"Imaginary Engineering" or "Re-imagined Engineering": Negotiating Gendered Identities in the Borderland of a College of Engineering

CINDY E. FOOR and SUSAN E. WALDEN

Explanations for women's continued underrepresentation in science, technology, engineering, and mathematics (STEM) have popularly employed a "leaky pipeline" metaphor. Recently, however, some have found the pipeline metaphor lacking in explanatory power for dealing with subtle, yet pervasive barriers embedded in specific cultures of engineering. The tension between culturally prescribed notions of masculinity, femininity, and engineering identities is one such barrier. Ethnographic interviews of 118 engineering undergraduates revealed multiple and shifting projects of constructing and claiming certain femininities and masculinities associated with engineering. Our analysis uses an intersection of feminist and discourse theory for a critical examination of multiple discourses contributing to the gendering of images, roles, positions, and a particular engineering discipline within our college and university culture. Loosened from the boundaries of gendered norms, this particular engineering discipline has become more "inviteful" to both women and men but requires different identity projects from each. Our goal is to contribute to discussions about gendered identities and cultures in engineering and to add our support to an emerging model in engineering education, the boundary model, for conceptualizing the movement of students into, across, and through the various domains of engineering.

Keywords: imaginary engineering / gender / identity project / boundary model / discourse / occupational segregation / industrial engineering

Introduction

Over the last thirty years, legislative and programmatic efforts in the United States have contributed to the dismantling of structural barriers which effectively limited, and in some cases barred, participation of women and minorities in many professions. History demonstrates, however, that attempts to achieve sex parity through programs grounded in discourses of liberalism and civil rights have accomplished only localized change. Recent data show that the total number of bachelor's degrees earned by women has increased from 49 percent to 58 percent between 1981 and 2006. Although women have reached similar representation in

many sciences (biological, 60 percent and physical, 42 percent), the proportion of women earning a bachelor of science degree in engineering has significantly lagged (CPST 2009; National Science Foundation 2009). From 11 percent in 1981, the percentage of BS engineering degrees awarded to women reached a plateau at about 20 percent in the twenty-first century. Like the calls for women to enter the production factories during World War II, the discourse of inclusion for science, technology, engineering, and mathematics (STEM) fields is more recently based on discourses of patriotism and economic necessity.

While legal barriers to inclusion have been legislatively dismantled, cultural barriers remain largely unchanged. Engineering in the United States continues to be perceived as a masculine domain[1] where female presence is experienced as transgressive (Drybaugh 1999; Frehill 2004; Riley and Sciarra 2006). Women who wish to answer the call for increased participation in engineering experience a cultural space enmeshed in a web of conflicting threads of possibility and frustration. Women who confront the traditional masculine norms shaping engineering must simultaneously respond to the conflicting feminine role expectations arising from the heterosexual social imperative (Bergvall 1996). Women are faced with negotiating both an educational and life experience within two competing discourses: "Engineering is Men's Work" but "Women can (and must) do Engineering." As a result, women are precariously positioned in often simultaneous compliance and resistance to the norms of hegemonic heterosexual femininity embodied in wife, mother, and nurturer (Newberry 2004).

We offer a critical analysis of the discourses contributing to the gendering of images, roles, positions, and a particular engineering discipline within our college and university culture. Our goal is to contribute to discussions about cultures in engineering and to add our support to an emerging model in engineering education, the boundary model, for conceptualizing the movement of students into, across and through the various domains of engineering (Gieryn 1983; Pawley 2007; Vallas 2001; Faulkner 2007).

Notwithstanding a name that might summon images of dark and dusty factories, the engineering discipline known as industrial engineering (IE), or in some areas systems or manufacturing engineering, has been at the forefront of increases in female participation. In the United States, women receive approximately 30 percent of the degrees awarded in IE, as they have for over twenty years. The 58 percent female enrollment in our local IE school was particularly noteworthy because no intentional effort had been put forth to accomplish that outcome. This sociohistorical background spurred an investigation by a multidisciplinary team into the seemingly organic attainment of sex parity in the undergraduate population within this specific school of engineering. Our research team embarked on a

four year study to identify the complex factors that contributed to the attainment of 58 percent female undergraduate enrollment.

While most themes that emerge from engineering education equity research focus on students and the obstacles they encounter along their educational and career paths (Stonyer 2002), this project joins an emerging body of research that focuses on the cultures of engineering (Drybaugh 1999; Shumar 2004; Miller 2004).

Over the past decades, theoretical explanations for the dearth of females entering the disciplines of engineering and the loss of many who do attempt to pursue the field have been modeled as a pipeline (Rosser 1995; Kimmel and Cano 2001). Recently, some engineering educators have begun to object to the pipeline model (Froyd and Watson 2007; Selingo 2007). We object to the pipeline model because it does not allow for consideration of differing cultures among disciplines or different educational environments, the sociohistorical processes that produce and reproduce the current educational system, or the possibilities of changing the system altogether.

Using a model based on the creation and maintenance of boundaries facilitates analysis of the ways in which space functions as a central organizing principle of social life with emphases on processes and relations to power (Spain 1993). Since these emphases examine the interactions between the students (the flow or agents) and the educational process embedded in power hierarchies (the pipeline or structure), the boundary model does not require the engineering education enterprise (including its beliefs and practices) to be assumed or accepted as given and fixed. Gerson and Peiss (1985) state:

> Boundaries mark the social territories of gender relations, signaling who ought to be admitted or excluded. There are codes or rules which guide and regulate traffic, with instructions on which boundaries may be transversed under what conditions. As a consequence, boundaries are an important place to observe gender relations; these intersections reveal the normal acceptable behaviors and attitudes as well as deviant inappropriate ones. At the same time boundaries highlight the dynamic quality of the structure of gender relations, as they are influenced and shaped by social interactions. (116)

Women in engineering occupy such intersecting boundaries or borderlands, zones of incommensurable contradictions where crossing is contested with frequent challenges to identity, authority, and autonomy (Gupta and Ferguson 1992). But, it is in the lived experiences in the borderlands where we locate the cracks in the hegemonic barriers through which emerge new definitional resources for women and men to claim (Anzaldua 2002). Boundaries function symbolically, metaphorically, and materially in constituting identities. In this paper, boundaries will be understood as sets of attitudes, practices, and discourses.

Table 1
Student participant demographic data

	IE*	EE/CE	CS	XE
Total	52	20	23	23
Female	28	3	9	13
Male	24	17	14	10
White	26	15	17	13
Black	8	1	0	3
Hispanic	6	1	2	4
Asian	6	1	2	0
Native American	3	1	0	3
Other±	3	1	2	0

*IE = Industrial Engineering, EE/CE = Electrical or Computer Engineering, CS = Computer Science, XE = Chemical Engineering; ± Other includes students who chose not to disclose, international students, and multi-ethnic students who chose not to claim one characterization. Race/ethnicity determinations are from student records or self-identification in their interviews.

Through the application of discourse analysis, we seek to understand how the community of IE at our university has come to be imagined within the interconnected hierarchy of schools and disciplines and how gendered identities have been produced, reproduced, and re-imagined in that community. These local discourses re-drew the boundaries and borders of engineering disciplines to create an inviting culture for women and men.

Methodology/Theory

Data Collection and Processing

Over the last four years, we immersed ourselves in over 4,500 pages of textual data generated from ethnographic interviews of 118 (55 female, 63 male) undergraduate engineering majors. Particular statements regarding engineering, as well as multiple and shifting projects of constructing and claiming certain femininities and masculinities associated with engineering, were identified as significant patterns emerging from student interviews. Some of the students were interviewed two or three times in order to achieve a longitudinal perspective. The 149 one- to two-hour semi-structured interviews included male and female students attending one large, predominantly white, comprehensive research institution in the United States (University of Oklahoma [OU]).

The interview protocol allowed the interviewer to augment standardized questions with additional probes as needed. Using nonprofessional interviewers, students were asked questions encouraging them to describe their educational background, family life, and experiences in college, as well as perceptions and personal opinions regarding certain topics. Interviews were transcribed, reviewed for accuracy, and coarsely coded using N-Vivo qualitative data analysis software (QSR-NVIVO 2002). Quotations from student interviews are used extensively. Their stories, perceptions, and language are the data for this paper, specifically their responses to questions on these topics: The interviewee's perception of other engineering majors' perceptions of the interviewee's discipline; the interviewee's own perception of his/her discipline and other engineering disciplines; the qualities or skills interviewees felt were necessary to be successful in his/her chosen field; the reasons the interviewee chose his/her particular field in engineering; why the interviewee thought there were so few women in engineering at large and why the interviewee thought something was different about the School of Industrial Engineering at OU.

The quotations have been edited for clarity and brevity. Square brackets indicate the addition of a word or words to help with contextualization. Quotation text in italics is author emphasis to highlight the specific germane language. Students are identified only by gender and major to protect privacy.

Theoretical Framework

We use an intersection of feminist and discourse theory to critically examine gender constructions surrounding the choice and pursuit of a particular engineering discipline. By recognizing the dynamic relations between culture and social action, feminists pointed the way to scrutiny and explanation of power and rejection of the distinction between subject and object implicit in structuralist thought. A feminist poststructural standpoint is an effective lens for exploring multiple, dynamic, and competing layers of being and meaning in the construction of gender roles and identities. Discourse theory, though not explicitly feminist, provides an important tool for examining fluctuating constructions of gender by supporting analysis of how written, spoken, behavioral, and symbolic communication define and build relational identities and knowledge in the context of social institutions. For example, Stonyer (2002, 393) suggested that engineering education is a "discursive complex" of interrelated and competing discourses generated within normalizing community practices that validate and seek to reproduce dominant embodied identities that in turn view these practices as normal and given. Although the belief has developed that the discourses surrounding these practices are an essential part of engineering, they are actually negotiated inventions passed

from one generation of engineers to the next. As such, discourses become bundles of culturally approved information that produce and reproduce appropriate gendered roles and identities, which in turn inform and validate the discourse.

We draw upon this intersecting framework to explore the ways in which women and men participate in establishing, maintaining, and, at times, altering the systems of gender relations from which future generations of engineers emerge. The use of this framework, particularly in Europe and the United Kingdom, is not new to the analysis of the gendering of engineering nor the underrepresentation of women in science, technology, engineering, and mathematics (STEM) (see, for example, Bergvall 1996; Henwood 1998; Walker 2001; Jorgenson 2002)

It may seem out of place to include the role of males and masculinity in this inquiry. However, like Barbara Reskin (1991), we believe that in order to have a complete understanding of the constructed nature of occupational sex segregation, we must bring men back into the discussion and not leave masculine relationships to engineering and technology unexamined. Cultural understandings of "appropriate" masculine and feminine roles do not exist in isolation from one another. Individuals who stand in the borderlands where cultural definitions are shifting provide a window into the ways that feminine and masculine identity are co-constructed, co-enacted, and co-experienced (Anzaldua 2002).

Feminine and masculine gendered identities are defined by negotiated and interrelated practices, but also delimit accepted practices and relationships within the social structures and hierarchies in which they are embedded (Walkerdine 1984). Engineering education, as a hierarchical social community, reinforces these relationships in the production and reproduction of acceptable gendered identities. The boundary model, employing terms such as intersections, hierarchy, boundaries, borderlands, and crossings, provides a better metaphor for examining the dynamic and uneven practices in engineering education than the fixed, static, uniform, and unidirectional form of a pipeline.

Results and Discussion

Here we present three discourses constructing IE as "imaginary engineering" and situating IE as a discipline within a community of articulated hierarchical disciplines. Then, we examine the discourse that pushes IE further to the margins by gendering industrial engineering as a "naturally" feminine endeavor. Finally, we examine students' perceptions of local practices and role models that provide resources for the identity projects of both male and female students as they negotiate a place within the local community of IE.

Creating Hierarchical Community—Industrial Engineering as "Imaginary Engineering"

For those who stand outside the community, engineering may appear as a monolithic whole: An engineer is an engineer. Subtle differences between disciplines can be lost on an outsider. Industrial engineering is an engineering discipline focused on the design, optimization, and integration of systems, including people, machines, materials, and the energy flows surrounding them (IIE 2009). This description identifies IE as a heterogeneous field concerned with complex systems of people and processes.

Students recognize that status and material rewards accrue to engineering professionals regardless of which discipline they have chosen. For example, when asked how her family was responding to her decision to pursue engineering, a female IE student responded, "He's [her father] so proud, oh my goodness, yeah, they [both parents] brag all the time. Another IE female responded, "It is funny when you tell people that you're an engineer, there is a respect that goes along with that." A female electrical engineering (EE) student's response is similar, "I think it is pretty prestigious to be in engineering." Yet, when asked to comment on her perceptions of industrial engineering she answered, "I think it might not be as hard [as EE]. I'm sure you've heard people call it 'imaginary.' I don't think that I would do industrial. I guess maybe electrical is more prestigious, trying harder, pushing more."

The term "imaginary engineering" has been in the engineering vocabulary for decades. Here, we demonstrate how the term "imaginary" creates a boundary between the "real" and the "imaginary engineers" and encapsulates distinctions which mark and set off IE from other engineering disciplines. We examine three narratives, "distance from technology," "less rigorous curriculum," and "business engineering" that contribute to the devaluation and delegitimization of industrial engineering. The distancing of IE from "real" engineering is an important element in the creation of hierarchy and thus legitimizing IE as an appropriate and gender-authentic place for women to occupy.

Distance from Technology

A significant boundary between IE and other disciplines is that of industrial engineering's *perceived* distance from technology. In this set of distinctions, IE is minimized by perceptions that it is furthermost from those aspects most closely associated with the masculine domain of engineering—technology and technical competence.[2] The following statements reflect the degree to which students just beginning a career in engineering have internalized that message.

> "They call it 'imaginary engineering.' I think because *we are not really designing as much,* we're just more about making things efficient. They don't see us as true engineers. They might look at us as not real." (male industrial engineer)

> "It seems to me they are *more about the people side of engineering than a really technical* engineering." (female electrical computer engineer)

> "How do others see it? You could say useless. It's *imaginary engineering*, you know because *it's not very physical* compared to mechanical or chemical. *It's more abstract* than a lot of the others. I would say because it is not very physical, when you picture mechanical, you picture mechanics or you picture people doing physical work and I don't see that when I picture industrial engineering." (male industrial engineer)

The perception that industrial engineering is less technical, less hands-on, and less physical contributes to pushing IE to the margins of the engineering hierarchy and establishes boundaries between "real" engineering disciplines and the "imaginary" engineering of IE.

Less Rigorous

A second element in the complex of imaginary discourse is the notion that the industrial engineering curriculum is less demanding than other engineering curricula. Even though as Faulkner (2000a) notes, there are significant differences between disciplines in terms of work context, approaches to problems, and their shared cultures in everyday practice, differences between disciplines at the level of educational curricula are minimal. Discourses produced within the domain of engineering, such as the ethos "work hard/hard work," echo with self-images that become symbolic boundaries of professional identity (Chachra et al. 2008; Drybaugh 1999; Mina et al. 2008; Ngambeki, Rua, and Riley 2006). Claims to the most difficult or time-consuming major are vital to engineering identity and status and further contribute to the marginalization of IE which is *perceived* as less rigorous:

> "I think they [other engineering students] think it [chemical engineering] is the hardest of the engineering disciplines. I think that it [IE] is the engineering discipline that requires the least amount of work to acquire a degree. Quite a few people have dropped out of chemical engineering and mechanical engineering to go to industrial engineering because they do feel that it is an easier major that requires less work. And they have done that because they don't want to work as hard." (female chemical engineer)

An assertion by students that IE is the easiest of the engineering majors, despite similar core curriculum requirements, calls into question industrial engineers' status as "true" engineers because they do not work as hard as other majors must. Industrial engineering students are well aware of

this perception. When asked how they thought other engineering students perceived IE, 29 (12 male, 17 female) of the 52 IE students responded with the adjectives "easy, easier, or easiest."

> "They say that we are the easiest and that we are the students that want to say they are engineers but don't want to go through the classes that they go through." (female industrial engineer)

> "Oh, [they say IE is] the soft engineering, it's the one that doesn't require as much hard work." (female industrial engineer)

Even though the following student freely admits he has never seen a degree requirement listing for any major other than his own, he still makes claims as if they were factual:

> "The industrial engineers have a less rigorous program than a lot of the other engineering programs so I probably am somewhat biased towards not allowing them the same level of respect I would give to engineers in my own department." (male electrical computer engineer)

Such notions devalue and delegitimize IE within a culture where the self-image is based on a code of hard work/work hard, further pushing this discipline past the boundaries of what is perceived as "true" engineering.

Business Engineering

The final narrative of the discourse of "imaginary" links IE to business. Due to IE's close association with organizational systems and processes, some students perceive IE as the last step before "going down" to the business college. To our participants, the professional degrees of business and management fall far below a prestigious degree in engineering. One male industrial engineering student referred to business degrees as a "dime a dozen." However, non-IE engineering students perceive IE with similar disdain.

> "Well . . . I think it [IE] is more like the business side of engineering maybe and less to do with the math and science and more kind of a business end." (male computer scientist)

> "I would almost see them [IE] more like a manager." (male electrical computer engineer)

To summarize, three symbiotic narratives contribute to the discourse of "imaginary": decoupling IE from technology, devaluing the IE curriculum, and linking IE to business. Electrical and computer engineer [ECE] males and chemical engineering [XE] females offer the most forceful devaluation of industrial engineering. Taken as a whole, these narratives serve to create

boundaries between industrial engineering and other disciplines based on codes and rules which signal inclusion and exclusion in the engineering community. IE is perceived as "the last rung." The following student sums up the perceived hierarchy within the College of Engineering in which IE is viewed as the last stop before switching out of engineering:

> "To be honest I have always heard that we have a hierarchy in engineering for your chemical and electrical engineers who are at the top and then you have your mechanical engineers and civil engineering and then industrial engineering. If you don't cut it in electrical or chemical or mechanical you end up trying your hand at industrial engineering because it is easier and if you don't make it there, you can go to MIS. And then you go to the business school after that." (male electrical computer engineer)

Next we turn our attention to a discourse that further devalues IE in the engineering hierarchy by constructing industrial engineering as a pursuit "naturally" suited for women.

Creating Borderlands—Feminizing Industrial Engineering

While the cumulative effect of the imaginary theme decouples IE from the masculine image of real engineering, the following theme links IE to the feminine. In this narrative, IE is constructed as a gender-authentic place for women to pursue engineering because women "naturally" possess the requisite skills called for in industrial engineering.

Claims for IE being a "natural" profession for women to pursue follow from linking:

- Women to the social aspect of IE
  "All engineerings [*sic*] involve going out and, at some degree talking to people, gathering information, but I think IE does more of the social interaction . . . I think that meets a lot more of the strengths of a woman than it does the strengths of a guy." (male industrial engineer)

- Women as naturally better at human interaction rather than the mastery of technology
  "Their [IE] processes involve people instead of machines and I just think women are more geared . . . they are more emotional and they can communicate with people better." (female chemical engineer)

- Women to business
  "It [IE] is more of a cross between psychology and business management . . . I don't want to say it [IE] is a feminine thing, because I know men do it too, but it is sort of like the more human side, of like in an office." (male computer scientist)

In addition to the student verbal discourse, the IE department's self-constructed image seen in recruiting materials is an example of the ways boundaries produced through written discourse contribute to the production and reproduction of gendered identities. Though recruitment of women was not an expressed goal of the IE school or the College of Engineering, a review of IE printed material and visual material used for recruiting high school students was found to foreground language and themes that have been demonstrated to appeal to females (Seymour and Hewitt 1997). These materials include a letter from the director of the School of Industrial Engineering (a woman) in which particular areas of study are highlighted**.** Language such as *solving complex problems*, *total systems approach*, *focusing on human elements*, *management*, *broad in scope*, *integrating systems,* and *involving people to achieve the best possible results for the benefit of humankind* is foreground in the director's letter as well as a PowerPoint presentation. Similar language is also used in both the ABET outcomes criteria (2009) and the National Academies (2004) call for the "Engineer of 2020" to refer to skills needed for all engineers. Nevertheless, the unintended consequences from the school's recruitment materials seem to contribute to the perception that IE is a soft, nontechnical engineering discipline, "naturally" suited for women.

> "IE, the way it is advertised, it is *not advertised as a sturdy engineering*, I don't think. So I think that makes it tons more appealing to everybody, not just to women, but to everybody. You are not going to have to get down and dirty with it." (male industrial engineer)

> "[It was] p*resented as a business type of engineering.* Yeah, yeah more people and a lot of math and I really like math." (female industrial engineer)

The heading, "Feminizing Industrial Engineering," applied to this section in our paper is a verbal handle we applied to the discursive bundle of labels, images, characteristics, and practices that construct the discipline as a "natural" place for women to be. In the student discourse examples above, female students' aptitudes for certain jobs are constructed from congruency with appropriate female behavior rather than from an ability to learn and perform skill sets that have historically been associated with males. Although the department's recruiting discourse does not link the attributes of IE specifically to feminine nature, it yields a similar result as the student discourse. Designating industrial engineering as a natural place for women to occupy assigns them a borderland in engineering, a space where their presence is not viewed as transgressive of normal feminine behavior and leaves male dominance in other disciplines unthreatened and unexamined.

Identity Negotiation and Construction—Local Practices

By providing resources for the students' co-creation of gendered possibilities, images of the department and faculty can also facilitate male and female IE students' re-imagined places in the engineering hierarchy. Here, we explore the image of female faculty as a support for the female students' claims to both a heteronormative female and an engineering identity. Next, we examine the re-definition of masculine identities based on a particular male faculty member's actions and the male students' push against male engineering stereotype by positioning themselves as the "anti-geek" and as engineering aristocracy.

Claiming Feminine and Engineering Identities

Even after decades of attempts at opening the borders of engineering to women, young engineers still perceive it as a hostile and transgressive place for women to occupy.

> "because a lot of the managers and the teachers still have the mentality that they *probably look down on women studying engineering* or trying to get an engineering degree or education. They see it as a male profession." (male electrical and computer engineer)

> "because it [engineering in general] is not a feminine major." (female chemical engineer)

> "because it [engineering in general] doesn't seem like a field that maybe a *woman can have a family in*." (female industrial engineer)

Overcoming the obstacle of the masculine and socially isolated image of engineers has been shown to be a significant barrier to the recruitment of women into engineering (Shehab, Rhoads, and Murphy 2005) and their persistence in STEM (Wyer 2003). At the time of this study, 40 percent (4/10) of the faculty members in IE at OU were female and the female faculty played an active and visible role in the daily life of the school and college. While we do not dismiss the significance of a high proportion of female faculty and high proportion of female students, we concur with Murphy and colleagues (2007) that concurrently high proportions of female faculty and students indicate possible correlation but not necessarily causation. Furthermore, abundant research documents that the quality and not the quantity of faculty-student interactions has the greatest impact on students (Astin 1993; Astin and Sax 1996; Sax, Bryant, and Harper 2006). Considering the identity-negotiation project undertaken by female engineering students and the societal messages that "image is everything," an environment in which female students can see themselves engaged in the work of engineering while still enacting a culturally authentic gender

identity may be more important than the number of females present. The following student understands the importance of image:

> "I think the best thing is to have women go talk to high school girls about it. To be like, look I am a woman and I like this. *I am not weird* or anything. *I am a mother and I have children and I have the same things that other women have*. I always think that the best way to communicate an idea is through example, so the more women you have out there talking to high school girls who are *success stories per se the better*." (female industrial engineer)

Success as an engineer for this female student cannot be uncoupled from success as a heteronormative female. Only by attaining the latter *with* the former will she not be seen as weird, something "other," or transgressive.

The IE female faculty members at OU provide these images and serve both male and female students as successful, professional, and heteronormative female role models. As one female student phrased it, "When you go into an office, and you see *women being women* but being professional that's very appealing to a girl." Contact with the gender-authenticated role models of female faculty with visible family lives positively affects women's beliefs about the compatibility of a career and family life by providing evidence of how dual roles are possible (Nauta, Epperson, and Kahn 1998). As a result, female students understand that they can pursue engineering without the threat of committing gender inauthentication.

> "She was another professor of mine, so that was really helpful and then to see her as the first and only female director of the School of IE . . . it is a definite role model, you know feeling like there is someone you can look it to who *has a family and things, too*." (female industrial engineer)

> "*. . . they have children, they have husbands. They are the PTA moms and everything else and that is neat, that is attractive because you feel like you can relate*." (female industrial engineer)

With these role models, women feel safe pursuing a degree in IE at OU because they can strive for personal satisfaction and engineering professional status without transgressing gender roles.

Furthermore, because of the marginalizing and feminizing discourses, pursuing a degree in IE (both professionally and locally) is perceived by student peers as the least transgressive of both doing engineering and being an engineer.

> "It has an appeal to it, a look to it that a woman could still be more *dignified or maybe still act as a woman* and still have an engineering job." (male industrial engineer)

> "I get asked if I work in a factory . . . do I ever wear a hard hat, like I ran into this guy the other day and he was like, 'no offense, but are you an engineering

> major?' I said yeah. And he said, 'well, *you don't look like one*.'" (female industrial engineer)

> "There is a stereotype about women going into engineering saying they are butch or manly and they are not feminine. It is different here . . . when I came, it was like an engineering open house or something, I saw a lot of females there and they really emphasized that you know this is a female engineer and *she is not butch and she is not weird.* She is a *normal girl* but she is really smart and she wants to do this." (female industrial engineer)

> "There are so many women in mechanical [engineering] that are not feminine versus girls that are in Chem E [chemical engineering] department that are very feminine. But there's a big difference in the Chem Es and the IE females that I've noticed. The Chem Es seem like they are very aggressive, versus the IE females who are a lot more sensitive . . . I think IE is more submissive girls [and] I think Chem Es are a little more aggressive." (female chemical engineer)

With the freedom to enact culturally prescribed notions of heteronormative femininity within the borderland of industrial engineering, the female students here claim a nontransgressive feminine engineering identity.

Counter-Claims for a Re-Imagined Masculinity

Because masculine and feminine gender identity projects are co-constructed, it is important to also examine the masculine identity project in the context of IE at OU. The discourses linking IE to attributes culturally deemed feminine create identity contestations for males and require the re-imagining of a new masculine identity in this borderland. For example, the following male IE student reflects his struggle with admitting he does not enjoy engaging in culturally masculine technology play while simultaneously operating within a discipline that is under construction as feminine:

> "It's called imaginary engineering, idiot engineering . . . Yeah, that was my roommate, he's in mechanical . . . and some more insensitive people have been calling it 'girls' engineering' . . . it's just that it's the major for girls it seems. But I'm not a girl, I don't do cars and stuff, but I'm still pretty smart. I don't like getting dirty, I have soft hands."

Two prominent discourses capture the students' efforts to follow one particular male faculty member's model of rejecting hegemonic masculinity: "Engineers with personalities" and "imagine me as your boss."

Contrary to the archetype of engineering masculinity, this male faculty member is perceived as the department "nurturer" (Rhoads, Murphy, and Trytten 2005). Often mentioned as the initial point of contact with the school by students who switched into IE from other engineering majors (Walden and Foor 2008), he was characterized as "happy and always there

to help." With students, he often initiated contact in informal situations and developed mentoring relationships. His presence and practices confound gender role models in engineering.

> "Because especially for . . . a freshman coming in, to see not just your typical engineering male professors it's comforting for a guy to not have some jerk of an engineering guy screaming at you like [male professor from another discipline]." (male industrial engineer)

Seen as personable and compassionate, this nurturing male faculty member provides male and female students new images of masculinity within engineering. Male students emulate this role model as they distance themselves from the archetype of the socially isolated engineer and negotiate an identity in opposition to that stereotype. Terms such as "creepy," "nerdy," "stinky," "boring," "geeky," "machismo," "robotic," and "enginerds" arose in interviews to describe how male engineers are generally perceived. The following responses demonstrate how new constructions of masculinity are positioned in contrast to dominant norms.

> "It [IE] doesn't have the *traditional engineer stigma* of, you know, being geeky, kind of male nerd kind of thing. It doesn't seem stereotypical . . . so you get all the good things that come with an engineering degree without this added baggage of being the geek with the engineering degree. So, we're *engineers with social skills.*" (male industrial engineer)

> "I think it [IE] really sets itself apart or it is set apart from all the other engineering. The quality of the kids that are in there [IE], we're as intelligent if not more intelligent than the other engineering degrees, but *we have personalities* because I know a lot of other people in other degrees and they lack in that area." (male industrial engineer)

According to another male IE student, IE students are not just "performing monkeys" because:

> "It takes a *different type* of person to be an IE . . . they [other engineering majors] are pretty much like robots, whatever you need to perform, and they're just going to do it. *But IEs aren't trained. We think*."

In the following example, a male computer science student extols the male "anti-geek" industrial engineer:

> "I have one friend that is in IE and he is a *really cool guy*. . . . The IEs I know versus the computer engineering and the electrical and the computer science are normal, whereas they are guys with high water jeans tucked in polo shirts and big thick glasses like the rest of engineering. *They're [IE males] pretty normal people.*"

In contrast to the image of the "engineers with personalities," participants describe students in other disciplines with language that creates the stereotypical images of engineers.

> "Those [stereotyped engineering students] are the people that girls think are creepy. . . . If I were a girl, I wouldn't want to be in class with some of the people I am in class with. I mean I am a boy and I am a little iffy about it sometimes." (male computer scientist)

> "There are so many dorky guys [in other engineering majors] and you've got to deal with dudes who work on robots and play Magic the Gathering or whatever video games all the time." (male industrial engineer)

Through the preceding narrative of a new and different male engineer, male students in IE re-imagine a masculine identity that simultaneously separates them from the archetypical engineering image and aligns them as the "natural companion" to "normal femininity." As one student commented, "Why wouldn't girls want to be in IE? That is where all the cool guys are."

Pushed to the margins of engineering status, many students embrace and promote the marginalizing attributes (business- and systems-related, people-oriented, and communication-abled) as they claim an identity as the future employers and bosses of all other engineers. Results from another analysis using a smaller sample size (Murphy et al. 2006) indicate that 57 percent (13/23) of male IE respondents at OU offered *status potential* as a descriptor for industrial engineering as a discipline. Conversely, only 27 percent (7/26) of females shared the same perception.

> "When people think of engineering they think of some guy designing a valve or something very concrete . . . industrial engineers work a higher problem domain. I like to call it top level engineering . . . we engineer the whole system. We need mechanical engineers to design our valves and chemical engineers to design whatever, but we also need industrial engineers who can stand atop of the whole thing." (male industrial engineer)

> "When they say IE is imaginary I just tell them 'IE's will be their bosses, CEOs, business owners. Imagine me being your boss.'" (male industrial engineer)

> "I think all engineers are gonna end up working for industrial engineers." (male industrial engineer)

> "I think that they [other engineering majors] think it's [IE] lower on the rung, but I think 'I'll manage them one day.'" (male industrial engineer)

Together, the "new and different" and the "I will be your boss" narratives are undertaken as a counter-narrative to the feminization of industrial

engineering, allowing the male students to construct a new masculine identity and to reclaim engineering status.

Cautionary Tale

Some students perceive IE as the "beach-head" from which women can eventually gain purchase in other fields of engineering, a term suggesting an all-out assault on the masculine stronghold of engineering. Another described IE as "the soft spot women started from before they gain the skills to *move up* to mechanical." The "soft spot" brings to mind the belly of the beast, as if female presence would eviscerate engineering.

History has demonstrated that it is dangerous to make claims based on "natural" qualities as justifications for inclusion or exclusion in the social and professional realm (Williams 1995). For example, though women have made in-roads in the historically masculine profession of medicine, women are overly concentrated in the primary care areas. According to a 2008 report by the American Medical Association (2008), females make up 49.5 percent of primary care practitioners. Women are still relatively rare in the highly prestigious areas of radiology, surgery, and cardiology. While women represent 54 percent of the residents in pediatrics, they represent a mere 5 percent of the residents in vascular surgery, one of the best paying and most prestigious specialties (DeLaat 1999). Justifications for this disparity resonate with the familiar mantra that women are naturally suited for these areas because women are more altruistic, people-oriented, better nurturers, and less interested in promotion and advancement than their male counterparts.

Gina Ryan (IIE 2001), as then CEO and executive director of the Society of Women Engineers, while celebrating increasing female enrollment in industrial engineering states, "I don't like to stereotype people or genders, but women have always been nurturers and caregivers, and those elements are right at the heart of industrial engineering practices" (13). Always? Naturally? By describing women and the field of IE as a natural fit for one another, the aptitudes, attitudes, and efforts required to pursue this engineering discipline are trivialized, and their fit with other disciplines is contested. Though the link between masculinity and engineering is looser within the particular context of IE at OU and more young women are encouraged to enter engineering across that weakened border, those links are not broken for engineering in general. From the discourse of "natural," heteronormative gendered prescriptions for women and men will continue to serve as gatekeepers to female inclusion to other engineering disciplines.

Conclusion

How do differences in content, context, and practice present in discourse in ways that open some engineering disciplines and close the border to others? One answer can be found in the "durable equation" between masculinity and technology and the ways in which dichotomous thought permeates engineering. Faulkner (2000a, 759) labels these "dualisms." Examples include people-focused versus technology-focused, hard versus soft, and abstract versus concrete. Though these dualisms are neither gendered nor fundamental to engineering, they are taken up in discourse as if they are. Another important point is that these dualisms are perceived as mutually exclusive, especially as they map onto cultural notions labeled masculinity and femininity. For example, Zengin-Arslan (2002) suggests:

> One of the ways through which the masculine discourse of technology constructs and legitimizes itself is the naturalization of the constructed differences between men and women; emphasizing especially the male competence/female incompetence in technical knowledge and skill. (400)

Multiple and complementary discourses grounded in dualistic notions contribute to the creation and maintenance of hierarchies and boundaries within engineering disciplines deemed to be more or less masculine or feminine "in nature."

The continued use of a pipeline as the metaphor for conceptualizing deeply embedded, yet subtle, barriers to women and minorities in engineering will not suffice. When examining inequities in engineering, we believe a model conceptualized as boundaries and borderlands will be more fruitful than one conceived of as a pipeline. Boundaries mark the social territories of interpersonal relations, signaling who ought to be admitted or excluded. Borderlands, such as IE at OU, represent those areas where renegotiated identities might shift boundaries and produce real transformations in engineering diversity.

Due to industrial engineering's marginalization as a result of the discourse of "imaginary," we suggest that IE is a discipline where men and women encounter weakened boundaries of gendered norms and archetypes of masculine engineering. Within IE both males and females have faculty role models: The female role models reinforce and even legitimize "normative" femininity; the male role model confounds constructs of masculinity providing male students with new ways to practice and identify with engineering, which in turn makes IE a more "inviteful" place for women, too. The weakened symbolic boundaries of appropriate gender behavior around IE at OU contribute to the attainment of sex parity, while the sex parity also contributes to weakening those boundaries. Unfortunately, direct definition of cause and effect would require an historical

perspective not available with our data; moreover, as synergistic processes, cause and effect may not be definable. Through the discourse of "natural," industrial engineering is constructed as feminine and women are able to preserve aspects of a heteronormative feminine identity. The familiar and comfortable culture of IE at OU provides a community where women can negotiate acquiring the status of "doing engineering" without committing gender inauthentication by "being an engineer." Understanding the tensions, contradictions, and ambiguity between the discourses of gender and those of engineering will inform the development of more effective strategies for the recruitment and retention of women in engineering.

Ultimately, claiming places within engineering based on "natural" inclinations will not help in achieving sex parity within STEM disciplines any more than claims that women's lack of participation is due to their "natural" limitations in mathematics. The success experienced in IE at OU might serve as a cautionary tale. Practices designed to contribute to improving equity might in fact create new hierarchies based on distinctions between essentialized female characteristics (business- and people-oriented, abstract, communication-abled) and essentialized male characteristics (hard technology-oriented, concrete).

Finally we offer a note on generalizability. Though genuine power in engineering remains largely a white, heterosexual, middle-class, technologically adept, fully able, virile male preserve—men of color, white women, and women of color are joining the engineering community of practice through various weakened borders. We are not attempting to address here a universal theme such as male dominance or contemplate an overarching social structure that maintains white male dominance. In fact we are suspicious of comprehensive generalizations.

Instead, we offer a model and a method to examine the local mechanisms that construct and reconstruct intersecting dimensions of identity of all persons who confront the traditional norms creating boundaries around engineering. Discourses that construct raced, aged, classed, and sexualized identities would contain their own codes and rules regulating which boundaries to inclusion are negotiable and which are not, where they are located and the consequences for crossing. Identities are produced in specific contexts (communities of practice) in relation to local social arrangements. While we suggest that the processes of identity construction exist universally, we make no assumption that the same patterns will be found universally. One cannot extrapolate findings from one community of practice to all of them. The constraints and possibilities available to women and men (of color, age, socioeconomic class, sexuality) are localized, context dependent, and open for local investigation in the minutiae of verbal interaction. There are complex and subtle mechanisms at play that shift the varied boundaries to inclusion and exclusion.

Understanding these mechanisms of constructing and negotiating identities is imperative for designing programs to enable and encourage all potential participants to maneuver within the competing discourses of engineering. This understanding can open spaces within engineering for counter-discourses and practices—that is, new ways for the being and doing of engineering. Unless expanded beyond the normative prescriptions, the traditional, restricted, engineering identities are not sufficiently inclusive for the diversity of individuals engineering needs to meet the challenges of the twenty-first century.

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Cindy E. Foor *(MA 2002 Cultural Anthropology) is the Associate Director/Research Associate for the Research Institute for STEM Education (RISE). Her contribution to the multidisciplinary team lies in qualitative methodologies, cultural theory, and the belief that outliers offer great insight into the workings of power. Her research interests include ethnography of marginalized populations, cultural theory, the cultural/historical construction of women's identities and roles in past and present societies, and most recently, equity issues surrounding gender and underrepresented populations in engineering education. She can be reached at cynthia.e.foor-1@ou.edu.*

Susan E. Walden *(PhD 1997 Computational Organic Chemistry) is the Founding Director of the Research Institute for STEM Education (RISE) and an associate research professor in the College of Engineering at the University of Oklahoma. She brings to this partnership experience with the cultures of science and engineering and a willingness and eagerness to learn feminist critical studies. Her research is grounded in a belief that advancing the diversity of engineering requires an understanding of the varied and complex experiences of individual and small groups of students. Of particular interest are the power of unintended consequences and issues surrounding the cultures of engineering and the ways they are produced, re-produced, and in some instances, re-negotiated. She can be reached at susan.e.walden-1@ou.edu.*

Notes

1. We note that the heterosexual gendered identities discussed here represent only one intersection of personal identity construction within or against the archetype of an engineer. Other aspects could include middle or upper class, able-bodied, and white.

2. There is a significant body of literature on engineering, technology, and masculinity, for example (Berner and Mellstrom 1997; Faulkner 2000a, 2000b; Mina et al. 2008).

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