

On-ramping: following women scientists and engineers through their transition from nonacademic to faculty careers

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Abstract A popular strategy for increasing women faculty in STEM (science, technology, engineering, and mathematics) departments is to hire from other universities, but this strategy fails to increase the number of women faculty nationally. This research investigates a new approach to faculty recruitment called “on-ramping,” the process by which women with PhDs leverage their nonacademic careers and enter academia as faculty members. This study follows women scientists and engineers from their non-academic to faculty career and analyzes their experiences transgressing the boundaries of STEM knowledge production sites. We used qualitative methods to collect and analyze semi-structured interviews about the experiences of ten female PhDs who successfully on-ramped into faculty positions with the support of a feminist professional community. Our data revealed four phases of on-ramping that characterized the transition to academia for our participants. Attention to gender in on-ramping also highlights concerns that span the personal and the professional in women scientists and engineers’ lives. By illuminating cultural and political practices in STEM sites of knowledge production and the effects of feminist interventions on women’s experiences of producing knowledge in STEM fields, this study offers a unique perspective that can elucidate the strengths and weaknesses of these sites, especially in regards to gender politics and knowledge production.

Keywords Women faculty · STEM · Gender · Knowledge economy · Feminism · Career path · University-industry partnerships

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1 Introduction

Women with PhDs in science, technology, engineering, and mathematics (STEM) fields choose industry or government positions more often than academic positions (Hoffer et al. 2007). These engineers and scientists are a potential new pool from which to recruit female faculty. Deepening the pool of female faculty candidates in academic STEM is one way to help to remedy the fact that women comprise only 19 % of full-time, full professors in STEM fields nationwide (National Science Foundation and National Center for Science and Engineering Statistics 2013). A popular recruitment strategy for increasing gender diversity among STEM faculty is hiring women from other universities, a strategy that fails to increase the number of female faculty nationally. An alternative strategy is to recruit women with PhDs in industry and government positions into academia.

Even when female PhDs in nonacademic STEM careers desire to become faculty and departments are eager to hire them, the pathway from industry or government back into academia is not always clear. In this exploratory study, we have coined the term “on-ramping” to describe the process by which people with doctorates in STEM fields working in non-academic realms can leverage their nonacademic skills and experiences into careers as faculty members. We created the On-Ramps into Academia workshops and professional community to illuminate this pathway for interested women PhDs in industry and government careers. Then, to understand the viability of on-ramping into academia, we conducted research to investigate the experiences of ten female scientists and engineers who made this transition. We asked: *What are the experiences of female STEM PhDs who participated in the On-Ramps into Academia professional community and successfully transitioned from nonacademic to academic careers?* We were especially interested in the phases of a career transition from non-academic to faculty careers and the strategies our participants used to mitigate difficulties in order to successfully transition into the professoriate. Mapping the terrain of this new pathway may prove useful for those committed to increasing women’s participation as faculty members in STEM fields. Achieving gender parity in the faculty ranks of STEM fields requires innovative methods and this paper explores a new, alternative approach to identifying or recruiting potential women faculty.

1.1 The On-Ramps into Academia professional community

Between 2009 and 2012, three On-Ramps into Academia workshops were held at the University of Washington (UW) to promote the viability of the industry-to-academia career path for female PhDs in STEM fields. These workshops were funded by the National Science Foundation ADVANCE program, which is aimed at advancing women faculty in STEM fields. The sixty-seven women who attended these workshops were employed in government, industry, or corporate science at the time of their application to the workshop. Workshop attendees came from a range of STEM fields backgrounds. The workshops consisted mainly of topical panels, where speakers, primarily successful female faculty who had themselves made the transition, shared their experiences. They offered participants advice and best practices for translating their nonacademic skills and career experiences into faculty positions. UW faculty members participated in hands-on sessions to provide participants with one-on-one advice on their curriculum vitae (CVs). Throughout the workshops, participants also had opportunities for informal discussions with workshop peers and current faculty. In addition to this professional development advice, the workshop offered in-depth discussions that included personal issues and life stories; interactions

with a small group of other potential on-rampers; exploration of strategies and tips for becoming the academics they want to be; and space to discuss how identities such as gender impact experiences in STEM. The workshops were, as described by one of the research participants, an opportunity to forge a “community of people...with the same motivations” [Anne, industry research]. After the workshop, the principal investigator (PI) of the program (and third author of this paper) mentored some of the participants by email and phone.

2 Related literature

Sectors in both the US government and US industry are responding to the paucity of women in non-traditional fields by exploring the efficacy of mid-career reentry pathways, i.e., “on-ramping” opportunities for professionals to return to their careers after taking time away (Hewlett and Luce 2005; McGrath et al. 2005; Shellenbarger 2006). In fact, companies that adapted to professionals’ varied career arcs improved the retention of female leaders in financial firms (Hewlett and Luce 2005).

Individual professionals in science and engineering fields are also exploring non-linear career pathways. Although literature on nonacademic-to-academic career transitions in STEM fields is scarce (Weimer 2001), the On-Ramps model is rooted in other STEM pathways literature. Like Pawley and Hoegh (2011), Soe and Yakura (2008) and Xie and Shauman (2003), the On-Ramps model contests the linear “pipeline” metaphor used to describe the career trajectories of women faculty in STEM fields. While the pipeline metaphor is helpful in assessing attrition from normative career pathways in STEM, a new conceptual framework is needed to support and proliferate multiple pathways by which underrepresented group members can become academic knowledge producers in science and engineering.

Sector-switching literature also provides a background to thinking about women on-ramping into university science. For example, Dietz and Bozeman (2005) investigate the career patterns of scientists and engineers and note their increasing movement between industry and academia, a trend they attribute to the growth of research centers in universities and growing networks between the two sectors. They go as far to argue that universities can boost their commercial productivity by hiring researchers from industry, a claim shared by a number of our research participants in this study. Numerous other studies document faculty members’ motivations to contribute or switch to industry (Fritsch and Krabel 2012; Bozeman and Gaughan 2007), many with a focus on women faculty’s entrepreneurial activities specifically (Fox and Xiao 2013; Thursby and Thursby 2005; Stephan and El-Ganainy 2007). These studies argue that some forms of technology transfer from academia to industry, like licensing and patents, are highly male dominated. More formal ties between industry and universities, like multidisciplinary centers, appear to promote equal participation and rewards for both women and men faculty (Corley and Gaughan 2005). The implications of these studies suggest that further investigation is needed to determine what institutional forms of scientific workplaces and university-industry partnerships can be effectively leveraged to achieve gender equity in STEM knowledge production.

While there is a robust literature on women faculty’s entrepreneurial activities and the outcomes and motivations for their participation—or lack there of—in commercial endeavors, this is the first study to examine sector-switching and the subsequent knowledge transfers for women scientists and engineers moving *from* industry *into* academia.

Enabling women with PhDs in STEM fields to pursue their research and share their knowledge in the academy not only accelerates the pace of building a “critical mass” of female faculty in STEM fields, but it also has the potential to improve the recruitment and retention of women at earlier points of the educational pipeline. A growing body of feminist scholarship argues that the presence of women faculty in STEM has a ripple effect and helps increase women’s overall participation in STEM fields in several ways. For example, female faculty have a positive impact on women’s persistence in the training stages of STEM fields careers and the most important predictor of undergraduate women’s success in STEM fields is the percentage of female faculty in their department (Carrell et al. 2010; Diekman et al. 2010; Price 2010; Robst et al. 1998; Shapiro and Sax 2011; Stout et al. 2011; Trower and Chait 2002). Universities are more likely to hire women when women are already a relatively high percentage of departmental demographics (Marschke et al. 2007). Furthermore, a critical mass of female faculty in STEM fields transforms institutional practices that improve women’s experiences in the academic workplace (Carrigan et al. 2011; Etzkowitz et al. 1994).

3 Methods

This study is grounded in an epistemological commitment to interpretivism. Interpretative inquiries are a search for meaning in human experiences, rather than laws or answers (Geertz 1973; Madison 2005). While interpretive inquiry inhibits generalizability, we chose this method largely because it was designed for solving social problems and places social relationships and institutional processes at the center of inquiry (Strauss 1987).

Since the On-Ramps into Academia program was a feminist intervention aimed at deepening the pool of female faculty candidates in academic STEM, this research study relies on feminist epistemologies, scholarship that investigate women’s lives and their social identities across the micro- and macro- dimensions of social domains (Collins 2000; Mohanty 2003; Hartsock 1998; Harding 1991; Smith 1987). We chose this framework to best understand the experience of undertaking major life changes to transgress the boundaries between academia and non-academic workplaces in STEM. We investigated the experiences of underrepresented group members in STEM “who cross boundaries among colleges and universities, business” and government organizations (Slaughter and Rhoades 2004, 9) to understand the experiences of the individual women undertaking this transgressive journey and the boundary implications between these entwined institutions. By following women across different social domains in which they produce STEM knowledge, this study offers insight into the different ways knowledge is produced in various sites and for what purposes. We make note of how participants framed their experiences of producing STEM knowledge. Based on this data, we make inferences about the institutional culture and the various norms, values and practices embedded in the production of STEM knowledge.

We rigorously assessed the workshop (in longitudinal intervals) and evaluation data showed that the On-Ramps into Academia improved attendees’ understanding of their career options; increased their confidence in applying for faculty positions; and provided them with much needed support for changing their career trajectory. After the workshops, we continued to provide support to those who undertook the process of on-ramping, and became privy to the experiences of these on-rampers. We became curious to know more about what it means to transition from nonacademic STEM careers into faculty positions,

particularly with support from a professional development program like the On-Ramps into Academia program. We chose a qualitative research design because of its suitability for investigating participants' feelings, beliefs and interpretations of their experiences, especially those who are a minority in a community and have traveled non-traditional paths in their lives (Miles and Huberman 1994).

We focused on on-rampers who had participated in the On-Ramps into Academia professional community for two reasons. First, because the on-ramping experience was recent and fresh in their minds, studying these on-rampers provided a chance to illuminate this stage of liminality in between academia and other sites of knowledge production. Liminality, a period of outsiderhood, can catalyze new perspectives on one's community and one's relationship to it (Turner 1972; Davis-Floyd 1992). Such new perspectives are desperately needed to end labor segregation in STEM knowledge production. Second, in order to collect rich and accurate qualitative data, it was important to establish a relationship of trust and rapport with the research participants (Guest 2013). Such relationships were developed among the On-Ramps into Academia workshop community.

Like other qualitative studies in engineering education, we prioritized emerging themes and ideas in our data analysis rather than merely verify existing claims (Koro-Ljungberg and Douglas 2008; Leydens et al. 2004). We use the data from this preliminary examination of on-ramping to generate new hypotheses and new ideas for future research about expanding the pool of STEM faculty candidates.

3.1 Research participants

Our research participants are ten women who participated in an On-Ramps into Academia workshop and transitioned to a faculty career. Six participants have PhDs in engineering fields, and four have PhDs in the physical and biological sciences. All had been in industry or government positions for at least 3 years prior to transitioning to academic positions. At the time of this study, 80 % of our study's participants are full-time, tenure-track faculty members in STEM fields. Table 1 provides a pseudonym for each participant and summarizes—research participants' non-academic background, the type of academic institution into which they on-ramped, and their position at the time of the study. We distinguish between three types of nonacademic career backgrounds and refer to them throughout the paper as *government*, *industry*, and *corporate science*, respectively. Specific STEM fields are not included to ensure participants' anonymity.

Women who on-ramp are well suited for a variety of academic institutions. For example, half of our participants obtained tenure-track positions at universities classified as institutions of "Very High-Research," according to Carnegie Classification (Carengie 2001). Four of the participants transitioned from positions in government research labs, four from industrial research labs, and two transitioned from corporate leadership or product development positions. All participants are currently employed at academic institutions across the United States. (Since the time of this study, three more participants have on-ramped to tenure-track faculty positions. Another two participants hold PhD-level educational staff positions in academia. Some participants decided that they were no longer interested in academia and others have applied to academic positions but have not yet been hired as faculty.)

Table 1 Participants' backgrounds and affiliations

Pseudo-nym	Non-academic background	Academic institution (Carnegie classification)	Academic position
Anne	Industry research	High-research	Tenure-track faculty
Beth	Corporate science	Very high-research	Tenure-track faculty
Carrie	Industry research	Very high-research	Tenure-track faculty
Faye	Industry research	Very high-research	Adjunct faculty
Gail	Industry research	High-research	Tenure-track faculty
Janelle	Government research	Very high-research	Tenure-track faculty
Karen	Government research	Specialized research	Tenure-track faculty
Niki	Corporate science	Comprehensive	Instructor
Sara	Government research	Very high-research	Tenure-track faculty
Trish	Industry research	Baccalaureate college	Tenure-track faculty

3.2 Procedures

The goal of this research was to understand on-ramping from the perspectives of women who had transitioned from nonacademic STEM fields and who had participated in the On-Ramps into Academia professional community. We chose individual interviews as our qualitative data collection method because we wanted to learn more about our participants' personal experiences during their professional transition. We developed a semi-structured interview guide with six open-ended questions: (1) Tell me about your return to academia; (2) What has been the most challenging part of making the transition to academia? (3) What has been rewarding about the transition to academia? (4) What are the three most useful tools that helped you to make a successful transition? (5) How did starting in industry help or hinder your career in academia? (6) How has your experience in industry or government affected your students? We did not ask about the On-Ramps into Academia workshops, but all of the participants mentioned their experiences there as helpful to their transition. We also did not ask explicitly ask about gender but were careful to note participants' perspectives on gender politics and relations in their fields in our analysis.

All but one of this paper's authors are women. All authors work in academia and are committed to advancing underrepresented groups' participation in STEM and transforming STEM cultures to welcome all. The first and second authors are social scientists and the others are engineers. Two authors are Asian American and four of the authors are white. Three levels of academic career stages are also represented: two authors are in the early stages of their academic careers, two are in the mid-career stage, two are full professors, and one is in a leadership position. Both the first author and the last author worked in industry before transitioning into academic careers.

Interviews were audio recorded if permission was given by the participant; interviews lasted between 40 min and 2 h and were conducted in-person, or over Skype when an in-person interview was not possible. The second author conducted all interviews over a 10-month period. The transcription process was contracted out to a third party, but the second author checked each transcription for fidelity to the audio recording (when one was available) and made any necessary corrections, including retaining the participant's natural inflections, and correcting any word errors. All data in the transcripts were made anonymous.

3.3 Data analysis

We used axial coding to generate concepts from our data that helped to explain the differences and similarities in our participants' transition experiences (Martin and Hanington 2012; Glaser and Strauss 1967; Strauss and Corbin 1998; Cohen et al. 2000). The first and second authors worked together to complete an open coding process. Next, we refined these codes into categories; questioned the relevancy of variables; and identified emerging themes. To avoid limiting the textual analysis with preconceptions and biases, we used participants' own terms in constructing codes and identifying themes.

Once we had identified conceptual categories related to barriers to and strategies for on-ramping, we identified the properties of each category—the particular aspects of a category that are found to be systematically related to it (i.e., “value/worth” was a property systematically related to the category of “nonacademic career skills”). After the first and second authors' initial analysis was completed, they debriefed with the other authors who had been directly involved in administering the workshops. The memos from this team discussion helped clarify the logics of our analysis, and develop linkages between core categories (Strauss 1987). The results of this collective analysis resulted in a reexamination of codes and memos; and the process of team memo-ing was repeated several times in the course of data analysis. This technique of debriefing with colleagues is important for ensuring the trustworthiness of our interpretations (Miles and Huberman 1994). Research participants had an opportunity to review their transcript data that were used in the context of the paper so that they felt comfortable that their anonymity would not be compromised.

4 Findings

Our participants identified four critical phases in their transitions from nonacademic careers to the professoriate: (1) evaluating the value of transferable nonacademic career skills; (2) bridging gaps in experience; (3) coping with both past and present gender discrimination; and (4) affirming the value of producing scientific knowledge in academia. Firstly, research participants found it difficult to assess and communicate the value of their nonacademic career experiences in the academic context. Participants from corporate backgrounds were especially challenged in providing evidence of their transferable skills because intellectual property concerns barred them from speaking in detail of their accomplishments and, in a number of cases, publishing their work. The participants' second step in on-ramping was creating and executing a plan for bridging gaps in their credentials. To do so, they took teaching jobs and post-doctoral positions, many in addition to their full-time job. Some participants even worked for free. This increased labor during this liminal stage speaks to participants' commitment to producing scientific knowledge in the academy. Thirdly, all participants shared the experience of coping with gender discrimination. After building individual capacity to address the three aforementioned phases to transitioning to academia, the new faculty reported experiences in academia that affirmed the value of their nonacademic career skills. Once they secured their academic position, participants communicated a strong sense of accomplishment and confidence about their nonacademic career skills and professional experiences. Participants' high levels of satisfaction once working in academia can be explained in part by their pleasure in sharing their skill set developed in their nonacademic work experience. But they also

raise a critical question about what is special about the experience of producing scientific knowledge in the context of higher education.

4.1 Evaluating the value of nonacademic career experiences

Many participants related that the beginning of the transition was characterized by doubt because they lacked insight into which of their nonacademic career experiences and skills would be considered valuable in the academic context. Moreover, many participants felt discouraged to transition from nonacademic to academia careers because of a belief that the faculty career follows a linear path from graduate school to tenure track. Sara [government research], received feedback from peers that suggested she had missed her opportunity to be a professor: “And I knew it was hard, because you hear a lot of things where people say it’s a one-way street. Once you go into industry you can never go back.” Sara’s reflection on pathways to the professoriate illuminate an cultural norm in academia that can fuel an individual’s self-doubts about her efficacy in academic careers. Faye [industry research] explains this doubt, “After you’ve been out of academia for a while, especially if you’ve been doing other things, you just really don’t know how you would fit back into academia, and where your skills would translate.” Trish [industry research], agreed: “It’s a hard step, and the credentials are so different. You’ve got to figure out how you fit in.” To best assess fit, Anne [industry research] treated on-ramping “as an experiment... a quest, and the quest is to figure out what I bring to the table. So I collected data.”

Faye [industry research] credited the On-Ramps into Academia community mentors with helping her to move from one scientific culture to another:

I think that having successful women, and there were men there too, sit you down and say “No, no, no, you have a great resume, these are great things, you might want to change these couple of things, but you’re a really good fit and this is why.” I don’t think there’s a substitute for that. It’s about you. It was huge. It made me feel like I can do this.

Women from corporate settings faced particular challenges to transitioning to academic jobs because of the ways in which their skill sets differed from those of their peers trained in industry and government research labs. Specifically, intellectual property rights prevented corporate scientists from publishing their research. Niki [corporate science] described the difficulty of communicating the value of her corporate experience without publications or other evidence of her research expertise: “The research is proprietary. You cannot say what you have done, what’s new and, you know, what kind of advantage you can bring. It’s very, very hard.” Niki contrasted her experience doing research in a corporate setting with academics who are “always advertising their research.” Note how, by framing academic publishing as advertising rather than a vital part of the scientific method whereby claims can be made public to a scholarly community and discussed, debated and contested, she elucidates the market values governing non-academic knowledge production.

Sara [government research] also commented on the consequences of the proprietary nature of corporate research: “The advantage I had with being in a government lab was, they didn’t tell me, there was no one who said, ‘that’s IP [intellectual property], you can’t publish it.’” Like many of our participants from government and research labs, Faye [industry research] remarked on the importance of publishing for a successful transition to academia: “It is very difficult to make that a porous boundary [between corporate science

and academia],” she said, “because every time you stop your academic career you’re not publishing. And publishing is key.”

In addition to differences in knowledge dissemination, Karen [government research] described another cultural differences between corporate science and academia that can influence the viability of the transition:

Because in government you are working on fundamental research so you are in the same state of mind as a university, your focus is on research. But in industry you have less time for research because you’re focused on the product. So I think coming from government is easier; you’re going to have an easier time transitioning than if you are coming from pure industry.

The various sites have different scientific priorities. Academic sites can focus on exploratory scientific questions without a specific commercial end in mind while corporate sites are concerned with protecting intellectual property. Adjusting to this cultural difference is part of the transition evaluation process. Regardless from which sector participants hailed, the first step toward transitioning to academia was learning to value their skills and translate their expertise to an academic audience.

4.2 Building bridges into academic careers

Once participants came to value and appreciate their skills, their next steps toward transitioning into academia was remedying gaps in their credentials. Niki [corporate science] explained that to “know exactly what is required” meant she was able to clarify her goals and motivate herself to undertake the challenges ahead in her transition to a faculty career.

Beth [corporate science] described how she worked to prepare and become a viable faculty candidate,

So actually I went back as a post-doc for 6 months where I got back my toes into research. Because, you know, when you’re away from the literature for a year a lot can happen. And then I also taught a course for the summer, which helped me immensely later in my academic job because I actually have the lecture feather in my cap.

Like Beth, Gail [industry research] also described feeling the need to get caught up via a post-doctoral research position before going on the academic job market,

So I did 3.5 years in industry, and even though it wasn’t a terribly long time I did feel that I was out of the loop. Mostly with regard to keeping up with the current technology and the current literature...For me it was a really good way to get back into it because it allowed me the time to get myself re-immersed into my field before I got into this [faculty] position.

Participants also took preliminary steps towards academic careers by volunteering to teach a college course or pursuing research on their own, in addition to working full-time. Faye [industry research] described juggling multiple career trajectories, “I worked over-time to keep one foot in the door. When I was running the business, I was teaching part time or doing research part time in my own time.” Like Faye, Sara [government research] taught classes: “I used to volunteer to teach classes, not being paid, it would be on my own time.” These stories stress the hard work required to on-ramp into academia; but getting a taste of labor in an academic context only strengthened participants’ desire to pursue a career as faculty in academia.

4.3 Unique challenges for women: coping with gender discrimination

Although our interview questions did not directly address gender, all ten participants in our study discussed gender discrimination in the academic context. Their experiences reflect broader trends of gender stratifications in both US workplaces and households. Some described how gender discrimination in the training stage of their careers dampened their enthusiasm for returning to academia. For example, Sara [government research] described her graduate school department as a “hostile environment especially for women and minorities.” Janelle [government research] was concerned that academia would be much like her graduate student experiences, where although policies were in place to discourage discrimination, “the proof is in the pudding in terms of what is actually done.” In other words, Janelle felt that institutional policies aimed at supporting women and underrepresented minority faculty do not necessarily translate into beneficial practices. Furthermore, Janelle noted that when faculty did accept institutional support for work/life balance, they faced cultural backlash from peers, a finding supported by other feminist scholarship (Ayre et al. 2013; Cech 2013).

Beth [corporate science] also critiqued academic institutional policies that favored males and shared her experience of being a post-doctorate while pregnant. To keep her benefits that would grant her maternity leave, Beth made a difficult choice, “So what I did was I went seriously part-time and then right in my last month [of pregnancy], I came back full-time. But this is where just having a uterus shouldn’t force us to make those decisions. And this is institutionalized policy.”

Identifying gender-specific barriers to on-ramping can illuminate gender inequities among women and men in the US STEM workplace. Reputable training and job titles in nonacademic careers did not always earn participants prestige in the academic context, nor translate into comparable salaries. Adjusting to a lower salary was of special concern to our participants. Gail [industry research] exclaimed, “It’s shocking to take your industry salary and slash it.” Niki [corporate science] shared a similar experience, “When I got the final number [pay rate] it was such a shock [...] I reduced my salary ... and I’m working much harder because I have to prepare all these courses that I have never taught.” Niki described it as taking “a big hit...in order to move forward.” While these salary issues are salient for both female and male on-rampers, it can be especially difficult for women who already make <20 % of their male peers’ salaries (AAUW 2015). This type of economic sacrifice made by people who are already taxed because of their marginalized status in US society also lends credence to the hypothesis that there is something special about scientific knowledge production in the academic context, as opposed to government or corporate environments.

In addition to wage concerns, participants were also keenly aware that faculty jobs are designed for workers with little to no familial responsibilities, putting women at a disadvantage (Williams 2000). Karen [government research] explained,

When you go to work in a university, there are not many women. And it’s a very workaholic environment... it adds a lot of pressure... When you have a family, the load is more for the women. So the fact that the environment is predominantly male, you are more interfacing with the guys who don’t have the same load as you. So somehow it’s a different interaction... If you don’t have female representation at universities, it’s difficult because your load of work at work and family work is different.

Karen is right. Women with full-time jobs are still the primary caregivers in US domestic households, doing twice the housework and twice the childcare as do their male partners (Parker and Wang 2013). Inequitable divisions of labor in the home influence academic organizational structures, so that the expectations of “ideal” faculty members are guided by implicit masculine principles that can differentially affect women and impede their success and advancement (Acker 1990; Williams 2000).

Given these inequalities in broader social domains, on-ramping was especially difficult to navigate for those participants who had children. Beth [corporate science] and Sara [government research] had male partners and children that shared in the distress caused by relocation. “Moving was hard,” said Sara [government research], “it was hard on my family.” In contrast, Karen [government research] and Trish [industry research] made it a priority to return to academia without the costs of relocation. Karen explained: “My husband has a [local] position, so I didn’t have a big radius. I had to be somehow local.” Similarly, Trish who described herself as transitioning “slowly into the academic space,” said, “I’m not really going to leave the area because I have kids.” Gail [industry research] acknowledged that even though she had to sell her home, she viewed these challenges as purely logistical, a perspective she attributes to her single status. Our participants’ experiences are consistent with the ideal worker literature which demonstrates that women’s private care responsibilities in the home impact their careers (Acker 1990; Williams 2000).

Though we did not ask questions about the influence of On-Ramps into Academia program, participants credited it with providing the support needed to navigate the realities of gender discrimination in academia. Gail [industry research] stressed that this community was meaningful not only because of shared (nontraditional) career aspirations, but because it was woman-centered:

I felt weird coming to a “woman thing,” ...I actually never participated in something that sort of a woman-only event or geared towards women. ... it was just really inspirational and motivational to be in a room with so many great intelligent, powerful women, I really, really enjoyed it, and I remember leaving just feeling excited and uplifted.

Much like feminist consciousness-raising groups (Sowards and Renegar 2004), the On-Ramps into Academia community created, as noted by Beth [corporate science], “a safe place for women ...to ask dangerous questions,” and to discuss the systemic nature of the sexism they faced and the changes required to transform academic institutions. Janelle [government research] said the On-Ramps into Academia community was a “safe place” to discuss sexism in her negotiation process with her new department. On-Ramps mentors advised her not only how to handle the issue herself but how to solicit advocates who could help ameliorate the situation. Beth [corporate science] said that the On-Ramps into Academia community helped her to feel confident that, even in the face of gender discrimination, she could transition to academia on the merits of her scientific credentials:

I [now] feel proud to be a woman. I should not have to apologize for not being a man I now have a clearer sense of how to be a woman professional without the world focusing on the “woman” part of it.

Participants’ experiences are refracted with gender stratifications. The On-Ramps women-centered community engaged feminist consciousness-raising practices to help community members navigate institutional sexism and see their individual experiences as part of systemic patterns of discrimination (Sowards and Renegar 2004). This finding suggests women STEM faculty and their allies must work collectively and systemically to

end the barriers to women's full participation in STEM. Furthermore, attention to gender in on-ramping highlighted issues that span the personal and the professional: wage, family and labor issues. The fact that participants were willing to work through these difficulties during the liminal stages of on-ramping suggests a strong desire to produce STEM knowledge in the academy specifically.

4.4 Affirming the value of on-ramping

Once in their faculty positions, our participants found that their non-academic experiences and broad connections in the engineering and scientific community were highly valuable to their faculty careers. Furthermore, participants found in academia an intellectual freedom that was missing in their previous positions.

Participants stressed their ability to help synchronize student learning with skills needed in industry. Indeed, some of the women defined their role in academia as liaisons between cutting-edge industry and academic institutions. For example, Anne [industry research] said that “the field has moved so far in industry, that there is a huge gap now....we [on-rampers] complete the cycle of student learning by having people from industry seed the next generation of scientists with the skills that industry needs to move forward.”

Other participants shared her sentiment, though none considered if more deeply suturing students' education to industry's needs might compromise the intellectual freedom that they now claim to enjoy in the academy. For example, Niki [corporate science] said that when she used to hire and train engineers in her company, she realized her academic peers were not amply preparing her future colleagues. When she spoke to academic colleagues she found that they themselves did not know of the strides corporate institutions have made in scientific knowledge production and this motivated her to on-ramp. However, it was not clear how the research she did in a corporate setting would be incorporated into her pedagogy, given its proprietary nature. Also Niki and the interviewer did not discuss a connection between the secrecy surrounding industry and governmental research and its lack of uptake in STEM higher education.

Other participants also drew a comparison between their unique expertise and those of their non-on-ramping peers. Sara [government research] described her government career as “experience in the trenches” that differentiated her from many of her colleagues. Trish [industry research] echoed this sentiment, stating: “My [industry] experience adds a dimension to my teaching that isn't necessarily there for other professors...to know what to expect when you get a job—that's helpful for students.”

Gail [industry research] described her advantage in terms of an acute ability to focus on and develop class materials that are “realistic, important, and relevant to current times,” in contrast to traditional textbooks that are “kind of outdated.” Janelle [government research] described one of her advantages as a professor with a background in government: “I'm really up-to-date with what's happening in the government's realm, the management realm of what we're doing with science in the *real world* (author's emphasis).” Janelle [government research] shared an example of how her lived experience influences her students: “My students will bring in newspaper articles and I can tell them the very latest that's happening. Give them insights into the people who are quoted because I know them personally. I think that gives them [students] the sense that I really know what I'm talking about.”

In this way, participants' government and industry experiences enhanced their sense of credibility with students. Carrie [industry research] explained: “That I was out in the world helps because they [students] tend to respect you more than if you were only in the shelter

of academia.” Niki [corporate science] summarized the impact of her career experiences on the classroom: “I think everything, practically, every single session I teach, that within a minute or two, I can link it to real life.”

Many participants reveled in the opportunity to close the gap between academia and “real life” and expressed ample confidence in their abilities to make a significant impact on both student learning and institutional success. While it is important to note how participants valorize the skills they learned in the jobs that they left, the language they use to characterize academic workplaces and non-academic workplaces invites closer attention. Governmental and industrial sites of scientific knowledge production are described as “real,” invoking military metaphors for survival like “the trenches,” whereas academia is a “shelter.” On one hand, this language seems to suggest an implicit denigration of academia—if it is “unreal” and “a shelter” how can it be a legitimate site of knowledge production? Could the language reflect values of our larger social domains, whereby scientific knowledge production is deemed irrelevant if it does not necessarily serve an predetermined end-goals like profit (corporate science, and industry research) or state-driven political agendas (government science)?

On the other hand, we could interpret this discourse in the context of participants’ concern for their students. They are mentoring students who will soon be making a transition from academia to non-academic sites of scientific knowledge production. Their language choices may signal a desire to more amply prepare students for the “realities” of producing science in certain types of institutions. Given that participants also discussed the limitations of non-academic STEM work and the intellectual freedom they enjoyed in academia, it stands to reason that these on-rampers will not only bring new knowledge into their classrooms but also prepare their students to transform the constraints that these on-rampers have personally experienced in non-academic STEM workplaces.

What is clear from this study is that research participants unequivocally stress a divide between academic and nonacademic STEM. Despite the increasingly close alliances between academia and industry (Kleinman and Vallas 2001), crucial differences may exist in terms of motivations, interpretations and applications, all of which involve relations of power and authority. Differences in work environments between the two sectors may also play a role in women’s decisions to on-ramp (Bozeman and Ponomariov 2009). Even though participants found their nonacademic work useful in their new positions, the fact is, despite the challenges of on-ramping (see phases 1–3 in the Findings section), they left industry and government work for academia. Why?

When delineating what was unique about academia, three participants used the term “intellectual freedom” to describe their research program in academia. For example, Carrie [industry research] stated: “The one thing with academia is that you’re your own boss and the intellectual freedom that you have in academia, you have nowhere else... You can set your own agenda.” Janelle [government research] said “I like being able to spend my time pursuing the questions that interest me, putting together the projects that I think really would make a difference.” Beth [corporate science] also felt that she was making a difference in her faculty job and enjoyed brainstorming with On-Ramps community members about how to best do so. Sara [government research] described how academic culture influenced her personally: “I’m getting more creative, I’m getting more intelligent just by being in this academic environment. Wow, this is [a] wonderful place to be.”

Academia offered on-rampers opportunities to pursue independent research agendas, and share their findings widely. Gail [industry research] said “I hated that we couldn’t share our science with everyone else. I mean that’s what has to happen in a company because they need to make money, so everything’s ‘hush, hush,’ and that’s not how I want

to do science.” Gail craved a scholarly community in which to publicly debate, consider, reject and reframe new knowledge.

Finally, feminist scholarship argues that women faculty inspire the next generation of the STEM pipeline for greater diversity in future faculty candidate pools (Carrell et al. 2010; Diekman et al. 2010). Gail’s [industry research] experience reflects this finding. As a female faculty member Gail can mentor students, especially female graduate students. “Men and women, but especially the young women—they look up to me. ...they can relate to me, and they see that if she can do this, well, I can do this.” Moreover, before the On-Ramps into Academia program, Gail had never participated in a women-centered programmatic STEM intervention. It is possible her participation in the women-centered On-Ramps into Academia community deepened her consciousness of gendered norms and values in science knowledge production and inspired her to become an agent of change in the academic arena.

5 Implications for practice

Differences exist between corporate-produced, government-produced and academia-produced STEM knowledge. Gender stratifications in broader US culture also create differences in how women and men navigate sites of STEM knowledge production. These differences accumulate to create uneven power relations within these institutions. We mapped some of these differences by studying the lived experiences of women scientists and engineers following non-traditional career pathways. Participants’ initial doubts about transitioning into academia contrasted sharply with their strong feelings of success and accomplishment once in their new careers. All of our participants contemplated a career transition, but, before the On-Ramps into Academia intervention, most doubted it was possible. Once they had successfully transitioned into faculty positions, our data showed that participants expressed high levels of confidence in their abilities, value and contributions, especially in educating the next generation of scientists and engineers. The On-Ramps into Academia program, a feminist community, helped reduce individual and institutional barriers to this unusual career path.

Individual barriers to on-ramping included the challenges of assessing and communicating the value of nonacademic career skills in the academic context and gaining academic credentials. Institutional barriers included gender discrimination and gender-specific effects of on-ramping. Our data suggest that individual and institutional barriers to on-ramping characterized different phases of the on-ramping process. We identified four phases of on-ramping, (1) evaluating the value of transferable nonacademic career skills; (2) bridging gaps in experience; (3) coping with both past and present gender discrimination; and (4) affirming the value of producing scientific knowledge in academia. These four phases are not necessarily linear. Rather our data suggest that on-ramping is an iterative process. We found that participants who sought to transition from corporate science had the widest gaps in credentials to bridge, and needed the most support during the first three phases.

We also found that our participants, once they had on-ramped into academia, had a strong sense of purpose that is characteristic of a “resilient faculty identity” (Reybold and Alamia 2008). This sense of purpose was primarily driven by the desire to effect change in academia, align academic and nonacademic training and research, and enrich both their students and their new institutions. This finding augments previous research that has found

women faculty to be primarily motivated by autonomy and intellectual freedom to pursue and persevere in academic careers (Fox and Colatrella 2006).

The On-Ramps into Academia program demonstrated the limitations of the pipeline metaphor, a linear, unidirectional framework widely used to describe women's career trajectories in academic STEM fields. The one-way nature of the pipeline to academic faculty positions is a missed opportunity to recruit more female engineers and scientists into faculty positions. In addition to diversity, academic institutions stand to gain several other benefits from on-ramping faculty. Our findings indicate that faculty from nonacademic STEM careers can bridge classroom learning to professional scenarios; connect students to industry and government contacts and resources; and attract funding. While female on-ramping faculty may face considerable costs associated with transitioning to the professoriate, our data support Sheran's (2007) finding that, for women, the benefits of entering the work force or reentering school after a period of absence outweigh the pecuniary and personal costs. Finally, Conley (2005) found that women are more likely than men to take nontraditional career paths to the professoriate. Therefore, on-ramping may be a particularly effective recruitment strategy for attracting highly trained female scientists and engineers to the professoriate. This may not only bring more talented women scientists and engineers into academia, it may stand to produce new scientific knowledge from a non-dominant standpoint (Wylie 2012).

6 Limitations and future research

This study was limited to a sample of female PhDs in STEM fields who had participated in the On-Ramps into Academia workshops and professional community and had successfully transitioned from industry and government careers into academia. We envisioned on-ramping as a means to increase the numbers of female faculty in STEM fields, but this unique career path could also augment the pool of excellent male candidates for STEM faculty positions. Future work could sample a larger population of both women and men to investigate factors that differentiate individuals who return to academia; those who choose to remain in industry or government; and those who want to transition to academia but are unsuccessful. Participants in this preliminary study of on-ramping made significant efforts to transfer their skills and labor to academia but more studies are needed to confirm whether intellectual freedom and open knowledge-sharing practices also serve as on-ramping motivations for others. Our participants also discussed their differential impact on student learning; however, it would be valuable to test this hypothesis in the future. Future longitudinal research could also investigate the success rates of on-rampers in academic leadership positions.

Women faculty who have produced scientific knowledge in more than one kind of institution have a transgressive form of knowledge that allows them to perceive the framework underlying social relations in the STEM workforce in new, fresh ways. For example, though our participants gave semantic clues that suggested scientific knowledge production in academic was less "real" or perhaps, less valuable than science done for corporate profit or government politics, their actions—on-ramping specifically—refute this. Further attention is needed to understand this gap between how on-rampers talk about the academy and how they relate to and act within it. Can on-ramping serve as a catalyst not only for desegregating STEM but also fostering public dialogue about the politics,

profits, and discursive, material and ideological power relations of scientific work in industry, government and the academy?

7 Conclusion

The boundaries between industry, academia and government are growing ever-more porous (Kleinman and Vallas 2001; Slaughter and Rhoades 2004; Giroux 2002). On-ramping, the process by which STEM PhDs working in industry and government bring their skills and labor into the academy as faculty, may play a role in these forging these alliances. Our study “followed the actors” (Latour 1987) who are crossing professional boundaries and creating non-traditional pathways to the professoriate. We explored not only what it means to transition from nonacademic STEM careers into faculty positions, but what it means to do so as an underrepresented group member in one’s field with the support of a professional community of women. These participants, who transgressed institutions of STEM knowledge production, have a unique perspective that can elucidate the strengths and weaknesses of these sites, especially in regards to gender politics and knowledge production.

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