) and awards, except grants and external funding, were considered, with fellowships conveying recognition/prestige (i.e., bestowed by an esteemed scientific body/organization), but not actual funding, included in this category. Poster and paper presentations at local, state, national, and international conferences were counted toward the Conference Presentations totals. Only external funding was considered for the Grants indicators, with primary agencies including the National Institutes of Health (NIH), National Science Foundation (NSF), and United States Department of Agriculture (USDA).

Finally, all the ADVANCE at WSU program participants had been informed that they would be asked to participate in a final program evaluation, conducted by ADVANCE at WSU. The narratives provided in response to these open-ended questions were processed using a thematic analysis approach. That is, participants responses were coded for key words and themes related to the guiding research questions of the project.

ANALYTIC STRATEGY

First, descriptive statistics were derived and distributions examined for each of the ADVANCE at WSU programs separately. We focused on the four 4-point satisfaction items (ranging from 1=not at all, to 4=completely) that were consistent across evaluation surveys conducted for each of the four programs: (1) "To what extent did the program meet your expectations?" (2) "Overall, how satisfied were you with the program?" (3) "To what extent did the program benefit you personally?" (4) "If a colleague or friend asked you about the program, how strongly, if at all, would you recommend it?"

Second, these four satisfaction items were factor analyzed to determine if a unidimensional satisfaction scale was tenable. Specifically, both principal component analysis (PCA) and maximum likelihood confirmatory factor analysis (CFA) were applied. These four items were then aggregated (by taking an unweighted average score), and the internal consistency reliability of this satisfaction scale was assessed using Cronbach's α and McDonald's ω (see, e.g., Hancock et al. 2018; 2020). Descriptives for this scale were computed for the ADVANCE at WSU programs: External Mentor, External Mentor-Pilot Extension, Transitions Grant, Leadership Award, with preliminary comparisons of differences performed via a one-way Analysis of Variance (ANOVA). Third, analyses turned toward seven productivity variables obtained from the WSU Office of Research and participants' CVs (Promotion, Leadership, Journal Publications, Honors, Conference Presentations, Grants Applied, Grants Awarded), with pre-post differences tested for statistical significance, including all participants across the four programs. With respect to the qualitative data analysis, information from participants' narratives was reduced to significant statements or quotes (Creswell, 2007), subsequently combining these into themes. This approach allows for a textual description (Fairclough, 2003) of the ADVANCE at WSU program experiences, meaning that short answers were gleaned for words, sentences, and sentiments that illustrated participants' experience and the meaning ascribed to these. Theme reduction efforts are inherently selective, and we were primarily interested in perceptions of acceptability and satisfaction, potential benefits (or lack thereof), resulting from the ADVANCE at WSU program participation to further gage their efficacy for increasing professional opportunities to aid in retention/promotion of women in STEM fields. This information is critical to the present evaluation effort, providing a window onto the richness of participant experience and reflection, captured through the aforementioned open-ended questions and resulting narratives.

RESULTS

Quantitative outcomes

Descriptive statistics were largely indicative of high levels of satisfaction across all of four programs evaluated herein: External Mentor, External Mentor-Pilot Extension, Transitions Grant, and Leadership Award (Table 2). Our attempt to build a satisfaction construct based on the four items consistent across ADVANCE at WSU funding mechanism was successful, with PCA yielding a first eigenvalue accounting for over two-thirds of the four items' variance. The satisfaction scale created by averaging these four items was internally consistent, with both the Cronbach's alpha (α=.85) and McDonald's omega (ω=.87) providing support for its reliability. The four program groups' scale means were 3.68 (External Mentor), 3.50 (External Mentor-Pilot Extension), 3.95 (Transitions Grant), and 3.33 (Leadership Award), with a difference that approached significance ($F=2.39$; $p<.10$). Post hoc comparisons relying on Tukey Honest Significant Difference (HSD) tests indicated a trend-level difference between Transitions Grant and Leadership Award recipients (mean difference = -.62; $p<.10$), with Transitions Grant participants expressing marginally greater satisfaction overall.

Table 2. General Questions about Program Satisfaction: Means and Standard Deviations.

	External Mentor (n=22)	External Mentor-Pilot Extension (n=6)	Transitions (n=5)	Leadership (n=8)
To what extent did the program meet your expectations?	3.52 (.59)	3.20 (.84)	4.00 (.00)	3.33 (.52)
Overall, how satisfied were you with the program?	3.73 (.55)	3.60 (.55)	4.00 (.00)	3.33 (.52)
To what extent did the program benefit you personally?	3.55 (.60)	3.20 (.84)	3.80 (.45)	3.33 (.52)
If a colleague or friend asked you about the program, how strongly, if at all, would you recommend it?	3.96 (.21)	4.00 (.00)	4.00 (.00)	3.33 (.82)

Note. Standard Deviations presented in parentheses.

As noted, all four ADVANCE at WSU programs were focused on retention/promotion and shared a common goal of supporting women academic staff in STEM fields in terms of their scholarship and advancing career trajectories; thus, productivity-related analyses examining potential contribution to career development relied on a composite approach (i.e., examining all the programs jointly). Pre- and post-program participation differences across all programs combined were examined for objective markers of productivity, including Promotion (whether or not the person has been promoted), Leadership (number of leadership positions), Honors and Awards (number received), and the number of Conference Presentations, Grants Applied, and Grants Awarded. Dependent-sample t-tests and tests of dependent proportions (for binary outcomes) revealed several statistically significant differences, including Promotion ($p<.01$), Journal Publications ($p<.01$), and Conference Presentations ($p<.05$), in the anticipated direction, with post-program gains for all ADVANCE at WSU program participants (Figure 1).

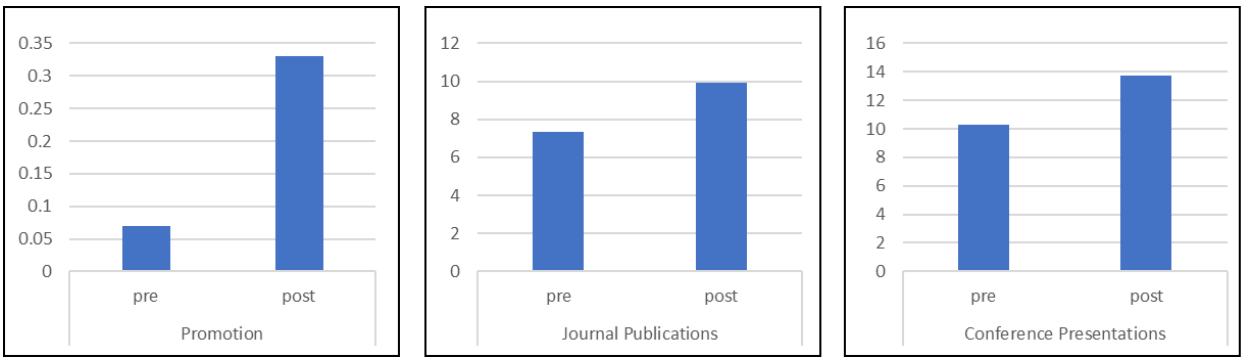

Figure 1. Objective Productivity Markers, Pre- and Post-Program.

Qualitative outcomes

Participants' responses to open-ended questions from the program participation report offered a qualitative perspective on the effects of ADVANCE at WSU programming. These narratives were indicative of several themes reflecting perceived benefits for those taking part in all four programs. Overall, themes discerned from responses speak to the acceptability of the programs offered and satisfaction with participation, which was viewed as leading to substantial personal and broader benefits. Specifically, prominent themes reflected that support provided through ADVANCE at WSU programs resulted in **greater productivity**, **enhanced professional networks**, as well as **enhanced research training** for students in participants' laboratories. Whereas the **greater productivity** theme was universally present in narratives across the four ADVANCE at WSU programs, **enhanced professional networks** were primarily noted by academic staff taking part in the *External Mentor* program, and **enhanced research training** was identified as a benefit by those involved in the *External Mentor and the External Mentor-Pilot Extension.* With respect to **greater productivity**, all participants described elements of this theme focusing on more extensive publication and grant-writing efforts. Not surprisingly, those who were recipients of the *Transitions Grant* noted work-life balance support in promoting publication and grant writing work (see example below). **Enhanced professional networks** were described by 17 of 22 External Mentor participants, speaking to the program's ability to expand the scientific community within which participating women academic staff were embedded. **Enhanced research training** was a less frequently appearing theme, that was nonetheless deemed important, as it was noted by some (3 of 6) *External Mentor-Pilot Extension participants*, as well as those taking part in the *External Mentor* program (10 of 22). Although this program was not intended to benefit graduate students studying with women academic staff taking part, this "trickle-down" effect provides support for its value in terms of facilitation of research activities, including mentoring of students. Some example responses to open-ended questions presented earlier illustrating these themes are provided below.

Greater Productivity

[Mentor's name] helped me prioritize some of my writing and publication schedule to meet my goals of having a strong portfolio for my application to full professor. As a result, I was able to publish twice the amount of journal articles/book chapters the following year (*External Mentor*).

My mentor provided access to samples and existing data that will form the basis of a publication and grant proposals that I could not have generated without the financial assistance and formalized collaborative agreement/structure provided by the ADVANCE program (*External Mentor-Pilot Extension)*.

It was important that my research progress not slow down or stop while staying home with my daughter. These funds allowed for me to continue to engage with a network of researchers and stay engaged with current research at the conference and continue project progress and active collaborations. I was able to balance having a new baby and a nearly 3-year-old all while still applying for grants and somewhat maintaining my sanity. I was recently looking back on emails from October and November 2017, and I was astounded with my own productivity! I attribute much of this to the grant and the ability to devote less time to the daily needs of the laboratory (*Transitions Grant*).

The leadership program helped me to develop a daily writing regime that has improved my writing productivity. Since my participation in the program, I have submitted one paper and two other papers are close to being ready to submit… By improving my writing productivity, I was able to submit numerous grant proposals last year, some of which were funded (*Leadership Award*).

Enhanced Professional Networks

Thank you because this was truly a wonderful experience. The formalization of a relationship with someone senior in the field is really something that most young academic staff would benefit from (beyond our formal mentors of PhD and other degrees). ADVANCE has been truly pivotal in my recent development as an associate professor (with an eye towards applying for full professor within the next two years). Not only has the ADVANCE External Mentor grant been financial supportive, but more importantly it has allowed me to create contacts both nationally and internationally that I believe will be beneficial for years to come (*External Mentor*).

I think the key assistance has been to help me feel like a part of the broader community studying plant-microbe interactions in agriculture, rather than an outsider. [Mentor's name] has also been helpful in connecting me to others in my field (*External Mentor*).

I feel that I developed a lifelong relationship with [mentor's name]. Before obtaining this NSF-funded grant, I already had the benefit of having several powerful female mentors in my specialty field; however, the world is small

and can be cliquey. Having this grant gave me 'cover' to expand outside my existing (sometimes insular) network (*External Mentor*).

Enhanced Research Training

One of my current Ph.D. students has directly benefited from the External Mentor Pilot Extension award by gaining access to preliminary data generated with the financial support from this program. The preliminary data demonstrate the feasibility of her dissertation research. My larger graduate cohort also benefited greatly from one-on-one meetings with my mentor during her visit. In particular, they benefited from being able to discuss the promise and feasibility of their potential research projects (*External Mentor-Pilot Extension*).

It allowed me to mentor a master's student relying on expertise I picked up from the exchange with my external mentor, which got me to feel comfortable to actually have a student do a project in a new/related area of science. I didn't have that expertise before and now there's a successful master's degree candidate because of that external mentorship, so I think that has definitely added to my ability to mentor students and educate students in the department (*External Mentor*).

[Mentor's name] came here, she spent several days here and she met with my graduate students. We talked about how to establish the lab, how to develop graduate students, she actually invited one of my graduate students to come to her lab (*External Mentor*).

Suggestions for Program Improvement

It should also be noted that a number of participants provided suggestions for program improvement, which have largely been implemented. For External Mentor, it was recommended for the ADVANCE program to facilitate the match between the participant and the mentor, making the initial outreach to the potential mentor. With respect to the Transitions Grant, a suggestion was to make this funding available to academic staff more broadly. Finally, there was a recommendation to extend the Leadership Award to funding opportunities enabling participants to become leaders in the field (e.g., attending steering committee meetings for scientific societies).

DISCUSSION

The present program evaluation was three-fold, making use of self-report survey data gauging satisfaction and perceived impact, objective markers of productivity, and qualitative data. Survey items indicated generally high levels of satisfaction/perceived benefits, with parallel themes emerging in participants' narratives. Preliminary analyses examining differences between ADVANCE at WSU programs indicated a somewhat higher level of overall satisfaction for the Transitions Grant recipients, relative to those receiving the Leadership Award. Importantly, analyses conducted with objective productivity markers indicated a greater number of promotions, peer-reviewed publications, and conference presentations following program participation; however, grant submission/funding

differences were not observed. Overall, results provided empirical support for effectiveness of the four programs examined herein: External Mentor, External Mentor-Pilot Extension, Transitions Grant, and Leadership Award, aimed at promoting scholarship, career advancement/retention for women in academic STEM, our primary focus as a function of inequities and lack of representation noted earlier (Allen, 2011; NSF, 2018; Van Miegroet et al., 2019; Xu, 2016). Although preliminary, it is possible that Transitions Grant awardees expressed greater satisfaction with program participation because of the critical need they experienced due to personal challenges that precipitated their application, and the program's ability to address this need – a sentiment apparent in the narratives provided by grant recipients.

Theme analysis of participants' narratives also provided evidence of acceptability and satisfaction with the ADVANCE at WSU programs, honing-in on specific features that made these programs particularly beneficial with respect to career development/advancement and retention of women academic staff in STEM fields. The notion of **greater productivity** resulting from program-participation emerged uniformly across all the four ADVANCE at WSU programs: *External Mentor, External Mentor – Pilot Extension, Transitions Grant and Leadership Award*. This pattern of results speaks to these programs reaching their common objective of facilitating professional development/retention, and further supports the analytic approach of combining participants across programs for the evaluation of productivity markers. The theme of **enhanced professional networks** was prominently featured in narratives provided in response to questions concerning the *External Mentor* program. This finding is in line with the notion that mentoring conveys access to 'scientific goods' (DiPrete & Eirich, 2006; Sheltzer & Smith, 2014), with a growing professional network key among these. Finally, the theme of **enhanced research training** was noted in responses of those participating in *External Mentor* and *External Mentor – Pilot Extension* programs. It is not surprising that students working with women academic staff who took part in these programs benefited as well, although the programs were not designed to benefit students per se. Nonetheless, this 'trickle-down' effect is a welcome additional feature highlighted in the open-ended question responses as a positive outcome of participation. It should be noted that support provided by ADVANCE at WSU programs examined herein goes beyond what has been typically available in STEM academic units. It may also be that women academic staff were particularly appreciative of, and tended to make the most of this support, especially given the challenges they typically face in scholarship/career advancement as well as achieving a healthy work-life balance (Van Miegroet et al., 2019; Xie et al., 2015). Overall, the observed pattern of results echoes prior program evaluation findings, demonstrating considerable benefits of professional development efforts focused on academic staff (e.g., Vaill & Testori, 2012), which could be replicated around the U.S. and world-wide.

External Mentor, Transitions Grant and Leadership Award participants also provided suggestions for program improvement (in the final open-ended question asking for any additional comments), which have been largely implemented. Specifically, it was indicated that it would be helpful if ADVANCE at WSU engaged in initial outreach to potential external mentors, facilitating the match. We are now taking

this approach in the regional programming in the U.S. Pacific Northwest that includes External Mentor as a key component (NSF Partnership Grant; HRD–1936019). It was also recommended that the Transitions Grant be made available to academic staff more broadly, and ADVANCE at WSU now supports this opportunity for all women academic staff, regardless of discipline (i.e., including non-STEM academic units). Finally, it was suggested to extend the Leadership Award to funding opportunities that can be leveraged to become leaders in the field, implemented as well. ADVANCE at WSU now provides Leadership Award funding for travel that enables women academic staff to take advantage of such opportunities (e.g., taking on leadership roles in scientific societies).

The long-term goal of these ADVANCE at WSU programs is to broaden participation, increasing representation of women at the highest levels of STEM professoriate. In the short-term, the four programs evaluated in this study functioned to foster equity, providing female academic staff in STEM with mentoring they were less likely to access compared to male counterparts (Bonetta, 2012; Hund et al., 2018), addressing personal transitions, generally more challenging to negotiate for female academic staff (Ahmad, 2017; Mason et al., 2013), and providing leadership opportunities that would otherwise likely not be available (McCullough 2011, 2019; Xu, 2008).

Results of this study provide further support for the existing literature documenting benefits of mentorship for women, especially in academic STEM (DeCastro et al., 2013; Gorman et al., 2010; Heilbronner, 2012). Importantly, such benefits have been demonstrated beyond the individual, with systemic level effects including increased productivity, enhanced communication, organizational stability, retention of employees, and support of cultural diversity (see Allen & Eby, 2011; Allen et al., 2004, 2017; Eby et al., 2007; Ragins & Kram, 2007). Although mentoring is typically provided by more senior in-house academic staff, external experts who serve as mentors confer considerable advantages. Relationships with external mentors are informative, for example, conveying expectations for productivity in other research-intensive settings, and effective work patterns (Haines & Popovich, 2014). In addition, external mentors are not affected by organizational relationships, and do not serve in an evaluation-related capacity with respect to participants, enabling them to avoid conflict-of-interest often unavoidable for mentors from within the institution. Importantly, outside experts provide networking opportunities transcending the mentee's institution (Cho et al., 2011), a theme echoed in narratives provided in response to the open-ended question portion of our program evaluation effort.

Results of this research suggest that academic staff development programs and evaluation efforts should be expanded across institutions and national boundaries and can yield similarly beneficial results for different higher education settings in the U.S. and internationally. Our findings indicate programs should be broadened in scope as well, beyond instructional techniques, which were frequently emphasized in earlier reports (Bland & Schmitz, 1990; Eggins & MacDonald, 2003; Sutherland & Grant, 2016). These efforts should reach concerns that lie outside the classroom and the laboratory, providing support in a more holistic manner, as advocated in

the literature (Blackmore & Blackwell, 2006; Sutherland, 2018). Importantly, the present study supports the importance of providing flexible academic staff development opportunities, encompassing different stages of the academic career trajectory. It may be particularly important to provide such programs for midcareer professors, defined as those who are one to ten years post-tenure (or equivalent promotion), as they often experience one of the most substantial career transitions, characterized as a time of reflection and reassessment (Austin 2010).

This work is not without limitations and is subject to those related to a small, localized sample (i.e., difficulties with generalizability, lower levels of statistical power; Henn et al., 2006). Although effect sizes associated with the interventions described in this manuscript are likely substantial, as these produced statistically significant results even with a small sample, the findings reported herein should be treated as preliminary, requiring replication with larger, more representative samples. Additional evaluation tools would have enhanced the present effort (e.g., obtaining information concerning program benefits from institutional stakeholders - department chairs, college-level administrators). Moreover, the pre-post single group design limits our ability to conclusively interpret observed effects, which could have resulted from non-program factors not subject to experimental control. We opted for this approach because a suitable control group did not present itself, as is often the case with real-life intervention scenarios. That is, random assignment would have resulted in withholding opportunities, and thus was not deemed viable given considerable needs expressed by academic staff in program applications, and also because those randomized to a control group may have felt disgruntled or demoralized, potentially skewing the data. Unfortunately, there were no immediately available quasi-experimental alternatives, since examining outcomes relative to non-participating (likely non-STEM) academic units would not have provided an appropriate comparison. Moreover, comparing participating women STEM professors to those opting out of these programs would not provide an adequate benchmark. Women with high levels of motivation, already on a rapidly rising career trajectory, could have self-selected for participation. On the other hand, academic staff who chose to participate may have faced formidable challenges in their career-development. In either case, comparing participating and non-participating eligible academic staff would be fraught with threats to internal validity due to inevitable self-selection. It should also be noted that in some STEM units there were not multiple women at comparable career stages to serve as a potential comparison group, which of itself speaks to the issues around recruitment and retention of women academic staff in these fields.

Future studies should address noted shortcomings, delivering similar programs in different higher education settings and cultural contexts that differ from U.S. institutions. Nonetheless, this evaluation provides important information regarding effectiveness of programs specifically targeting women academic staff in STEM fields, which can be readily disseminated to other institutions in countries struggling with similar representation issues. The latter is particularly important, given that academic career development efforts are often undertaken without attention to theoretical considerations or bases in empirical evidence (Blackmore & Blackwell, 2006).

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