Organizational Pathways toward Gender Equity in Doctoral Education: Chemistry and Civil Engineering Compared

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Despite gains in baccalaureate and master's degree attainment, women continue to earn lower shares of doctor of philosophy degrees (PhDs) in many fields, a pattern that is often pronounced in science, technology, engineering, and math (STEM). This article uses comparative case study to understand organizational trajectories toward gender parity achieved in two STEM PhD programs—chemistry and civil engineering—in which women have earned significantly higher shares of PhDs than is typical in their fields. Our analysis uncovered a surprising pattern of progress toward parity occurring as an unintended consequence of other changes. Structural reforms implemented to maintain these departments' relevance and stature in changing disciplinary fields had ripple effects that included reducing their gender enrollment gaps in graduate programs. Their trajectories differed, however, and comparing them affirmed the potential of mindful organizational learning as a means of achieving sustainable progress toward equity.

Gender disparities in graduate education are part of a broader pattern of postsecondary stratification in which we observe widening access to higher education as a whole, with "durable inequality" (Tilly 1998) in its most selective and prestigious sectors (Karen 1991; Posselt 2014). Women, Latinx, and African American students have rapidly increased baccalaureate attainment (Buchmann and DiPrete 2006; Fine 2015) and participation in master's degree-level programs over the past 40 years (Buchmann et al. 2008; Torche 2011), but their progress toward equitable representation in doctoral education, relative to the

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population, has been slower (Mullen 2003; Posselt and Grodsky 2017). Recent estimates indicate that women are overrepresented by 15 percentage points among master of arts degree recipients but underrepresented among master of business administration and doctor of philosophy (PhD) degree recipients (Torche 2011).[1] Between 2004 and 2014, women earned less than 32% of the PhDs awarded in physical sciences, mathematics and computer science, and engineering (National Science Foundation 2017).

Gender stratification in doctoral education is a function both of inequalities in baccalaureate attainment and social origins (Mullen et al. 2003) and of background differences in the colleges and majors that students tend to choose (Bowen and Rudenstine 2014; Xie and Shauman 2004). These precollege and college factors are related to one another, to public policy, and to doctoral programs' admissions and recruitment policies (Bersola et al. 2014; Posselt 2016). Quantitative and qualitative evidence converges on Graduate Record Examination (GRE) scores and college and university selectivity as two of the most heavily weighted factors in doctoral programs' admissions decisions (Attiyeh and Attiyeh 1997; Posselt 2016). However, men have higher mean GRE scores (Educational Testing Service 2017) and stronger odds of enrolling in very selective institutions (Bielby et al. 2014; Posselt et al. 2012), which helps explain this group's advantage in admissions. Lovitts and Nelson (2000) found that women in PhD programs leave graduate studies in higher numbers than men, despite earning higher average grades. They concluded that gender disparities in doctoral attainment rates should be understood not as a problem of student ability but of departments' ability to equitably serve and retain students (Lovitts and Nelson 2000).

Within science, technology, engineering, and math (STEM) fields where gender disparities in doctoral enrollment are the norm, how do some PhD programs close the gap? What characterizes their trajectories? This article answers

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these two questions, building knowledge about gender as an institutionalized but dynamic force within academic STEM departments and disciplines. We offer an in-depth comparative case study of trajectories toward gender parity in two unique PhD programs that, for at least 5 years, have both enrolled and graduated significantly larger proportions of students who identify as women than other programs. These highly selective civil and environmental engineering (CEE) and chemistry programs are both located in well-known public research universities in states with bans on gender and racial or ethnic affirmative action in admissions. The departments vary, however, in their intellectual focus as applied versus pure fields.

In a finding that is unusual for education research, our extended retrospective analysis uncovered how progress toward parity in graduate education may emerge as an unintended consequence of other organizational changes. We found that structural reforms implemented to maintain these departments' relevance and stature in changing disciplinary fields had ripple effects that included reducing the gender enrollment gap in their PhD programs. The chemistry and engineering programs' trajectories differed in important ways, however, and comparing them affirms the potential and superiority of mindful organizational learning processes for maintaining progress toward equity and inclusion. Compared with change that comes about unintentionally, intentional change processes possess sufficient breadth and depth to become self-sustaining. In addition to contributing new theoretical insights on organizational change for equity in higher education, our findings inform efforts of faculty and administrators to broaden women's participation in STEM. Specifically, we identify three conditions that may create more fertile ground for departments to reduce gender inequalities in doctoral education.

Producing Gender in STEM

Scholars have advanced the study of gender from treating differences as biologically determined to understanding processes by which gender shapes individual beliefs and assumptions, social relations, and organizational structures (Acker 1990; Risman 2004; Scott 1999). Although it is now commonplace to say that gender, like race and other social identities, is socially constructed, it is less common to delineate how this takes place and what the implications may be for the maintenance or disruption of gender hierarchies. In this section we lay out three domains of change in STEM doctoral departments that align with three levels of analysis at which sociologists argue that gender is created.

Sociologists argue that organizations construct gender through cultural beliefs, interactions, and structures and that these interact in complex ways (Ridgeway 2009). At the cultural level, we construct gender through "routine, me-

thodical, and recurring" (West and Zimmerman 1987, 126) activities based on normative beliefs about of one's sex category in a particular situation. Gender-stereotyped beliefs that cast men as agentic and competent and women as communal and emotionally driven continue to confer higher status to masculine traits across contexts (Ridgeway 2011). Within interactions, gender is one of the few primary ways we categorize people (Ecklund et al. 2012; Ridgeway 2011; West and Zimmerman 1987). It also shapes other social roles, working as "a kind of ghost in the background while other identities and activities are performed in the foreground" (Ridgeway and Correll 2004, 522). Finally, at the structural level, gender is integral to creating and maintaining processes of dividing labor, communicating systems of meaning, establishing power and position, and assessing gender presentations (Acker 1990). Rather than being a separate or additional process to ongoing identity-neutral organizational life, gender "is a constitutive element in organizational logic, or the underlying assumptions and practices that construct most contemporary work organizations" (Acker 1990, 147). In the following sections, we outline current research and theory about the production of gender at each of these three levels within STEM.

Cultural Beliefs

Researchers find an apparent paradox between the common belief that scientific investigation is a gender-neutral activity and the disproportionately low number of women faculty and graduate students in engineering, math, and physics (Ecklund et al. 2012; Fox 2010; Kulis et al. 2002). This structural inequality holds even when controlling for the number of women in the doctoral labor supply and the presence of women faculty in STEM fields (Fox 2010; Kulis et al. 2002). Ecklund et al. (2012) found that scientists in biology and physics cited innate gender characteristics and predispositions to explain the higher proportion of women in biology. However, women in both disciplines were more likely to cite discrimination as an impediment to their progress and inclusion. Ecklund et al. (2012) argued that their results align with a view of gender as a "master identity status" that influences both perceptions of STEM fields and the scientists working within them.

Essentialist gender beliefs also negatively affect expectations and evaluations of women faculty members (August and Waltman 2004; Bailyn 2003; Maranto and Griffin 2011; Terosky et al. 2014), leading Fox (2010) to propose interventions in the distribution of work-related resources and family-supportive policies. Implicit biases that favor traditionally masculine working styles and that allow discrimination to continue unchecked also need to be addressed (Ecklund et al. 2012; Rhoton 2011; Trix and Psenka 2003). Judgments of merit

for admission to highly selective PhD programs may also reflect gendered cultural beliefs. Faculty commonly define and infer academic ability and potential from metrics that underpredict women's performance, and their interpretations of personal statements, letters of recommendation, and interviews often involve gender-biased judgments of professionalism and seriousness (Posselt 2016). At each stage along the pathway through academic life, academic cultural beliefs confer greater status to traditional norms of masculinity.

Interactions

Social relations within STEM departments may intersect with gender beliefs by framing shared expectations of performance, roles in the academy (e.g., student, scientist, or professor), and interactional patterns. In a study of 102 tenured women faculty members in STEM, Britton (2016) argued that gender was less of a looming, exclusionary presence (as suggested by "chilly climate" literature) than it was evident in and endemic to interactions. From decisions about employee pay to critiques of women's wardrobe and work-life strategies, Britton (2016) found that gender "merged forcefully into the foreground" (17), reminding women of their position in departmental hierarchies.

Gendered beliefs that give privilege to masculine practices and working styles also influence how women interact with others and present themselves within STEM departments. As such, women in STEM can also function as purveyors of gender stereotypes (Rhoton 2011). Investigating how women scientists in 17 STEM fields took up gender norms, Rhoton (2011) found that more women scientists adopted practices "congruent with masculinity" (698), such as assertiveness, objectivity, and dominance. Women in the study also avoided overly feminine gender displays, and they negatively viewed female colleagues who showed emotion, who were overly feminine in their presentation, or who worked to address gender bias in the department. They also strove to minimize effects of everyday gender discrimination in the department by developing "thick skin" (Rhoton 2011, 711). In sum, women scientists often fit their gender presentations and interpersonal interactions to prevailing traditionally masculine "cultural norms and expectations" (Rhoton 2011, 698) in their departments.

These tendencies may take hold in graduate school. Similar to Rhoton (2011), Powell et al. (2009) found in interviews with second-year women graduate students in male-dominated engineering fields that participants sought acceptance by managing their gender presentation to fit masculine norms, minimizing the effect of discriminatory experiences, and distancing and criticizing women who displayed feminine attributes in and outside their field (Powell et al. 2009). Gendered cultural norms and beliefs therefore become reinscribed

at the interactional level in STEM through both discrimination and gendered performances of early career women trying to establish legitimacy in a male-dominated space.

Structures

That women faculty respond to discrimination with individual-level strategies and that men are less likely to even recognize gender-based discrimination (Ecklund et al. 2012) explain why both groups may be inclined to "resist efforts to create structural change" (Rhoton 2011, 712). However, after women faculty members at the Massachusetts Institute of Technology (MIT) demonstrated gender biases, a team of administrators and women faculty members promoted gender equity with a theory of change that explicitly examined organizational practices against the quality of people's home and work lives (Bailyn 2003). This intervention allowed deans at MIT to examine the gendered effects of "entrenched academic practices" (Bailyn 2003, 145) and thus to find more equitable policy and practice alternatives. This work, paired with evidence from the National Science Foundation's ADVANCE program, also suggests that structural change processes can be helpful in uncovering embedded norms used to legitimate everyday routines and practices that disadvantage women.

Change in Gendered Organizations

The cultural, interactional, and structural levels at which gender is constructed produce the potential for "many different stories" (Alvesson and Billing 2009, 5) about gender in academic organizations. We are interested in the ways that gender dynamics at each of these levels may be intentionally re-created or may quietly shift in STEM PhD programs, leading to substantive increases in women's enrollment rates. An open systems view (Scott and Davis 2015) acknowledges how sociopolitical and intellectual environments may present organizations with incentives and motivations for change. In this section, we describe these theoretical perspectives and how they may intersect with those in the literature summarized above to explain change in PhD programs.

Adaptive and Isomorphic Change

In most educational research studying organizational change, scholars have focused on deliberate change—that which comes about through intentional, strategic planning.[2] Less frequently studied are cases of change in higher edu-

cation that take place informally, reactively, even unconsciously, through adaptation and imitation. However, when looking outside higher education, scholars have found that repeated cycles of incremental adaptation to environmental conditions may, in time, produce significant organizational change (Hannan and Freeman 1977; Weick 1979, as cited in Van de Ven and Poole, 1995). Others have documented that intentional change in one organizational domain may have unintended cascading or rippling effects in other domains (Cameron and Quinn 1988) and that unintended outcomes (both positive and negative) may follow middle managers' implementation of upper level leaders' intended policies and change strategies (Balogun and Johnson 2005; Lipsky 2010). Even highly managed change processes can take on lives of their own, so both organizational pathways and their destinations are rarely fixed. Whether such unpredictability is true of change toward gender parity in higher education has rarely, if ever, been considered.

Organizational Learning and Institutionalization

Environmental demands may compel adaptation that gives rise to structural features with the appearance of progress toward equity (DiMaggio and Powell 1983). Such adaptation, however, should not be confused with more agentic processes of organizational learning that can institutionalize equity as a value. Single-loop organizational learning changes structures or processes already in place, and double-loop learning also strives to change organizational beliefs, values, and cognitive frames (Argyris and Schön 1978, 1996; Bensimon 2005), which can condition longer term structural change. Because double-loop learning may destabilize the organization during the change process, however, organizations more often engage in single-loop learning (Argyris and Schön 1978, 1996) and adaptive change (Cameron 1984).

Crossan et al. (1999) identify four processes through which learning involves the flow of feedback between the organization and its members: intuiting, interpreting, integrating, and—ultimately—institutionalizing. They argue that power inheres in these four processes and in larger patterns of organizational learning (although traditional models of organizational learning left power largely unexamined) because organizations are inherently political. Power and politics may also help explain why some organizations have a greater capacity for learning than others (Lawrence et al. 2005). In processes of institutionalization, which are of particular interest in this study, power and politics determine which norms are institutionalized and the political savvy of leaders (whom DiMaggio [1988] dubs "institutional entrepreneurs" [14]).

Applying these ideas to the study at hand, we propose that improvement in PhD programs on student metrics that indicate progress toward equity may

come about through adaptation, through learning, or as a fortuitous by-product of other changes but that these should be understood as qualitatively different processes and outcomes. We would expect to find gender equity promoted more sustainably within PhD programs whose faculty members are agentic and open to learning. We would also anticipate a distinctly potent opportunity for change when and where institutional entrepreneurs press their colleagues to see—and shift—the power relations that typically operate within systems of admission, recruitment, mentoring, and teaching and learning more broadly. Indeed, structural reform alone will be insufficient to realize long-term change. It must be connected to changes in key stakeholders' cultural beliefs, patterns of interactions, and relationships (Griffin and Muñiz 2011; Rogers and Molina 2006; Tierney and Sallee 2008). Reform of structures alone can even operate as a smokescreen in higher education environments, concealing persistent climate problems, intraprogram segregation, and uneven mentoring (Bensimon 2005; Posselt 2016).

Method

This article draws from a comparative case study at two major research universities that investigated how STEM PhD programs maintain or increase diversity in the absence of affirmative action. Case study research provides "in-depth description and analysis of a bounded system" (Merriam 2009, 40), with cases identified for their "typicality, uniqueness, [or] success" (41). The primary distinction between single-case studies and comparative case studies lies in the ability to observe patterns across cases. Comparative case study analysis involves "within case analysis" and "cross-case analysis" (Yin 2014, 204). Comparing patterns in the deep, context-specific evidence that case studies generate makes this method well suited to uncover social mechanisms (Yin 2014). We examined the following questions: Within STEM fields where gender disparities in doctoral enrollment are the norm, how have programs closed the gap? What characterizes the programs' trajectories?

Sampling and Data Collection

Case sampling.—We intensively analyzed the trajectories of two STEM programs at two universities that, from 2009 to 2014, enrolled and awarded a significantly higher proportion of PhDs to women than the national rates for their respective fields while maintaining compliance with state affirmative action restrictions. The programs are in two Carnegie-classified Research Universities

with Very High Research Activity and are both in well-known state flagship institutions but are located in different regions of the United States.

To identify these case study sites, we worked with the graduate schools of each university to obtain lists of STEM doctoral programs that, for the last 3 to 5 years, had enrolled and graduated significantly higher proportions of women than their disciplinary counterparts. The project's principal investigator spoke with administrators in the graduate school and with chairs in the prospective PhD programs to assess three other case-level criteria: the program's history of engagement with underrepresented populations, admission and recruitment practices, and leaders' willingness for the program to be part of the study. The two programs described in this article met all criteria for inclusion in the study.

Within-case sampling.—Characteristics of the sample within each of the two cases (CEE, $n = 13$; chemistry, $n = 21$) are summarized in table 1. Within cases, we employed criterion sampling at two levels. First, program chairs assisted us in identifying faculty and staff who were engaged with diversity or equity issues within the department and who thus could serve as informants about the content and process of changes to date. Then, current department administrators, faculty, and staff aided us in identifying a sample of students and alumni who collectively maximized variation among cohorts, program concentrations, genders, and races or ethnicities.

Data collection.—For each case study, we conducted interviews, observations, and document analysis to develop an in-depth understanding of the program as a social context for diversifying graduate education. Our team collected data in the chemistry and CEE programs over a 19-month period (from November 2014 through May 2016) with a total of 34 faculty, staff, students, and alumni. Interviews were the primary form of data collection. We conducted interviews with 21 people in chemistry—15 informational or semistructured interviews with individuals and 2 semistructured focus groups involving three current PhD students each. Because of scheduling challenges during our site visit, we conducted only individual interviews in CEE—a total of 13 interviews with faculty, students, and staff.

Data collection at each campus began with an informational interview with the relevant department chair and ended with an informational interview with a university administrator who was familiar with the program's work on diversity-related issues. Between these, we conducted semistructured interviews with faculty, staff, and students. These interviews ranged from 30 to 75 minutes and collected narratives about the program's history and admissions practices and about gender dynamics and trajectories toward equity within the program. In chemistry, we also conducted two 90-minute student focus groups to clarify student experiences with the program's climate for diversity. All in-person interviews and focus groups with students and faculty took place in private

TABLE 1

Characteristics of Data Collected by Program, Role, Gender, and Interview Type

	FACULTY		STAFF		STUDENTS		ALUMNI		
COLLECTION METHOD	Male	Female	Male	Female	Male	Female	Male	Female	TOTAL
Chemistry:									
Informational and semistructured interviews	3	3	1	2	1	2	1	2	15
Focus group	0	0	0	0	2	4	0	0	6
Total	3	3	1	2	3	6	1	2	21
CEE:									
Informational and semistructured interviews	7	1	0	1	0	4	0	0	13
Focus group	0	0	0	0	0	0	0	0	0
Total	7	1	0	1	0	4	0	0	13
Grand total	10	4	1	3	3	10	1	2	34

NOTE.—CEE = civil and environmental engineering.

spaces within their respective program areas and were transcribed verbatim, changing only personally identifiable information to ensure accuracy and participant confidentiality in the analysis process.

Data Analysis

We analyzed data using within-case and across-case analyses. We used NVivo 10.0.3 for within-case analysis of interview and focus group transcripts, employing line-by-line coding to allow themes and patterns to emerge about program members' attributions for the change in the program's composition. In addition to inductive analysis eliciting unexpected themes (e.g., university context, intentionality, disciplinary relevance), constructs from our literature review and theoretical framework provided us with sensitizing concepts (Bowen 2006) representing dimensions present in typologies of organizational change. These were evolutionary and strategic change, first- and second-order change, and individual and collective change (Kezar 2012; Van de Ven and Poole 1995). Data from these categories were entered into a shared coding matrix using Google Sheets. After this initial round of identifying themes, we reconvened to drop some codes from further analysis (e.g., first- and second-order change was not readily apparent) and to discuss possible axial codes—themes with more abstraction than those elicited through open coding. Here, we found the three levels at which gender is commonly produced (i.e., individual, interactional, and structural) to serve as a useful organizing tool for our themes.[3] With these findings, we developed case narratives about each program. We concluded with a cross-case analysis (Merriam 2009) that compared the programs across three organizational change dimensions (intentionality, individual and collective effort, and depth of change) and the three levels at which gender is produced.

Trustworthiness and Reliability

Our team implemented several strategies to increase the trustworthiness and reliability of the data and findings. Strategies to enhance reliability included reflective memos throughout the data collection and analysis processes to make our interpretations more transparent, biweekly discussions of interpretations during the analysis period and interrater reliability checks, member checks of the preliminary findings with program chairs, and multiple rounds of analysis to refine our interpretations. All members of our racially and ethnically diverse team were involved in the data collection and analysis.

Our findings are more trustworthy because data obtained from varied interview formats (i.e., unstructured informational, semistructured, focus groups)

and diverse perspectives (i.e., students, faculty, staff, and alumni) yielded similar conclusions within each case. In addition, we triangulated interpretations throughout the analysis process, comparing faculty, staff, and student perspectives in each department to identify inconsistencies based on role and individual experience and seeking evidence from participants in multiple roles to corroborate preliminary findings. Finally, we attended to our positionalities and subjectivities, both as individuals and as a team of three cisgendered women, two from racially or ethnically marginalized backgrounds. We discussed how societal, institutional, and personal events affected us as women and as women of color studying gender, and we engaged in a writing exercise midway through the analysis process to reflect on potential blinders in data analysis that relate to our identities or personal frames. Discussion of this exercise allowed us to check our own and one another's subjectivities.

Limitations

The primary limitation of the study concerns balance in our corpus of data: we have somewhat more participants in chemistry than CEE, more women than men in the sample overall, and focus group data only in chemistry because of scheduling difficulties. It is notable, however, that we reached saturation in analysis in both departments, suggesting that we obtained a comprehensive picture using the types of data that were available to us. A second limitation of the study derives from our use of an organizational-level theoretical framework, which may prevent us from seeing the more hidden ways that gender can operate at the level of individual cultural beliefs and one-to-one interactions. In a different design of the study, we might have asked more explicit microlevel questions about gendered interactions.

Findings

In this section we present composite narratives describing the pathways to improving women's enrollment in these PhD programs over time and then a cross-case comparison linking our findings back to the theoretical perspectives introduced earlier. However, it will be helpful to readers to obtain a broader perspective on gender and graduate education in these fields. Table 2 presents the numbers and percentages of women earning bachelor of science (BS) degrees, enrolling in graduate programs, and earning PhDs in 2000 and 2011. With the exception of a slightly declining proportion of BS degrees awarded to women in civil engineering, women's representation modestly increased over time for all levels captured in both fields. In 2011, women earned 39% of the

TABLE 2

Number and Proportion of Women in Chemistry and Civil Engineering, 2000 and 2011

	EARNED BS DEGREES		GRAD STUDENT ENROLLMENT		EARNED PHD DEGREES	
	2000	2011	2000	2011	2000	2011
Chemistry:						
Total	10,388	12,888	18,105	22,802	2,090	2,685
Women	4,905	6,328	6,756	9,441	664	1,047
%	47.2	49.1	37.3	41.4	31.8	39.0
Civil engineering:						
Total	9,571	14,840	16,541	19,596	628	894
Women	2,325	3,278	4,277	5,589	115	239
%	24.3	22.1	26.0	28.5	18.3	26.7

SOURCE.—National Science Foundation (2014a, 2014b, 2014c).

chemistry PhDs awarded nationally and 27% of the PhDs in civil engineering; in the programs studied, women completed nearly 50% and 40%, respectively, of the PhDs awarded in those fields from 2009 to 2014.

The qualitative case studies enabled us to look inside these programs to understand how and why their representation is closer to parity than the national average. We found that women's enrollment in chemistry increased through a long process of organizational learning about gender equity that was sparked by the need to improve hiring and tenure outcomes among women faculty. Women's enrollment in CEE, however, emerged as a by-product of curriculum reform designed to maintain the program's relevance in engineering and was sustained by a small group of women faculty. In contrast to a model of strategic enrollment management, we find an important role for isomorphic changes: the gender composition of both programs shifted as an unintended consequence of efforts to protect the programs' relevance and competitiveness within their fields.

Chemistry

In chemistry, what a professor described as a "commitment to increase gender diversity in the department" developed in the late 1990s out of recognition that the program's ranking and national reputation was suffering. A professor recounted: "As an academic department at High Tower University [pseudonym], it is very difficult to understand what it is like to be ranked so low. It is a head-hanging embarrassment in your professional community. . . . It is the faded movie star [*laughs*] kind of thing: 'You . . . are High Tower. How can you be ranked so low? You're High Tower. You're better than that.' But the place

was devastated." The flagging ranking stemmed in part from a failed history of recruiting and retaining women faculty, and this motivated department leaders to seek solutions that would enhance both their standing and the representation of women. The chair reflected: "When I arrived, I was the second full professor female ever in the department. . . . They had hired a number of female assistant professors who didn't get tenure. A year before I came, there was a legal challenge over one of those. So when I went back and looked, you know, almost every male faculty member had gotten tenure and just one female." Department leaders parlayed the department's vulnerability in the discipline and a collective acknowledgement that "something was wrong" into a constructive organizational change process.

Institutional partnerships and resources fueled collective effort.—Recognizing that they lacked the expertise that significant changes would require, department leaders turned to university partners for guidance, and the intellectual and financial resources that followed seeded a series of reforms. The chair proudly described, "We got one of these institutional transformation grants in the early 2000s—and using that, we went through *all* of our policies, *all* of our procedures, and worked on trying to make them more inclusive." In time, the department began to draw prominent female faculty. One, who was also the admissions chair, shared: "One of the biggest contributors to the attractiveness of this department was the number of female faculty. It is highly unusual in chemistry. For my PhD, there were very few faculty. . . . And then you come here and there [is] . . . a ridiculously large number compared to everywhere else . . . And our chair is a woman. . . . The presence of women and the leadership of women in the department has led to the point where I don't feel like I'm a minority anymore. I feel like I'm an equal contributor." The department chair also described ripples of change in the student community as faculty composition shifted: "With the grant, we made a commitment to increase gender diversity in the department. And we started with faculty, but it had a feel that it was a department that was friendlier to women, particularly in certain areas like organic synthesis, which is typically really macho. . . . For women students who want to go in that area, I think, this [department] is a really different experience." Every single professor and staff member that we interviewed concurred that the presence of more female faculty favorably influenced recruitment of female doctoral students. A staff member reminisced: "It empowered other people in the department who were thinking diversity thoughts, and not just about faculty. . . . It encouraged a conversation about diversity. . . . They hired these dynamite women who were better than the men they could hire. . . . They went up in the rankings. . . . It was kind of clear that diversity was doing good things for them. . . . So I think that created a very fertile ground for them to diversify the graduate student population." From the perspective of organizational learning, the "conversation about diversity" required to pass and institutionalize faculty policy reforms,

followed by the success of those policies in hiring "dynamite women," created "fertile ground for them to diversify the graduate student population."

Critical mass of women faculty signals cultural change.—As a critical mass of women joined the faculty, the PhD program made them part of the image it presented to prospective PhD students. A previous admissions chair shared: "The graduate students, when they come here on recruiting weekends . . . see the number of female students . . . [and] the number of female faculty members that are here, and they realize that this is a place where as a female they will not stand out. And I think that makes a huge difference to them in terms of the environment." She continued, reflecting on both the explicit cues students see in a department with a critical mass of female faculty, such as women in leadership positions, but also implicit cues about work-life integration: "Almost all of our faculty believe that we should have pictures of our family out—little cues. And at our graduate recruiting weekends frequently people bring their kids, so they'll see kids running around. The male faculty bring their kids too . . . and so I think it is not explicit cues but some of these implicit cues, and I would say that is deliberate by the women faculty, because we definitely believe that you ought to be able to be in academia and have a family whether you're male or female." Such subtle messages may go unnoticed by some, but for many others, they signal cultural values and beliefs that make the program stand out in the field.

Revisiting graduate recruitment and admissions strategies.—Attention to their systems for recruiting and promoting faculty has recently led department leaders to formally reassess practices for admitting and recruiting graduate students. Department leaders have made some bold moves in this regard. A past admissions chair recounted, "My year [as chair], we didn't look at GRE scores at all and then this year, we didn't require them." She acknowledged that the same program that provided the institutional grant to address faculty hiring and promotion "convinced" her that GRE scores were not correlated with the outcomes the department sought. Professors have also begun privileging applicant research experience because it aligns with the work students are expected to do, and research opportunities are viewed as less likely to be gendered.

Today, doctoral student recruitment is not left to accident or coincidence. Rather, staff and faculty see graduate recruitment efforts as, in the words of one professor, "extremely important to the continuation of this department" and the mechanism by which they will yield their strongest students. Female faculty members phone prospective students, for example, and thoughtfully pair current and prospective students for meals, housing, and other events during Campus Visit Day. They go so far as to design seating arrangements to maximize the chances for honest conversations.

What started as an intervention to improve the department's flagging ranking and poor record with female faculty developed into a long-term process of making its policies, practices, and eventually its culture more inclusive of women—

first on the faculty and, later, in the PhD program. Today, the department is proud of its success and of its reputation in the discipline for progress toward gender parity. The organizational learning that transpired now fuels new efforts to improve the department's ability to admit, attract, and retain scholars of color.

Civil and Environmental Engineering

In contrast to the chemistry program's proud and public record, gender equity has not been a formal aim at any point in the CEE department's history. Indeed, program leaders were surprised to learn from us upon our initial contact that they had been enrolling and graduating significantly higher shares of women than is common in the field. However, when prompted to reflect, PhD program leaders could easily identify resources that have allowed them to increase and maintain the department's enrollment of women doctoral students. Faculty and staff described success attracting and graduating women graduate students as the fortunate outcome of an organizational history that unfolded through momentum generated by the intellectual focus of the department, a growing pool of female undergraduates, and the mentoring provided by women faculty members who were eventually hired into it.

An important decision with unintended consequences for women's PhD enrollment was made by department leaders in the 1960s. Looking to incorporate subfields related to water and the environment, which were emerging in importance within the geosciences and engineering, an influential dean reformed the program's curriculum and renamed the unit "Civil and Environmental Engineering." Making explicit the intellectual connections of engineering with life sciences was intended to maintain the department's relevance in a changing disciplinary landscape, but it also attracted women to its undergraduate program—and eventually the PhD program. Compared with other engineering subfields in which the gender distribution is more imbalanced, environmental engineering tended then, and continues today, to enroll a higher proportion of women. The potential for engineering applications that directly serve humanitarian aims has been identified as a possible explanation for this trend (Ecklund et al., 2012).

Research with undergraduate students facilitated PhD admissions with minimal attention to the GRE.—Enrolling more women as undergraduates might never have affected the PhD program were it not for an integrated approach to recruitment and admissions. Unlike many in engineering, CEE commonly recruits and admits PhD students from its research-intensive undergraduate and master of science (MS) programs through an admissions process that subordinates almost everything to research experience and, as summarized by one professor, "knowing a student's creativity and work ethic." The confidence born of faculty mem-

bers' first-hand exposure to these qualities through students' engagement in research as undergraduate and master's degree students also gives faculty confidence to minimize the weight they attribute to the GRE. A faculty member shared: "Most of the students that go on to a PhD, we already know really well. We don't need the GRE. We see them in class. They've sometimes done a master's thesis. . . . They may have done a little bit of lab work. . . . Most of the students by the time they're asking to be in the PhD program, we know quite a lot about them." As a result, the department chair explained, women students from the master's degree and undergraduate programs proceed through a "gender-neutral admissions process in decent numbers." Paying minimal attention to GRE scores was a natural extension of paying considerable attention to students' experience with the sort of work they would be expected to do as PhD students and of the pathway the department had created into the PhD program from its undergraduate and MS programs.

Presence and role modeling of women faculty attracted prospective women students.—In addition to its unusually high enrollment of women in the PhD program, the CEE department stands out for holding the highest percentage of women on the faculty in the university's engineering school. Although the graduate chair cited current numbers as "frankly still too low," student, faculty, and staff participants alike credited women's presence and mentoring as crucial to the PhD program's record with women students. Specifically, women faculty—who identify with several racial and ethnic backgrounds—provided women students with encouragement and opportunities to see themselves in successful academic roles. One student who had come up through the undergraduate program shared: "There is a lot more room to be able to communicate personal stories, and to then feel comfortable and feel like they're going to understand your situation, and provide the support that you need. And so I've actually never been close to any of the male professors. I came here as an undergrad as well, and I was a chemical engineer back then. And I never felt comfortable speaking to any of the professors. . . . I switched to environmental from chemical engineering specifically because of those two professors—those two women." In another example, an undocumented immigrant student expressed the value of having women on the faculty to whom she could open up about her status and its related challenges and who knew of resources through which she could navigate the university bureaucracy.

Women faculty in our sample were not shy to join the consensus about their important role in attracting and supporting women students. They named the time they gave and their approaches to mentoring when discussing conditions within the program that support women's enrollment. They engaged students' interests outside of coursework, encouraged women undergraduates to apply to the doctoral program, and shared their knowledge of departmental and campus resources. They also modeled strategies for navigating the multiple demands

that come with work and family, even when this modeling required them to challenge unspoken norms in the department, such as when and where it is appropriate to work. A woman faculty participant said that she felt comfortable bringing her children to the office, and her male colleagues reported feeling "proud" of accepting children in the space. However, in interactions with some of those same professors, she received rude comments about the choice to leave the office at 3 p.m. to spend the after-school hours with her children: "What they don't see is that I'm going to work all night, or that maybe I started at 4 in the morning. . . . I'm here showing priority for my family because that's what attracts women . . . so many students say that they love that I leave early because then they see themselves having a job that's flexible. Why would you want to work 90 hours here every week? That's not role modeling." Without departmental flex-time policies or a critical mass of faculty experimenting with work-life strategies, the strategy this woman professor had created stood out and invited gendered interactions that caused her to feel "vulnerable" for prioritizing her family.

To summarize how cultural norms, interactions, and formal structures combined in CEE, our participants pointed to the strategic change of the department's name and curriculum as a spark for increasing women's enrollment at the undergraduate level. By cultivating research relationships with those undergraduates and emphasizing research experience in the PhD admissions process, the department created a pool of prospective women doctoral students who could be considered for admission. And among those admitted, the influence of women faculty as advisors and role models has encouraged women to matriculate and persist.

We did not observe overt use of individual power or department politics to undermine opportunities for women or to resist proposed reforms. However, we also did not see men using their privilege to actively advance a more inclusive policy, climate, or culture. The department never specifically sought to enroll more women in the PhD program, and few men in the sample expressed counternormative gender beliefs. One PhD student astutely characterized CEE as "supportive for a department that is not knowledgeable" and observed that an important next step would be "professional development that teaches how to best optimize for diversity, how to best welcome diversity." Though CEE seems far, in our judgment, from institutionalizing gender equity, the agency of current female faculty coupled with past changes to the program's intellectual focus, curriculum, and admissions have narrowed gender gaps to a degree that surprises even the program's leaders.

Discussion

To understand how PhD programs in STEM fields might effectively increase women's enrollment, this study investigated the organizational trajectories of

pure and applied PhD programs that have been enrolling and graduating women at significantly higher rates than is typical in their fields. Although sociologists have found gender to be produced at multiple levels, the structural level was most important as an impetus for change in these departments. We found in both programs that the trend toward enrolling more women could be traced to structural changes aimed at improving or maintaining each department's stature in its respective discipline. This pattern is consistent with the notion that disequilibrium with one's environment can catalyze change that cascades beyond the initial domain of reform. In both programs, changing policy and practice not only smoothed the way for female students to obtain access but also made the learning environment more appealing to women. Narratives of access and choice—often constructed by education researchers as distinct—are intertwined in explaining how these programs diversified.

Although the specific catalysts differed, a similar motivation compelled both programs' structural changes: a desire to maintain relevance and stature among departments in their fields. Chemistry aimed to boost the program's reputation amid failures with faculty recruitment and retention, whereas CEE wanted its intellectual offerings to reflect the growing differentiation within engineering. Today, in addition to isomorphic tendencies among peer and competitor institutions, departments may experience pressure to diversify from external agencies (Deem and Ozga 1997). Accreditation standards and position statements issued by professional associations have compelled some departments to make changes that enhance opportunities for women (e.g., the American Astronomical Society urging departments to discontinue requirement of the GRE), as have moves by funding agencies such as the National Science Foundation and National Institutes of Health to weigh broader social impacts when awarding grants. Collectively, such trends support a proposition inherent to institutional theory: when powerful resource providers and leading members in an organizational field shift their priorities, it can induce change in other members' priorities and behavior and, thus, in the system as a whole. This article is one of the first to document that equity-related changes may be among this sort.

Within CEE, disconnected, episodic reforms had cumulative effects over time, whereas chemistry underwent a change process that was a near-textbook case of organizational learning. First, chemistry faculty acknowledged a need for change in how they had created opportunities and barriers that affected women faculty. As a result of targeted reforms, the composition of the faculty changed, yielding a host of subtle shifts in the cultural cues that prospective students picked up about gender dynamics in the department. This combination of steps, they believed, helped them to attract a critical mass of women PhD students, and they took the momentum, knowledge, and capacities gleaned from reforming faculty-level policy and practice to explicitly reform policies in the PhD program. Consistent with Bensimon's (2005) work encouraging or-

ganizational learning through the Equity Scorecard, faculty actively engaged with data to expose the nature and scope of their problems with gender in the professoriate, and they have continued to use data over time to monitor the efficacy of their solutions. Chemistry developed reforms through department-chair-initiated efforts, which expanded to collaborations across department concentration areas and with campus experts on institutional change. The department accomplished a combination of structural and cultural changes, surfacing embedded assumptions about gender that permeated its policies and practices. Today, the department carries forward 2 decades of learning with respect to gender to make changes that will improve racial and ethnic equity among its faculty and graduate students.

CEE had not been consciously trying to improve women's representation, but when probed, leaders pointed to factors that made their department unique: the addition of environmental issues to their departmental expertise, attracting undergraduate women; their willingness to recruit graduate students from that undergraduate pool (and a willingness to downplay the GRE in favor of research experience); and the positive influence of women faculty on women students' enrollment and persistence. CEE's pathway did not have any of the typical characteristics of organizational change for equity that higher education scholars have identified, such as active use of disaggregated data (Bauman 2005; Harris and Bensimon 2007; Kezar 2012), making implicit processes explicit (Bensimon 2005; Kezar et al. 2015; St. John 2008), or employing context-specific leadership (Kezar 2007; Kezar et al. 2008). However, this could be because most research on organizational change in education has focused on strategic change processes. Long-term organizational adaptation has much less frequently been the subject of study, though it takes place around us every day.

Implications for Practice

Attending to the multiple levels at which gender is typically produced—cultural beliefs, interactions, and structures—offers one way of comparing the progress toward gender parity and implications for practice in other programs. Table 3 displays these salient areas of change and negotiation.

Structural changes.—Both chemistry and CEE identified structural efforts unrelated to graduate education as catalysts for enrolling women doctoral students. In CEE, adding environmental engineering to the department's purview almost 60 years ago set the stage for attracting a larger share of women undergraduates than is typical within engineering writ large or even in civil engineering. The catalyst in chemistry was a thoroughgoing assessment of how its policies and practices may have curtailed the full inclusion of women on the faculty. By

TABLE 3

Cross-Case Comparison: Areas of Change or Negotiation Affecting Doctoral Enrollment

	Structures	Interactions	Cultural Beliefs
Chemistry	GRE subordinated to research experience or eliminated in admissions Composition of the faculty Assessment and reform of formal policy and standard practices through institutional grant	Presence and mentoring from a critical mass of women faculty encourages matriculation and persistence Strategic connections fostered during recruitment weekend Women PhD students describe not being isolated	Meaning of merit for admission Norms for work-life integration Women as department and admissions leaders
Civil and environmental engineering	GRE subordinated to research experience in admissions Composition of the undergraduate student population Niche intellectual focus attracts women	Presence and intensive mentoring from a small number of women faculty encourages matriculation and persistence Women PhD students describe supportive faculty relationships	Meaning of merit for admission Appropriateness of recruiting from its BS and MS programs Norms for work-life integration

changing the subject matter in CEE and changing the gender distribution of the faculty in chemistry, both programs created more attractive learning environments for women students.

Cultural beliefs.—We saw changes in cultural beliefs about gender less clearly in CEE than in chemistry, which is consistent with the latter department's engagement in a more mindful, collective process that reflects tenets of organizational learning. According to our participants, though, norms about work-life integration remain one domain of cultural beliefs that is under negotiation in both places. In CEE, women faculty who deviated from a 9-to-5 office schedule received informal criticism from male colleagues. Yet in both programs, at least some faculty attended to the cultural cues about work-family integration that might be sent through their offices, time use, and department events. In the chemistry department, we observed that professors' (both men's and women's) offices included yoga mats or treadmill desks on the floors, and almost all had photos of family members or children's artwork on walls or desks. Another area of change in cultural beliefs involved the judgments about what makes an ideal graduate student and how that should inform admissions decisions. Both programs systematically deemphasized the GRE relative to research experience, and CEE established alternative pathways into the PhD program that helped explain its strong representation of women.

Interactions.—At the level of interactions, both programs also encouraged women's matriculation and persistence through the presence and mentoring of women faculty members. Women faculty in CEE appeared to play an intensive mentoring role within the life of the department, given their small numbers. In chemistry, where a critical mass of women professors had been hired and tenured, and which had actively worked through the implications for gender equity in its faculty policies and practices, women professors also served in formal leadership roles (e.g., department chair, admissions chair). Also at the interactional level, women PhD students in both programs discussed the quality of the climate. Those in CEE insisted that a key feature of the department was its supportive relationships, whereas those in chemistry shared that the critical mass of women (in both the PhD program and on the faculty) prevented feelings of isolation that women often experience in academia.

What can other PhD programs learn from this comparative case study?.—For institutions looking to change the composition of their PhD programs, revisiting recruitment and admissions practices, which often present structural barriers to underrepresented groups, may have the most immediate impact. However, inequalities may resist technical policy solutions in the long run because they are part of complex systems. We have discussed how structures, interactions, and cultural beliefs individually and interactively construct gender within organizations (Ridgeway 2009). Changing policies and practices—without revisiting their legitimating cultural assumptions and norms or the interactions

and relationships among people who enact them—can thus deliver only shallow, short-lived change.

Similarly, in PhD education, recruitment, admissions, and retention individually and interactively shape student opportunity (Posselt 2016; Rogers and Molina 2006), so it should not come as a surprise that PhD enrollment changed not only by changing proximal pathways into programs—admissions and recruitment—but also through work of faculty agents to shift the intellectual focus and faculty composition and enhance student mentoring. These factors conditioned the conduct of admissions, the efficacy of recruitment efforts, and PhD student retention.

Implications for Future Research

This work contributes to the nascent literature on organizational behavior within academic departments and graduate programs, especially organizational dynamics that affect stratification in graduate education and the professoriate. Our conclusions suggest the need for longitudinal organizational research, examination of ties between gender equity in graduate programs and students' professional trajectories, and further research on power-sensitive organizational learning.

We see two directions for longitudinal organizational research. First, given the compelling case for intentionality as a guiding principle in equity-oriented change efforts (Bensimon 2005; Chang 1999; Smith 2015), the unlikely story of CEE's success begs for research about the depth and sustainability of equity outcomes achieved without intentionality. We question whether programs that do not design for a given group's access or opportunities can consistently achieve positive outcomes. Second, we observed that chemistry seemed well positioned for efforts to close racial equity gaps because of a willingness and capacity for change that had been cultivated through its work on gender equity. However, the extent to which organizations with a record of gender equity work can transfer their learning to racial equity has never been investigated. To answer these questions and others, we hope that this article will encourage education scholars to consider embarking on longitudinal case studies of educational organizations to track their trajectories—in real time, rather than retrospectively.

It would also be valuable to document whether women with PhDs are more likely to pursue the professoriate when educated in graduate programs with more equitable representation of women or that have made conscious strides to improve inclusiveness. Graduate students are exposed and socialized to many of academia's norms and practices, and women may be more inclined to continue to the professoriate if they are a part of PhD programs with healthy and re-

spectful relationships and egalitarian cultures or where they observe incentive and evaluation structures that support gender equity.

Finally, we need research that examines twenty-first-century universities—and departments within them—as learning organizations. Like all social relations, gender relations are "not statically structured and defined once and for all, but are emergent and changeable" (Alvesson and Billing 2009, 7). We need to know much more about how universities and units learn to challenge entrenched power relations to encourage equity. Further research can clarify how collective learning toward equity may enable future generations to encounter better learning environments and academic workplaces than those who came before them.

Notes

1. Women's overrepresentation in master of arts (MA) degree programs is in part related to their overrepresentation in education programs; education is, by far, the most frequently pursued field of study for MA degrees.

2. Teleological models of organizational change propose that specific agentic change is achieved through a socially constructed cycle of "goal formulation, implementation, evaluation, and modification" (Van de Ven and Poole 1995, 520).

3. Note that whereas Ridgeway (2011) classifies cultural beliefs as the locus at which gender is produced at the individual level, we include broader individual factors.

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