Practices of Brokering:

Between STS and Feminist Engineering Education Research

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Abstract

This project documents my efforts to publish STS- and gender theory-informed articles in engineering education journals. It analyzes the processes of writing and revising three articles submitted to three different journals, aiming to shed light on the field of engineering education, gender research therein, and contribute to feminist science studies literature on the challenges and opportunities of interdisciplinary work across women's studies and STEM fields. Building upon Wenger's concept of brokering, I analyze how I brought previously underexplored STS and feminist theory literature into engineering education journals. In producing this dissertation, I aim to illuminate some of the efforts and challenges of bringing STS and Women's Studies (WS) topics into engineering education journals – thus producing an account of brokering practices and an example of scalable scholarship.

The first chapter introduces engineering education research (EER) as a field of inquiry, situates my project with respect to current feminist science studies, summarizes the framework of brokering that informs my analyses, and describes my methodology. The second chapter describes my initial attempts at brokering by identifying and bridging differences and the preliminary brokering practices that emerged through writing and revising the first of my three articles. It discusses an article published in *Journal of Engineering Education* that analyzes the uses of feminist theory in EER and argues that further engagement with a broader range of feminist theories could benefit EER. The third chapter describes how some of these practices were reinforced, but also supplemented, while writing and revising the second article. It discusses an article published in *International Journal of Engineering Education* that analyzes problematizations of underrepresentation in EER and argues that further reflection upon and formal discussion of how underrepresentation is framed could benefit EER. The forth chapter describes how the established brokering practices guided writing the third article, making the process easier as I had become more comfortable with the requirements and challenges of brokering. It discusses an article submitted to *European Journal of Engineering Education* that analyzes feminist research methodologies in the context of EER, using data from interviews with feminist engineering educators. The fifth chapter concludes by summarizing the brokering practices and discussing their respective challenges, discussing the implications of this project for STS and WS, and, finally, by discussing other implications for peer review engineering education. The Appendix contains aims, scope, author guidelines, and review criteria for the three journals.

Chapters 2, 3, and 4 each begin with a narrative recounting of the practices of brokering that went into producing and revising each article. The narratives describe processes of writing and preparing to submit the articles, reviews received, and subsequent revision processes. The published or submitted articles appear after the brokering narrative.

Acknowledgments

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Additionally, I thank Maura for her help and support in writing and revising the articles, and for everything that I learned during those experiences. I am so grateful for the lessons and knowledge gained through doing that work – as well as all the other work over the past three and a half years. It is only because of the opportunity to work with Maura that I have a dissertation at all.

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Chapter 1 – Introduction

Whether we like it or not, by making knowledge claims that pose new entities or offer new distinctions, we engage in ontological marketing that responds to existing configurations of dominant images and, hence, must take account of audience. When we respond only to disciplinary codes in our work, we can perhaps satisfy ourselves with extending disciplinary agendas and seeking elite disciplinary identities in the hope that the benefits of disciplinary insights will somehow diffuse into outside worlds. However, when we step onto an interdisciplinary stage, we accept an identity whose very legitimacy is defined by the expectation to intervene in some dominant mode of theorizing by making visible what it hides and pointing to, if not plotting, alternative pathways.

–Gary Downey and Juan Lucena (2004, p. 413)

I. Overview and Aims

Currently, many feminist science studies scholars are interested in reaching across disciplinary boundaries to work with and in science and engineering fields – rather than critiquing those fields from the outside. Parallel aims can be found in STS more broadly, and most recently in engineering studies specifically. This project shares the goals of "critical participation" put forth by Gary Downey for engineering studies and of matching critique with reconstruction put forth by leading feminist science studies scholars.

In an article laying out aims for engineering studies and STS more generally, Downey advances the ideal of *scalable scholarship* (2009). Scalable scholarship is "audience centered work, critically engaging dominant images and practices on which those audiences rely" (p. 58). It is scholarship that transcends the borders of academic theorizing to influence practices, realities, and knowledge of other audiences. Downey sees scalable scholarship as contributing to "Big STS," which he contrasts to "Little STS,"

> Little STS comprises work focused wholly on 'getting right' what is taking place with science and technology in society. Little STS is published in restricted STS venues and relies largely on the diffusion model for its performative effects. It also tends to treat listeners external to the restricted intellectual group as potential apprentices. Big STS, by contrast, highlights the broader range of practices involved in not only analyzing dominant practices of science and technology in society but also formulating and scaling up practices that critically engage them. (p. 73)

Thus, and necessarily, "scalable scholarship avoids the comforts of resolute pessimism, and the pursuit of isolated critical virtuosity. It relies upon the intellectual work of critique for its contents" but recognizes that critique alone is not sufficient and requires scaling up (p. 73).

Like Downey's article, which recounts his efforts at scalable scholarship, my project aims to highlight "the processes through which engineering studies scholarship might scale up and critically participate in dominant practices" (p. 57). Critically analyzing pathways for scaling up scholarship on engineers and engineering education, Downey contends, is "integral to scholarly work" (p. 58). Elaborating the argument that such work should be seen as legitimate scholarship, he states,

> It should be both acceptable and desirable to include within the boundaries of scholarly discourse in engineering studies not only how we go about our research and what we find but also what might be the broader-scale implications of those findings. We should analyze and discuss where and for whom our accounts have benefits and costs, both to our audiences and to ourselves. (p. 73)

A key feature of scalable scholarship is that it must consider and engage with audiences' agencies (i.e. their ability and willingness/unwillingness to interpret, use, engage, and critique scholarship) because it is through their agencies that academic ideas become reality and gain authority. Yet researchers pursuing scalable scholarship encounter added challenges to their own agency and identity: "Calling attention to audiences renders more problematic the agencies of researchers, for their practices and identities also become subject to change" (65). My project can serve as an example of how audience agency influenced attempts to produce scalable scholarship, challenging my agency and identity in the process.

Sharing similar goals of critical participation, feminist science studies scholars have advocated working across academic boundaries and within science and engineering departments (Mayberry, Subramaniam, & Weasel, 2001b), and this work is discussed in more detail later in this chapter. Yet, accounts of their efforts to work in science fields do not provide sufficient details for others to understand and build upon their practices or to shed light on the inner workings of those fields, nor are they widely focused on publishing. Furthermore, in-depth accounts of the production of journal articles are scarce, despite an interest in STS in knowledge production and scientific texts. *Writing Biology* is one notable exception (Myers, 1990). To move beyond normative calls to participate, to understand knowledge production in STEM fields and how knowledge from other fields can be incorporated and developed within them – and to understand how critical participation and reconstruction via scalable scholarship can be achieved – detailed accounts of such efforts are needed.

To that end, this project documents my efforts to publish STS- and gender theory-informed articles in engineering education journals. It analyzes the processes of writing and revising three articles submitted to three different journals, aiming to shed light on the field of engineering education, gender research therein, and contribute to feminist science studies literature on the challenges and opportunities of interdisciplinary work across Women's Studies,[1] STS, and STEM fields. Building upon Etienne Wenger's concept of brokering, I analyze how I brought previously underexplored STS and feminist theory literature into engineering education journals.

[1] Throughout this dissertation, I use *Women's Studies* for simplification purposes, but I include in that term gender studies. It would be more accurate to read *women's studies* as *women's and gender studies* each time. Historically, *women's studies* has been used more commonly, but *gender studies* is increasingly being added to or replacing the more traditional terminology.

In producing this dissertation, I aim to illuminate some of the efforts and challenges of bringing STS and Women's Studies (WS) topics into engineering education journals – thus producing an account of brokering practices.

I aim to highlight the value of undertaking such work, both to engineering education and to STS and WS. The challenges and potentials of brokering (and producing scalable scholarship) will be important to understand if more STS scholars are going to aspire to critical participation. More specifically, I hope that by documenting the work that went into these articles, those interested in doing similar feminist work, or those who have tried to publish similar work in the past, will find something useful or insightful that will advance feminist engineering education research. It has been argued that opening the "black box" of peer review can help empower authors by providing them with knowledge of the usually hidden processes (Roth, 2002a). Analyzing review processes is valuable because describing practices of brokering reveals facets of each field that may be largely taken for granted within that community. Furthermore, it is valuable in providing insights for the historical record of disciplinary development, for those interested in the history of engineering education research and those interested in the development of feminist theory within academic fields.[2]

This chapter introduces engineering education research as a field of inquiry, situates my project with respect to current feminist science studies, summarizes the framework of brokering that informs my analyses, and describes my methodology. The second chapter describes my initial attempts at brokering by identifying and bridging differences and the preliminary brokering practices that emerged through writing and revising the first of my three articles. The third chapter describes how some of these practices were reinforced, but also added to, while writing and revising the second articles. The forth chapter describes how the established brokering practices guided writing the third article, making the process easier as I had become more comfortable with the requirements and challenges of brokering. The fifth chapter concludes by summarizing the brokering practices and discussing their respective challenges, discussing the implications of this project for STS and WS, and, finally, by discussing other implications for peer review engineering education. Further details about the articles are provided in the Methodology section of this chapter. The Appendix provides an overview of the aims, scope, and review criteria for the engineering education journals to which the articles were submitted.

II. Engineering Education Research as a Field of Inquiry

A. Engineering Education Research: An Overview

In the United States, Europe, and Australasia engineering education research (EER) is increasingly being promoted and studied as a distinct field of scholarship, or even a discipline by some in the US. The increased activity around EER has included: journal articles on the status and emergence of EER, large-scale research and advocacy projects undertaken by professional societies and their journals, research networks and groups, refashioning journals to focus on empirical research, university departments, centers, and degrees, and new conference series.

[2] There is a body of literature on feminism in the development of academic fields. See, for instance, (Gelsthorpe & Morris, 1988; Hutchings, 2008; Paludi & Steuernagel, 1990; N. Riley, 1999; Schiebinger, 2001; Spender, 1981; Stacey & Thorne, 1985; Stanley, 1997; Stanton & Stewart, 1998; Strathern, 1987).

These recent projects build on a longer history of journals, conferences, and societies that were traditionally less research-oriented. For example, while the *Journal of Engineering Education (JEE)* dates back a century, in 2003 it was refashioned as a journal that would only publish empirical research.[3] In this section, I discuss each of these activities listed above before turning to an overview of how research on women and gender is situated within this sphere of activity.

A brief history of the emergence of EER in the US is sketched out by Jamieson and Lohmann, who relate recent research trends to national interests dating back to the 1980s:

> The importance of engineering education research began to surface in the United States in the mid-1980s, when the National Science Board issued its report Undergraduate Science, Mathematics, and Engineering Education (National Science Board, 1986), in which it stated: "The recommendations of this report make renewed demands on the academic community—especially that its best *scholarship* [emphasis added] be applied to the manifold activities needed to strengthen undergraduate science, engineering, and mathematics education in the United States" (p. 1). The report helped revive the National Science Foundation's role to initiate and support science and engineering education programs. The report was also among those efforts that sparked a vigorous national dialogue on the role of scholarship in improving the quality of U.S. higher education (Boyer, 1990; National Science Foundation, 1992). The introduction in the 1990s of EC 2000 was also a major driver to improve the quality of U.S. engineering education (ABET, 1995). Its outcomes-focused, evidenced-based approach characterizes many aspects of systematic educational innovation.
>
> These and other efforts paved the way for the assembly of a small community of scholars in engineering education by the beginning of this century. (2009, p. 9)

They go on to list factors that have accelerated the growth of the EER community, including: the Center for the Advancement of Scholarship on Engineering Education (CASEE), established by the National Academy of Engineering (NAE) in 2002; the repositioning of *JEE* as an education research journal in 2003; Virginia Tech and Purdue's Department/School of Engineering Education, which grant PhDs;[4] other university centers, including at Utah State and Clemson, dedicated to engineering education; the Research in Engineering Education Symposium (REES) conference series, launched in 2007; and engineering education research funding from the NSF.

Evidence of growing interest in EER as a field/discipline can also be found in the recent publication of several studies in *JEE* and the *International Journal of Engineering Education (IJEE)*. Early assertions of EER as a distinct discipline included "Development of Engineering Education as a Rigorous Discipline: A Study of the Publication Patterns of Four Coalitions" in 2007 (Borrego, 2007b) and "A New Paradigm for a New Field: Communicating Representations of Engineering Education Research" in 2008 (Borrego, Streveler, Miller, & Smith, 2008). In 2009, Jesiek, Newswander, and Borrego published "Engineering Education Research: Discipline, Community, or Field?" (Jesiek, Newswander, & Borrego, 2009). They assert that, "Engineering

[3] However, they also still publish other scholarly work, such as literature reviews.

[4] Purdue's Ph.D program was established in 2005 and Virginia Tech's in 2008. For further information about the history of engineering education degrees and departments in the US, see Benson et al, 2010.

education research has experienced a notable scale-up in recent years through the development of departments and degree programs, high-profile publication outlets, research agendas, and meetings" (p. 39). Based upon data collected at the inaugural International Conference on Research in Engineering Education (ICREE) in 2007, they concluded that there was "both an overall lack of clarity and continued sense of ambiguity about the identity and status of engineering education research" and that stakeholders should "work to clarify the goals and objectives of engineering education research, especially to inform the continued development of the field's identity and supporting infrastructures" (p. 39). Most recently, in 2011, Borrego and Bernhard published "The Emergence of Engineering Education Research as an Internationally Connected Field of Inquiry" in which they state that, "Engineering education research (EER) has emerged as an internationally connected field of inquiry through the establishment of EER conferences, interest groups within engineering education societies, Ph.D. programs and departments and centers at universities" (p. 14). They also continue the discussion on EER's status as a community, field, or discipline. Finally, one team of researchers, of which I was a part, has produced several publications on the internationalization of EER (Beddoes, Borrego, & Jesiek, 2009; Beddoes, Jesiek, & Borrego, 2010; Jesiek, Borrego, & Beddoes, 2008, 2009; Jesiek, et al., 2011). We found that in many engineering education publication outlets, the percentage of empirical papers, as opposed to purely descriptive ones, has been increasing in recent years, thus attesting to the growth of EER as a research field (Jesiek, et al., 2011). While these publications have come from only a handful of scholars, the other activities, discussed below, evidence more widespread interest in the development of EER.

In addition to the articles devoted to studying and advancing EER, there have also been several large-scale research projects with similar aims undertaken by professional societies and journal editors. One such project was Advancing Global Capacity for Engineering Education Research (AGCEER), organized by the editors of *JEE* and the *European Journal of Engineering Education (EJEE),* which entailed special sessions at ten conferences around the world in order to collect information about EER in various countries and foster relationships between researchers (Jesiek, Borrego, & Beddoes, 2010a, 2010b; Lohmann, 2008). More recent, and still underway, is the Creating a Culture for Scholarly and Systematic Innovation in Engineering Education (CCSSIEE) project undertaken by the American Society for Engineering Education (ASEE) (Jamieson & Lohmann, 2009). This project aims to enroll engineering faculty across the US in processes of systematic research and innovation, and identify barriers to doing so.

As these publications mention, the development of departments, centers, degrees, research networks and working groups, and conference series also attest to the emergence of EER as a field. The growth is not limited to the US either. In Australia, for example, the first "winter school" for engineering education was held in June 2011 (Australasian Association for Engineering Education, 2010), and the professional society the Australasian Association for Engineering Education (AAEE) has an Educational Research Methods (ERM) division. In Europe, there are degrees offered in engineering education, the European Society for Engineering Education (SEFI) has a working group on Engineering Education Research,[5] and there are also regional research networks, such as the Nordic Network in Engineering Education Research[6] (Borrego & Bernhard, 2011). These activities are being supported by

[5] SEFI working group on engineering education research: http://www.sefi.be/?page_id=1192
[6] Nordic Network in Engineering Education Research: http://www.didaktik.itn.liu.se/nneer.html

cyberinfrastructure like the development of databases for collecting and searching EER publications,[7] an online bibliography,[8] websites to collect and share knowledge gained from NSF-funded projects,[9] and websites to facilitate networks of researchers.[10]

More specific details about EER as a field are provided by Borrego and Bernhard, including who does it, what motivates it, where it is published, what infrastructures support it, and differences between EER in the US and Europe (Borrego & Bernhard, 2011). Several of their discussion points in particular are worth noting because they provide necessary background information on my project. First, "the primary audience for EER is engineering academics. At present, the majority of scholars who identify with the emergent field of engineering education have been formally trained as engineers and have instructional responsibility for engineering students, or they work closely with engineering educators in a staff/faculty development role" (p. 23). This fact influences expectations for EER publications. Because the *intended* audience is engineers, there is an expectation that the research include "implications for practice," even though the actual audience is more likely to be other engineering education researchers, which is an audience with more social scientists represented. Compared to other fields, reviewers are more likely to come from the target practitioner audience rather than from the ranks of peer researchers. Moreover, because EER is a new and emerging field, many leaders, such as journal editors, are longtime administrators and reformers, but not educational or social science researchers.

Secondly, despite the fact that the majority of those involved in engineering education research are still engineers, EER is an interdisciplinary field that draws from and collaborates with fields such as education, psychology, sociology, and women's studies. The extent to which it draws on those fields varies greatly, however, and positivist contributions from fields like psychology are likely more readily accepted without great effort on the part of authors than are critical qualitative approaches from, for example, gender studies. As Borrego and Bernhard (2011) report, "Research on primarily U.S. engineering education researchers indicates that they are more comfortable with quantitative research approaches, but are open to qualitative methods when faced with the complexity of studying human beings in classrooms and similar settings" (p. 23).

Thirdly, EER is published in many different outlets. There are several journals devoted specifically to engineering education; however, EER also appears in general education journals, women's studies journals, and discipline/domain specific journals.[11] One reason that authors might choose to publish in outlets outside the field of engineering education is that those journals may not be perceived to be up to the standard of other disciplines. For instance, not all engineering education journals conduct double-blind reviews. An overview of the leading engineering education journals discussed in this dissertation can be found in the Appendix.

[7] iKNEER: http://ci4ene04.ecn.purdue.edu/ikneer/welcome.php
[8] AAEE online bibliography: http://aaee-scholar.pbworks.com/w/page/1177020/Bibliography
[9] CLEERhub: http://cleerhub.org/
[10] Research in Engineering Education Network: http://grou.ps/reen/home
[11] For a list of outlets that publish engineering education scholarship see: Borrego & Berhard, 2011; Engineering Subject Center, 2011: http://www.engsc.ac.uk/engineering-education-journals

However, all of this is not to say that engineering education research is widely supported among the majority of engineering educators and administrators or that there is consensus regarding what qualifies as EER and how the field should develop. "As both an emerging and interdisciplinary field, EER does not have widely agreed upon expectations for what constitutes quality work." (Borrego & Bernhard, 2011, p. 24). In fact, many of those interested in and supportive of EER question its sustainability, and many others question its necessity and value (Jesiek, et al., 2010b; Jesiek, et al., 2011).

B. Engineering Education Research on Women and Gender

Engineering education research on women and gender has been part of the broader field since at least the 1980s. Although such scholarship has always been only a small percentage of all engineering education scholarship, there are indications that it is increasingly seen as important and is bound up with the push for scholarly research. One indication of these dual developments is that "engineering diversity and inclusiveness" was one of the five research priorities identified by the National Engineering Education Research Colloquies in 2006 as part of an agenda for the "new discipline" of engineering education research (Steering Committee of the National Engineering Education Research Colloquies, 2006).[12] Another indication, also described by Garrett et al., lies in national governmental reports such as the *Science and Engineering Indicators*, which highlight the recruitment and retention of minority and women students (Garrett, Coleman, Austin, & Wells, 2008). Furthermore, "increasing diversity" was among the five motivations for doing EER identified (based on patterns in the literature) by Borrego and Bernhard in their 2011 article on the emergence of EER as an international field of inquiry (Borrego & Bernhard, 2011).[13]

Despite such expressions of interest, however, there remains a gap between the stated priorities and the actual research that has been conducted. Garrett et al. found that there is an "obvious…research gap in the area of diversity, and especially its benefits…the number of publications on research in diversity is still quite small" (p. 6). Furthermore, they argue, the gap is worsened by the fact that "nearly all of the articles that are published on diversity focus on the 'burden' of creating and encouraging diversity and not on the benefits of diversity" (p. 6).

The scholarship on women and gender has not been studied to a similar extent as the larger body of EER. In addition to the Garrett et al. conference paper cited above, there are several other conference papers, which I worked on, that examine the state of international engineering education research on gender and diversity (Beddoes, et al., 2009; Ihsen, Jesiek, Kammasch, & Beddoes, 2010). In addition to these studies, one other publication analysis revealed that out of 22 keyword categories, *gender/women* was ranked the twelfth most common in *JEE,* but it did not analyze those papers in detail (Wankat, 2004). As Brent Jesiek and I discuss briefly elsewhere (Ihsen, et al., 2010), large-scale reviews of EER on gender and diversity are scarce. Several that do exist focus more on key books and general trends, as opposed to looking at

[12] The others were: engineering epistemologies, engineering learning mechanisms, engineering learning systems, and engineering assessment.

[13] The others were: improving public image and understanding of engineering, preparing students to solve complex problems, meeting the challenges of globalization, and deeper understanding of learning in order to improve learning.

engineering education conference papers and journal articles in great detail. The most in-depth literature review on women and gender in engineering specifically I am aware of is part of Elizabeth Godfrey's dissertation (Godfrey, 2003). In a section on *Gender and the Culture of Engineering Education*, Godfrey summarizes the major works done in English on women and gender in engineering and engineering education (pp. 56-78). Additionally, she analyzes them to identify five gaps in the literature, including:

- "limitations of intervention strategies"
- "lack of definition of concept of 'culture'"
- "limitations of theorising from previous research on the interaction of gender with the culture of engineering education"
- "almost complete lack of theorising on subcultures within the culture of engineering education"
- "limited research on the process of enculturation – 'Learning the culture'" (pp. 78-82).

Another work that comprehensively presents findings of the major studies is a chapter from Donna Riley's *Engineering and Social Justice,* which is also concerned with diversity more broadly (2008). Riley summarizes work on "sexist cultures in engineering," the gendering of the field of engineering, and "sexist technologies" (pp. 90-94). The first two articles of my dissertation represent probably the most in-depth and comprehensive study of EER journal articles and conference papers on women and gender that exists. However, Ihsen is also currently analyzing *EJEE* publications in related ways (Ihsen, et al., 2010).

The subjects covered in the engineering education scholarship on women and gender are wide-ranging, but center around several key themes. In one prior study, for example, my co-authors and I found that the international research publications could be divided into two general categories: recruitment and retention (Beddoes, et al., 2009). The category *recruitment* included studies concerned with issues such as: pre-college outreach/preparation, reasons for entering engineering, university policies/admission, the image of engineering, and early career aspirations. Retention included studies concerned with issues such as: mentoring/role models/support networks, atmosphere/climate of engineering programs, discrimination/harassment, self-confidence/efficacy, faculty/teachers, gender inclusive curriculum, women only programs/courses, pedagogy and assessment, research/work experience, learning styles/skills, leadership, identity development, and academic advising. In a 2010 study, Ihsen identified the leading topics in Germany and noted an increasing move in Europe away from program/outreach description to research:

> During the last two decades in Europe research on gender and diversity in science and engineering started (In Germany for example in 1987 [3]). Besides a lot of articles about single projects at universities and industry on how to motivate and integrate more women into these fields and mainly written by the project leaders, researchers took more and more notice of this topic. The proceedings at the first European Conference on Gender and Diversity in Engineering and Science, run by the VDI in 2009, give a good overview of the topics and players of gender and diversity research in this special area [1]. (Ihsen, et al., 2010)[14]

[14] The references Ihsen is citing are: [1] Ihsen, Susanne, Klumpers, Johannes, Pageler, Sylke, Ulrich, Roya, Wieneke-Toutaoui, Burghilde (2009): Gender and Diversity in Engineering and Science. 1st VDI European

She then lists the main research topics as: "women leadership," "models of work-life balance in engineering and sciences," "changing the engineering profession – changed professional image," and "gender relevance in engineering education " (p. 2). Based upon the studies discussed above, as well as the research that went into this dissertation, I would suggest that on a very general level EER on women and gender can generally be described as including: descriptions of outreach initiatives; studies to determine why female students enter, remain in, or leave engineering programs; and experiences of women in engineering programs and in engineering careers.

Several other features of this scholarship are worth stating here. In relation to EER at large, the work on women and gender more often has authors with academic credentials from outside of engineering, including women's and gender studies, sociology, and education. The institutional basis for much of the work on women and gender is the same as for EER more generally: professional societies including SEFI and ASEE have working groups or divisions for such scholarship; local research groups have been formed in the US and Australia; and in Europe, Australia and the US national and supra-national funding has been given to study women in engineering education. Finally, as with EER at large, EER on women and gender is published in a variety of outlets that are not all specifically devoted to engineering education, including women's studies journals such as *Gender and Education*, *NWSA Journal*, and *Journal of Women and Minorities in Science and Engineering*. This last fact is important to note because of the way it affects what gets published in engineering education journals, which I discuss in chapter 4.

The EER to which I have been referring thus far is that concerned with some aspect of women or gender, most of which could be labeled "feminist" by some interpretations of that term. However, this scholarship by and large does not engage feminist theory or use the word "feminist." The limited use of feminist theory in EER is the subject of chapter 2. There have recently been efforts by small pockets of engineering education researchers to advance explicitly feminist research. In the US, beginning in 2002, there have been papers and special sessions on feminist research and pedagogy at the annual Frontiers in Education (FIE) Conference (Eschenbach, Cashman, Waller, & Lord, 2005; Lord, Cashman, Eschenbach, & Waller, 2005; Lord, Eschenbach, Waller, & Cashman, 2004; Pawley, Riley, Lord, & Harding, 2009; D. Riley, Catalano, Pawley, & Tucker, 2007; Tucker, Pawley, Riley, & Catalano, 2008; Waller, 2005a, 2005b).[15] The first special session on feminism at FIE in 2004 (Lord, et al., 2004) won the Helen Plants Award for best non-traditional session. There have also been recent journal articles on *feminisms in engineering education* and *feminist engineering*; however, these were published in women's studies journals, not engineering education journals (D. Riley, 2008; Udén, 2009). Additionally, in both the US and Australia there are now feminist engineering education research groups (Mills, Gill, Franzway, & Sharp, 2009; Pawley, 2010).

In summary, then, engineering education research is an emerging field of inquiry of which scholarship on women and gender comprises a notable part. Yet this body of scholarship remains

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Conference.,Düsseldorf; [3] Janshen, Doris / Rudolph, Hedwig (1987): Ingenieurinnen. Frauen für die Zukunft. Berlin / New York.

[15] Frontiers in Education (FIE) is a long standing, annual engineering education conference organized by the American Society for Engineering Education and the IEEE.

largely unexamined, both within engineering education and within STS. By analyzing it through STS and feminist lenses and publishing those analyses in engineering education journals, my articles follow in the footsteps of other feminist science studies scholars, comparisons to which I now turn. Yet, as readers will see, there are also important differences that distinguish my project from prior feminist science studies.

III. Feminist Science Studies

My dissertation is characterized by many of the same concerns as other recent feminist science studies (FSS) scholarship, namely:

- an emphasis on interdisciplinary practices
- a concern with reaching outside women's studies audiences, including by valuing accessibility for non-women's studies audiences
- a commitment to expanding beyond mere critique
- a focus on gender construction rather than underrepresentation and only trying to increase women's participation in sciences/engineering
- and a focus on intersectionality (Mayberry, et al., 2001b)

In this section I primarily orient my work with respect to the edited volume *Feminist Science Studies: A New Generation* (Mayberry, et al., 2001b) because that volume is unique in its focus on what I call *brokering* between natural/physical sciences and women's studies. *Feminist Science Studies* is divided into four sections. Here, I focus on the first two, as the final two are more concerned with feminist leadership, pedagogy, curricula development, and activism outside of the academy. My project is more squarely aligned with efforts described in the first two parts focused on interdisciplinary experiences and scholarship within the academy.

The essays in Part 1, (Un) Disciplined Identities: Forging Knowledge Across Borders, describe how the contributors came to be feminists working in the sciences, their struggles with doing so, and how they have found ways to cross the boundaries between science and women's studies to incorporate aspects from one into the other in their teaching and scholarship. They "offer us voices of those who have charted new paths through the academy, both interrogating the rigidity of fixed disciplinary boundaries and institutionalizing new hybridizations of fields formerly thought to be unrelated" (Mayberry, Subramaniam, & Weasel, 2001a, p. 6). The editors are optimistic because some scholars are successfully doing such interdisciplinary work, yet they are wary of the barriers that still exist:

> Young scholars have used feminist science studies as a bridge to traverse disciplinary and interdisciplinary boundaries. What seems striking to us is that rather than letting academic structures define and limit what they can and cannot do, the new generation of feminist science studies scholar have found ways to do the intellectual work they love through new and interesting institutional locations and career paths. The ability of young scholars to circumvent and overcome the barriers and obstacles of the academy are encouraging and exciting. However, it is also clear that we must find ways to ease the route to such innovations. (p. 10)

Difficulties for those who attempt to create pathways between women's studies and science fields can in part be explained by the fact that people who pursue these projects work isolated in

different departments and "the theory and research that emerges does not fit into the neat dimensions of prevailing frameworks. Indeed, such theory and research is at its best when it can catalyze work that challenges these frameworks" (Wyer, 2001, p. 72). Because the "institutional and disciplinary boundaries can...lead to feelings of isolation" and idiosyncrasy, the editors intend for these stories to "provide the current generation of feminist science scholars as well as those to come with role models and roadmaps for successfully navigating the thickets and underbrush of a well-disciplined academia" (Mayberry, et al., 2001a, p. 7).

To that end, the questions addressed by the personal narratives in Part 1 are:

- What ways have scholars developed to creatively circumvent disciplinary, intellectual, and institutional boundaries?
- How can we begin to respond to the challenges of occupying the liminal space of the insider-outsider and to the challenges presented by transdisciplinary work?
- What are the practical effects of conducting transdisciplinary work?
- What feminist and scientific questions – practically and theoretically – emerge from border crossing perspectives? (Mayberry, et al., 2001a, p. 7).[16]

For instance, Ingrid Bartsch identifies barriers and challenges to interdisciplinary work and being what she terms a "resident alien" in women's studies. She felt like an outsider; her women's studies work was seen as a "demotion" by her science colleagues and was perceived to be unfocused rather than "demanding, creative, and synthetic;" and it was unclear how her interdisciplinary work should be "counted" for tenure and promotion purposes (p. 32). One essay that is particularly germane to my project is "What do you do over there, anyway?" Author Caitlyn Allen sees herself as a translator between natural science and women's studies. She says, "My job is to mediate a real exchange of ideas and foster mutual understanding and respect between science and feminism" (p. 22). In discussing how she raises critiques of science among her science colleagues, she explains that she "must perform this job as an ambassador in order to keep…[her] job as a scientist" (p. 23). Doing so requires that she and others in similar positions "must understand these two cultures well enough to successfully develop dual professional personae as respected scientists and feminist critics. They must become dual citizens, fluent in at least two scholarly languages" (p. 29). The efforts described in this dissertation are similar to Allen's work in these regards.[17]

Banu Subramaniam likewise first imagined her role as one of translator between women's studies and science. However, unlike Allen, she came to find that translation efforts were unsuccessful because the language, tools, and methodology of each discipline were created to answer the questions of that discipline, not to facilitate interdisciplinary work. Therefore, she found that she had to create a new dictionary of language, tools and methodology to do the

[16] Although these authors use the term "transdisciplinary" and I use "interdisciplinary" throughout the rest of the dissertation, I am not making a distinction between transdisciplinary and interdisciplinary, and those authors are not using the term "transdisciplinary" in a way that distinguishes it from "interdisciplinary." Different definitions of these terms exist, but suffice it here to say that I consider my project interdisciplinary in the sense that I am getting a degree in one field but have been working to publish articles in another field, and in a similar sense those articles attempt to introduce knowledge and approaches from one field into the other.

[17] In STS more broadly, Peter Galison's (1997) work on trading zones and pidgin and creole languages developed to facilitate work across scientific boundaries also highlights the significance of translation and language when working across boundaries.

interdisciplinary work of reconstructing biology with feminist perspectives (Subramaniam, 2001).

Part 2, Altered States: Transforming Disciplines from Within, moves to the "fruits of feminist border crossing." It explores questions such as, "How have feminist scientists incorporated feminist research into their everyday practices?" and "How can we reenvision scientific theory and methodology?" (Mayberry, et al., 2001a, p. 7). The editors add, "The work described in this section represents an important turning point in feminist science studies, one in which critique is matched by reconstruction, and feminist principles guide rather than follow the trail of science" (pp. 6-7). This is one feature that characterizes "the new generation" in contrast to prior work. Contrasting *feminist science studies* with *gender and science* and f*eminist critiques of science*, the editors explain that they prefer *feminist science studies* "because the field does more than critique. It allows for progressive, positive readings of science, and of reconstructions of science consistent with feminist theories, ideals, and visions" (Mayberry, et al., 2001a, p. 10). As Wyer notes of the earlier "generation,"

> The feminist critique of science began with a reevaluation of scientific knowledge, opening the door to questions about the degree to which objectivity within male-centered scientific institutions was achievable or even desirable. Key studies demonstrated the distortion in methods and misinterpretations of data that stemmed from gender-bounded preconceptions. (p. 74)

Among the significant scholars in this vein she counts Donna Haraway, Ruth Bleier, Evelyn Fox Keller, Helen Longino, and Hilary Rose.[18] In this sense, my project and the work in *FSS* is also similar to Haraway who contends that changing/reconstructing a field requires participating in that field. It requires that we "write computer programs, argue for different data collection protocols, take photographs, consult on national policy bodies, write high school texts, publish in the right journals, etc." (Haraway, 1989, p. 303).

Thus, Part 2 focuses on the ways authors have tried to intervene in a scientific field's research. Michelle Elekonich, for instance, conducted research on song sparrows to challenge theories of aggression that have been shaped by gender biases. J. Kasi Jackson similarly "offers a case study in the reconstructive vein, to explain how the details of a debate in her field highlight theoretical challenges to assumptions about sexual dichotomization (Wyer, 2001, p. 76). C. Phoebe Lostroh introduces new metaphors and models for cell function in order to reconstruct masculine biases in cell biology . Finally, Montserrat Cabré undertook yet another reconstructive project in the history of science, attempting to attach increased value to the history of women in medicine . Each of these studies shares a similar aim of moving beyond critique from the outside to intervening from within. As noted, this is one of the primary features that distinguish the new generation of feminist science studies from previous work.

Additionally, one chapter from Part 3 must also be highlighted as particularly useful to my project in ways that are elaborated upon in the analyses. I find it to be the best example of specific knowledge and useful insights gained through attempts at what can be considered brokering. In "Difficult Crossings: Stories from Building Two-Way Streets" the authors describe

[18] This is not to say that some of these scholars have not also been involved in more reconstructive projects as well. In fact, Haraway has a chapter in the second section of the book.

two year-long seminars they ran to start conversations between women's studies and science faculty (Baker, Shulman, & Tobin, 2001). They recount lessons learned and mistakes made. Their findings include the following insights around language and goals of the two groups:

- The language they used immediately put scientists on the defensive because their worldview was being challenged (p. 159).
- Scientists were unfamiliar with categories of analysis feminists took for granted and they were "antagonistic" toward the word *feminist* (p. 159),
- "Within particular discourse communities, words have meanings that cannot be easily disentangled from the contexts of those communities…and they found the language used by feminist theorists opaque, verbose, manipulative and repetitive" (pp. 159-60).
- Frustrations and misunderstandings can be attributed to different understandings of the words *gender*, *objectivity*, *content,* and *critique* (pp. 160, 169).
- Scientists wanted practical and concrete help, to know how to recruit and retain more women, but feminist theorists thought it was impossible to address climate and participation without a firm grounding in the feminist critiques of science. This was perceived as pushing an agenda (pp. 162-63).

The work collected in *Feminist Science Studies: A New Generation* intersects with other bodies of scholarship that also influence my work. Namely, that of Donna Haraway, Patti Lather, bell hooks, and Gary Downey which argues for increased use of research methodologies aimed at changing that which we study (Haraway, 1989; Lather, 1991, 1995), making critical scholarship more accessible (Downey, 2009, hooks, 1989), and critically participating in the fields we study (Downey, 2009; Haraway, 1989). I turn now to a discussion of brokering, explaining what it offers to the work described in *Feminist Science Studies* as well as to my project.

IV. Brokering

As just discussed, feminist science studies scholars have described their work across disciplines as *dual citizenship*, *a meandering river*, *boundary crossing*, and *building two-way streets*, among others (Ginorio, 2001, p. 19). Such metaphors can be interesting, but I have found Etienne Wenger's notion of *brokering* to be the most applicable and useful for my project (Wenger, 1998).[19] The insights and guidance stem from the fact that brokering is introduced within the framework of communities of practice, which provides explanations for the challenges and opportunities of interdisciplinary brokering work, in ways that the FSS scholarship generally does not. This more elaborate framework connects identities, learning, knowledge, social positions, and available opportunities. Communities of practice are "formed by people who engage in a process of collective learning in a shared domain of human endeavor" (Wenger, 2006). Brokers are people who work in multiple communities of practice and, while negotiating their own activities and identities, also shape the relationships between their communities of practice. As Wenger explains:

> Brokers are able to make new connections across communities of practice, enable coordination, and – if they are good brokers – open new possibilities for meaning.…The job of brokering is complex. It involves processes of translation, coordination, and

[19] Although the brokering metaphor invokes economic images of buying and selling, Wenger uses it to describe processes of translation, communication, and reconciliation between different communities of practice.

> alignment between perspectives. It requires enough legitimacy to influence the development of a practice, mobilize attention, and address conflicting interests…It also requires the ability to link practices by facilitating translations between them, and to cause learning by introducing into a practice elements of another. (p. 109)

Wenger see brokering as complementary to creating boundary objects. He defines boundary objects as "artifacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnections" (p. 105). In addition to brokering, boundary objects are another way that connections between communities of practice are made. However, boundary objects do not require participation like brokering does. Negotiating membership in different communities of practice requires negotiation of identities, which has great potential to change the communities in which brokers work, but also carries the risk of being underappreciated and invisible. Discussing the potential that brokering has to change communities, Wenger states:

> …we negotiate our own activities and identities, and at the same time the histories of relations among our communities of practice. The creative negotiation of an identity always has the potential to rearrange these relations. In this regard, multimembership is not just a matter of personal identity. The work of reconciliation is a profoundly social kind of work. Through the creation of the person it is constantly creating bridges – or at least potential bridges – across the landscape of practice.

However, he goes on to recognize that such potential also carries risks for those attempting the work:

> And yet, the work of reconciliation can easily remain invisible because it may not be perceived as part of the enterprise of any community of practice…Even though each element of the nexus may belong to a community, the nexus itself may not. The careful weaving of this nexus of multimembership into an identity can therefore be a very private achievement. (p. 161)

In this regard, brokering parallels Downey's discussion of scalable scholarship (2009). Downey also recognizes that attempting to produce scalable scholarship and critically participate in non-STS communities "can produce transformations on both sides" (p. 65) but that "scaling up can generate considerable discomfort for its practitioners" (p. 73).

Thus, brokering is about working across boundaries of communities, changing those communities and their practices, and creating a new identity for the broker in the process. It is about participation and creating connections, not simply reification (creating boundary objects and sending them off). The work upon which my project is founded entails brokering between communities of practice: on the one hand, feminist science studies, STS, and gender studies, and on the other, engineering education. It should be noted that the concept of brokering is a theory of how such work *can* happen, and, for those who aspire to it, an ideal. That is not to say that brokers are always, or even usually, successful. Wenger stresses that their work is often not appreciated or recognized. Certainly brokering attempts can fail.

Finally, it is worth noting that other STS scholars have recently taken to using the term *broker* as well. *The Brokered World: Go-betweens and Global Intelligence, 1770-1820* uses the term in a

manner similar to Wenger, although it does not invoke Wenger's work (Schaffer, Roberts, Raj, & Delbourgo, 2009). Brokers, in this edited volume, were people who moved across various social and spatial boundaries. Specifically, like Wenger, these scholars are interested in the knowledge that brokers take with them across those boundaries. Additionally, like Wenger, they see brokering as work that establishes relationships and translation between different domains. A broker, or "go-between," is "not just a passer-by or a simple agent of cross-cultural diffusion, but someone who articulates relationships between disparate worlds or cultures by being able to translate between them" (Schaffer, et al., 2009, p. xiv).

V. Methods

A. Methodology

1. Production of texts and peer evaluation processes

Methodologically, this project is built upon STS foundations that recognize that what gets published in scientific/academic outlets, and what becomes knowledge, is the result of social processes and deliberations and reflects what communities value. As such, those processes and the resulting published artifacts merit examination as sites of knowledge construction as a social phenomenon that can reveal insights about how a community thinks and what they value. Very few studies, however, have documented and analyzed these processes at a micro-level, and even fewer have done so for their own work. In that regard this project is a novel contribution to STS literature.

Most notably, my project draws inspiration from Greg Myers' book *Writing Biology* (1990). Myers examines biology articles and funding proposals, employing multiple drafts of the texts as they underwent revisions, and authors', reviewers', and editors' comments and responses to uncover the processes, decisions, and negotiations that lie behind the texts that ultimately got funded and published. His motivation is to illuminate the social construction of knowledge in the development of scientific texts. He explains,

> The purpose of this study is to provide some interpretations of scientific texts in their social context that will help us understand how texts produce scientific knowledge and reproduce the cultural authority of that knowledge. I shall give to drafts and published versions of biologists' writing – grant proposals, articles, and popularizations – the kind of detailed attention usually reserved for literature…[T]he close attention is meant to bring out the social aspects of scientific work, aspects that may be missed in the usual course of reading textbooks, newspaper reports, or journal articles. … [I]f texts are structures both for thinking and for social interaction, we can ask what they tell us about scientific knowledge. Following some sociologists of scientific knowledge…I trace the power of this knowledge to social processes. (pp. ix-x)

Summarizing Myers' findings and his contribution to STS, Sismondo states that the "histories [of those articles] are a series of rhetorical responses to different contexts," and, "considerations of the identities and interests of readers shaped the writing of different texts" (2004, p. 144). More specifically, Myers is interested in the review processes. As he elaborates,

> I would like to look at the processes of review and revision, not from the perspective of the individual researcher confronting the individual reviewer, but from a broader perspective in which these processes are part of the functioning of a scientific community. I will suggest that the procedures of review and revision of the text can be seen as the negotiation of the status the scientific community will assign to the text's knowledge claims. (pp. 64-65)

My project is similar to Myers' in these regards. It is also similar in that the scientists Myers studied worked on boundaries between fields (including cell biology, population biology, physics, physiology, herpetology, neuro-endocrinology, zoology, botany, and entomology), which created "tensions" and highlighted the "social networks involved in scientific publication" (p. 35). In particular, Myers addresses several other issues that I discuss in my own analyses in the following chapters. They include a text's "appropriateness" for a given journal, expectations for form and tone, and levels of claims.

As Myers notes, his work builds upon prior STS scholarship on scientific publication and peer review. However, his study is unique in its depth and level of detail. Others have examined various biases in peer review and explored questions of secrecy (Hull, 1985), and decisions regarding how texts are written so as to maximize impact and speak to existing networks (Callon, Law, & Rip, 1986, Part II: The Power of Texts in Science and Technology; Law & Williams, 1982). Law and Williams, for example, contend that, writing a scientific paper is a "struggle to impose value" and that "Power in science, as elsewhere, comes from the successful capacity to create and impose value. And it is for this capacity that scientists struggle when they write a paper" (1982, pp. 538-539). However, these early STS works – Myers being an exception - are more concerned with making claims about how "science" in general works or demonstrating how text production evidences Actor Network Theory, and less concerned with the micropolitics of any given field.[20] In contrast to these works, then, my project provides an opportunity to discuss issues of interest to STS (e.g. how is knowledge produced), and an opportunity to explore the micropolitics of engineering education. At the same time, the microlevel analysis also opens possibilities to speak to (inter)disciplinary politics in a more generalizable way.

In science education, on the other hand, scholars have documented and analyzed their own review experiences and critically written about the review process more generally, including publishing reviewer and editor comments and their formal responses to those comments. One scholar, Wolff-Michael Roth, seems particularly prolific in this area, having written numerous articles on the topic of peer review in publishing and funding decisions and as guest editor for a special issue of *Research in Science Education* on the topic of peer review in science education (Roth, 2002a, 2002b, 2002c, 2004). Roth, and the other authors in that special issue raise many important issues and questions about the peer review process in general and use their own reviews as data. While I believe many of these issues and questions are interesting and important for engineering education researchers to consider, I must limit myself here to discussing those most germane to the brokering project at hand.[21] In the first place, I mention such science

[20] Feminist science studies has until recently also suffered from a lack of discipline-specific analyses (Wyer, 2001, p. 73), so that is another contribution of my project to FSS literature.

[21] I also have concerns that discussion of many of the issues would look like criticism of the specific journals and their editors and reviewers, which I want to avoid.

education literature to establish precedent for publishing verbatim one's reviews and seeing value in un-blackboxing the review process by writing about the micro-processes involved with the aim of empowering other actors. Secondly, I mention them because they recognize the value of discussing the affective dimensions of peer review. I was largely uncomfortable doing this – because it is not normal and because I worried many might not see the value in it. However, I have attempted to do so in several places to stretch my comfort zone and in hopes that it might help others doing gender research in engineering education to know the frustration that I experienced before getting my articles published. Third, I mention them because they raise questions germane to my analyses that are explored in greater depth in relevant chapters and the Conclusion. They include questions such as: Should the role of reviewers be gatekeepers or advancers of new ideas? Does the answer to that question affect the development of EER? Does it matter if some journals develop a reputation (however real or perceived) as either a gatekeeper or an innovator? Who is a "peer" for someone wanting to publish feminist science studies work in an engineering education journal? Are there enough such people?

Very recently several engineering education scholars in Australia have also begun to publish conference papers that analyze peer review practices in engineering education (Jolly, Willey, Tibbits, & Gardner, 2011; Willey, Jolly, Tibbits, & Gardner, 2011a, 2011b). Specifically, they studied reviews and experiences of being reviewed for the Australasian Association for Engineering Education (AAEE) conference. Considering questions similar to those I am discussing, they ask, "How are neophyte engineering education researchers able to be developed within formal structures that reward the familiar and the well-established?" and, does peer review "actually work to discriminate against innovation and impede the development of the field"? (Willey, Jolly, Tibbits, & Gardner, 2011a, p. 1).

Other relevant work on peer review includes Michèle Lamont's *How Professors Think: Inside the Curious World of Academic Judgment* (2009). Lamont interviewed panelists from five national funding organization panels in a variety of humanities and social science fields in order to study how different communities evaluated proposals and how they defined "excellence." As she explains her motivation,

> I approach the riddle of success by analyzing the context of evaluation – including which standards define and constrain what we see as excellent. …Most of all, I want to open the black box of peer review and make the process of evaluation more transparent, especially for younger academics looking in from the outside.[37] I also want to make the older, established scholars – the gatekeepers – think hard and think again about the limits of what they are doing, particularly when they define "what is exciting" as "what most looks like me (or my work)." (pp. 3, 12)

My project similarly aims to un-blackbox peer review of feminist articles in engineering education journals in order to provide insights to other scholars and, perhaps, to encourage "gate keepers" to re-examine their own judgments in a new light.

2. Developing theory through narrative

In addition to the methodological inspiration from STS work on the production of texts, peer review, and value judgments therein, my project also draws inspiration from scholars who have attempted to use personal narratives as sites of knowledge creation and theory development. In STS most recently, such efforts can be seen in a 2010 special issue of *Science as Culture* (Cohen & Galusky, 2010). The issue brings together a collection of STS scholars writing about tensions they encountered around issues of identity, engagement, and participation in various arenas that stem from their STS commitments. The guest editors, Benjamin Cohen and Wyatt Galusky, situate the issue in relation to STS work that seeks to influence others outside of academic STS circles, or that seeks to "place scholars explicitly within the systems and communities affected by the knowledge the scholars produce, to play a role in transforming a world in which they themselves live" (p. 2). Discussing the benefits of personal narrative, they state:

> …this is a turn toward the self and personal reflection as a way to communicate research and illustrate embodied conflicts. …From this grounding, the personal narrative format stands as a mode of communication that complements more conventional scholarship…both as a method of thinking and as a style of writing. ... STS scholars have a role to play with their own experience. It is with this in mind that we wish to promote participation as a goal and narrative as a means … the personal narrative offers different possibilities for argument construction at the same time that it offers unique opportunities to speak to audiences beyond peers alone. (pp. 2-3, 5, 6-7)

As Cohen and Galusky note, and as should be clear from section II of this Introduction, the essays in their issue build upon long-standing STS ideals of critical participation and, in particular, the work of feminist STS scholars. Recognizing the significance of that feminist work to their project they contend that, "This pioneering work helped to demonstrate that such an innovative rhetorical approach, while centered on the experiences of the writer, still allows scholars to promote both intellectual rigor and a strong grounding in current theory" (p. 6).

Similar work can be found in the field of education as well. Jean Anyon's edited volume *Theory and Educational Research* uses personal reflections following each chapter in which the authors analyze their own research, specifically struggles and insights over using and developing critical theory (2009). The introduction by the series editor, Greg Dimitriadis, suggest the value in such work:

> A rigorous engagement between theory and research, Anyon argues, can come only with intense reflection and hard, empirical work. In many respects, it emerges from the particularities of research projects themselves…We also witness a range of theoretical actors "in motion"…But perhaps most importantly, each of these authors offers intense personal reflection on their struggles with theory in their projects. This is not mere "naval gazing." Each shows how theory helped them to understand their data in different more powerful and expansive ways. (p. viii)

My project is thus similar to Anyon's in regard to its explorations of theorists (in my case Wenger, Downey, and hooks, among others) "in motion" and self-reflection on the use of theory in educational research. Moreover, in many ways, Anyon's volume parallels the work of bell hooks, arguing that we need broader notions of what theory is and how it can be developed

(hooks, 1989). Lastly, I note that the essays in *Feminist Science Studies*, discussed in the previous section, are also part of the trend toward theory development via personal narrative.

In sum, then, the methodological framework underlying my project combines two lines of STS inquiry (personal narrative and peer review/text production studies) to produce narratives of my brokering experiences.

B. Sources and Analysis

This project began by producing three articles intended for engineering education journals that introduce various feminist and STS theory and approaches to that audience. The first article, discussed in Chapter 2 and published in *Journal of Engineering Education*, analyzes the uses of feminist theory in EER and argues that further engagement with a broader range of feminist theories could benefit EER. The second article, discussed in Chapter 3 and published in *International Journal of Engineering Education*, analyzes problematizations of underrepresentation in EER and argues that further reflection upon and formal discussion of how underrepresentation is framed could benefit EER. The first two articles are content analyses (Leedy & Ormrod, 2005) of EER journal articles and conference papers. The third article, discussed in Chapter 4 and submitted to *European Journal of Engineering Education*, analyzes feminist research methodologies in the context of EER, using data from interviews I conducted with 15 feminist engineering educators. Each article was submitted to a different leading engineering education journal, thus allowing analysis of similarities and differences across journals and a broad picture of the field to emerge.

Chapters 2, 3, and 4 each begin with a narrative recounting of the practices of brokering that went into producing and revising each article. The published or submitted article appears after that. The narratives describe processes of writing and preparing to submit the articles, reviews received, and subsequent revision processes. The sources for the narratives include: different drafts of my articles as they went through review and revision(s) as well as drafts leading up to what was originally submitted to a journal, reviews, editors' comments, discussions with my co-author/co-advisor (who is in the core of the engineering education community), personal journal entries made along the way, and the websites of the journals to which I submitted. The narratives were developed by analyzing those sources, reflecting upon my experiences throughout the processes, and, in the Conclusion, relating both back to the relevant literature discussed in this chapter. The Appendix provides an overview of the aims, scope, author guidelines, and review criteria for the engineering education journals. Relevant differences among the journals in these regards are discussed throughout the dissertation.

C. Necessary Partiality

While documenting my own publication production process, as opposed to that of others, lends this project a beneficial level of detail and "insider" insights, the closeness also introduces limitations and challenges. Namely, my account is partial. This partiality is "necessary" on two levels.

The first level of necessity is inherent. It stems from the fact that the narratives I present can only be my own experiences and perceptions. Editors and reviewers involved would no doubt have different, although still partial, narratives. I have reflected upon and discussed my experiences with one of my advisors, who is, to use Wenger's terms, at the core of the engineering education community of practice, and who co-authored one of the articles. I indicate in the narratives when a perception of the process came from her. Yet, the narratives remain partial. Moreover, there is, as of now, no way to know how representative my experiences are. No one else that I am aware of has documented in public format their experiences trying to get feminist work into engineering education outlets. As I suggest in the Conclusion, if more gender scholars would document their review experiences we would have a fuller, deeper picture of what the engineering education community thinks and values. My interviews, the subject of Chapter 4, suggest that at least some engineering education researchers have had review experiences that can provide insights into how feminist theory is and has been received by that community.

The second level of necessity is strategic. It stems from my aim of brokering and critical *participation*. Recall that brokers try to work *within* several communities of practice. I am trying to work *within* engineering education, to participate in it. I am a graduate student who would like to continue working in engineering education, which means that I need to be on good terms with those who may read this account, including those persons, such as reviewers, editors, and advisors, featured in my narratives. These circumstances mean that I have had to consider carefully what to include in the narratives and what to leave out. To the greatest extent possible within the confines of maintaining good relationships, I have tried to provide a full, accurate analysis of the production of these three papers. Such is the challenge for those wishing to broker in similar ways. I think this raises important issues about the tendency for STS scholars to critique from the outside, which are discussed further in the following chapters and which have been signaled out for critique by feminist science studies scholars, as discussed above.

Chapter 2 - Feminist Theory for *Journal of Engineering Education*

I. Overview

The article that appears in this chapter was published in the *Journal of Engineering Education (JEE)* in April 2011. It is a content analysis of research on women and gender in three leading engineering education journals: *Journal of Engineering Education (JEE)*, *European Journal of Engineering Education (EJEE),* and *International Journal of Engineering Education (IJEE)*. The aim was to determine how and to what extent feminist theory was used and systematically developed within those journals between 1995 and 2008, and to make an argument that EER could benefit from further engagement with feminist theory. The article begins by briefly discussing the use of theory in engineering education, feminist theory in other fields, and features of engineering that pose a challenge to incorporation of feminist theory, based on the histories of other fields. It then discusses five branches of feminist theory that are particularly germane to EER, as evidenced by their use in the dataset, providing an introductory overview of each branch, suggesting further readings for each, and offering concrete examples of how the theory could be put into practice while doing empirical research. The branches are: liberal, standpoint, intersectional, interactional, and masculinity studies. Next, the results, organized into the same sections as the literature review, one for each branch, describe the use of each in the dataset. It discusses the extent to which each branch is engaged and points to key examples of articles in which each is used, also noting when and how deeper engagement could have benefitted an article. It demonstrates that several key branches of feminist thought are underutilized within engineering education scholarship and argues that deeper engagement with a wide range of feminist theories is one way forward for those concerned with increasing the participation of women in engineering and changing the cultures of engineering education. The article concludes with an *Implications for Future Research* section in which we suggest two strategies for researchers wanting to engage further with feminist theory. The article also includes an appendix that represents the categorization of the dataset, stating the number of articles that were put into each category (branch of feminist theory) and citing examples of articles that were put in each category.

In this opening section I discuss the work that went into writing the draft that was originally submitted and then the three revisions that it went through, discussing each in a separate section. I focus on practices and events most salient to the development of engineering education as a field and feminist scholarship there in. Certainly this focus necessitates leaving out parts of the story. Preparing the paper for *JEE* meant thinking about how to frame it so an engineering education audience would see its value, modifying which and how concepts were introduced and providing examples, moving beyond critique with recommendations and a more constructive tone, and reorganizing the contents. Satisfying reviewers and the Associate Editor during the review and revision processes meant navigating divergent opinions about the state of EER on women and gender and about appropriate expectations for the first article on feminist theory in *JEE*.

While reading this narrative (as well as those in Chapters 3 and 4), it is important to keep in mind the locations of those involved. When I wrote the first draft of this paper, I was a Science and Technology Studies PhD student between my second and third years of graduate school, and I

had just finished my first year working as a graduate research assistant in engineering education for Dr. Maura Borrego. Maura is an Associate Professor[22] in Virginia Tech's Engineering Education department who has had much success in that field. She has a record of publishing numerous articles in *JEE*, received an NSF CAREER award for engineering education research, and received a Presidential Early Career Award for Scientists and Engineers (PECASE). In Wenger's terms, she is very much at the core of the engineering education community of practice. However, Maura did not have a background in STS or women's studies (WS). I state this because it meant that she was reading the paper as most of the *JEE* audience would, as someone to whom feminist theory was largely unfamiliar. This shaped the form and content of the original draft submitted to the journal. My point in explaining these two things about Maura is that I was working with someone who was very much in a position to know what *JEE* would want and to know what the general engineering education community would expect, appreciate, or value in such a paper. Working closely with someone at the core of the community greatly increases the chances of success, I believe, based on my experiences. Additionally, Maura's location in this field and her relationships with the Editor and one Associate Editor of *JEE* are important factors in the narrative. They made it possible to discuss our reviews with editors when someone in a different location and without those relationships may not perceive or realize that they have that option.

II. Preparing to Submit to JEE

This article developed out of final papers I had written for two of my graduate classes: *Feminist Theory* (in which I wrote most of what eventually became the literature review and analyzed a small subset of Australian articles), and *History of Science* (in which I added parts about the history of feminist theory in other fields and analyzed the full dataset). In May 2009, I shared the paper with Maura and we discussed which journal to submit it to. She believed it was good enough to try for *JEE*, and I saw no reason not to try publishing it there. She believed it was worth trying for *JEE* because the article fit a trend in the journal of promoting theoretical development within EER as part of its development as a rigorous/scholarly research field, and there was precedent for content analyses in that journal.

However, before it could be submitted, I spent the summer of 2009 revising the paper to bring it in line with the norms for a *JEE* article, based on Maura's suggestions. By and large the changes were aimed at making the paper more accessible, and therefore potentially more valuable, to an audience without a background in feminist theory. I do not want to imply that no one in the engineering education community is familiar with feminist theory. Indeed, as I discuss in the article, there are some who are. However, because this was the first paper of its kind in *JEE* and because I wanted it to have value to a wide audience, not just those already familiar with or interested in feminist theory, I wanted the article to be introductory, that is, to be understandable to anyone reading *JEE*. Essentially, then, I was trying to turn two papers that were intended for WS and STS courses/professors into an article that would be accepted by an engineering education journal.

I recognize that I am making homogenizing generalizations about both STS and WS here, and that there is scholarship in those fields for which my analyses in this dissertation do not apply. I also lump STS and WS together because they share many features that are germane to these

[22] During the time period discussed this chapter, she was an un-tenured assistant professor.

analyses. I believe these generalizations are warranted and that the features I identify as characterizing those fields would not be disputed by most in the field. My focus on feminist science studies also brings the two fields together for the purposes of this project.

First, it was important to frame the paper correctly in the Introduction. While this is an important step for *all* authors, I contend that it is particularly important for brokers trying to introduce new approaches and ideas into a field. I did that by situating it within EER as an emerging research field in which there was a need to develop theoretically, and suggesting that feminist theory was one way to do that. Embedded in this, of course, was an understanding that equity for women in engineering is a big problem in the field worthy of continued study. The Introduction followed a model common in *JEE* and aligned with other recent calls to make EER more systematic and theoretical. However, as discussed below, one reviewer and the AE did not like this, and almost all of the original framing was deleted in the end.

Second, I adjusted what concepts were mentioned, how they were discussed, and the terms that were used to discuss them. For instance, whereas in my course papers I had used words such as *hegemony*, *hierarchy*, *politics*, and *power*, and taken for granted that I would be understood, in preparing the article I either needed to remove these words, stop and explain what they meant, and/or provide an illustrative example. "Heteronormative" for example, required explanation. In many cases I just removed the terms in question, either because they seemed too difficult to explain or because doing so would have greatly disrupted the flow of the paper, especially as footnotes and endnotes are not used in engineering education journals.[23] Other times, I needed to add illustrative examples to explain an idea that was not commonplace in engineering education. For example, the basic idea that engineering has masculine biases had to be explained. Hence, sentences such as the following appear in the final version: "Masculine characteristics of engineering include competitive (as opposed to collaborative) classroom environments and design projects that are decontextualized or have military- or weapons-related applications only" (287).

A third change required[24] going beyond critique to reconstruction (in the words of the editors of *Feminist Science Studies: A New Generation* (Mayberry, et al., 2001b)). In this case, reconstruction meant giving specific and concrete recommendations on how engineering education research on women and gender could be improved through greater engagement with feminist theory. This is often referred to as "implications for practice" in engineering education, and reference is even made to it in *JEE*'s information for authors, as seen in the Appendix. It is a norm that distinguishes EER from STS and stems largely from engineering norms and expectations having carried over into EER. In general, STS and WS value raising and discussing problems and issues – without the expectation to provide answers or solve those problems – more so than does EER, in which solutions to problems are valued and often expected. I was coming from fields where simply pointing out problems is not only sufficient but basically all that most scholars do, but Maura kept asking me to explicitly state how the insights generated through critique yield concrete recommendations for improving EER. I struggled with this because by and large I did not have WS or feminist STS work to draw on for recommendations

[23] This in itself is a notable stylistic consideration that reflects different cultures of academic work.

[24] Again, by "required" here I mean recommended by someone with an extensive knowledge of and experience publishing in *JEE*, but with no background in STS or WS.

on to take many of the insights from feminist theory and apply them to develop implications for research practices. Scholars in those fields have typically not written with the aim of being practically useful to scholars conducting empirical studies of women and gender, and so have not had to provide reconstructive guidance. I, like many current feminist science studies and STS scholars, as discussed in the Introduction, have come to see this as a problem. As one example, in a section about postmodern and post-structural feminist theory I had written:

> Drawing from French postmodern and poststructuralist theorists, such as Jacques Lacan, Jacques Derrida, and Michel Foucault, postmodern feminist theorists like Judith Butler and Joan Scott argue that gender does not exist as any original referent; it exists only in the ways in which we continually (re)produce it, only as a sign. Focusing on discourse and deconstruction of categories postmodern theorists attempt to denaturalize gender orders and categories so that they can be remade, resignified.

Maura asked in her comments, "Would it point out behaviors to avoid?" and said it needed to be "slightly more concrete." Similarly, in the section on Interactional feminist theory, I needed to add concrete examples of how gender is reproduced in everyday interactions. Thus, I wrote, "Examples of everyday behaviors to pay attention to could include tasks that are split along gender lines in engineering classrooms or labs (e.g., when men work with equipment and women write group reports), and subtle instances of discrimination" (286). Related to this, I later added a section called *Implications for Future Research*. I felt, and still do, like these concrete examples and recommendations are the weakest part of the paper. I believe this feeling is evidence of a limitation of feminist theory, which scholars such as bell hooks and Patti Lather have critiqued (hooks, 1989; Lather, 1991, 1995). Namely, that highly theoretical work is what is most valued within the academy and has become the standard, despite its lack of practicality. I take up this issue again in the Conclusion.

As part of the reconstructive aims, I also changed the "tone" of the paper in many places. The tone needed to be more constructive, less harsh, less "snipey" as one reviewer would later comment. In part, this was because the reviewers would likely be the authors of the pieces we were critiquing. But more generally, it points to an important difference between STS/WS and engineering education. In general, the paper shifted from critiquing the problems found in the dataset and pointing out problems with individual papers, to pointing to *positive* examples and more gently suggesting how they might be improved by further use of feminist theory.

Additionally, I rearranged the contents of the article to make it more accessible to a broad audience without familiarity of these topics. The typical format of an engineering education article includes the following sections in this order: Introduction, Literature Review, Methods, Findings, Discussion, and Conclusion. For this article, given the complexity of feminist theory and the many different branches of feminist thought being discussed, Maura argued it would be helpful to readers to have the overview of each branch of feminist theory in the Findings section: she found it difficult to keep all five branches sorted out while reading. Including the overviews alongside the Findings would make it easier for those with no background because they would not have to refer back to the literature review section and risk getting bogged down or confused by the intricacies of the five different branches discussed. I also thought this was a good idea and so we deviated from the typical layout of a *JEE* paper and placed large pieces of the literature review in the Findings. In other words, the subsections of the Findings each began with an

overview of that branch of feminist thought, followed by the findings from the dataset. There was still a separate literature review section in the normal place, which mostly covered the history of feminist theory in other fields (this largely became the Discussion section in later revisions). As discussed below, this is a second change that was revealed in the review process to be unsuccessful (the first being the framing).

In summary then, preparing the paper for *JEE* meant thinking about how to frame it so an engineering education audience would see its value, modifying which and how concepts were introduced and providing examples, moving beyond critique with recommendations and a more constructive tone, and reorganizing the contents. Many of the norms of STS and WS made the original paper I shared with Maura unacceptable or inaccessible to the general engineering education audience. At the time, I found this a frustrating process, and affective dimensions of brokering will be taken up in the Conclusion. Following this summer of turning the STS and WS course papers in to a potential *JEE* article, I submitted it to the journal in August 2009.

III. The First Set of Revisions

I received a Major Revision decision from the Associate Editor (AE) and reviews from three reviewers in November 2009.[25] Two of the reviews were quite positive and one was quite negative. Moreover, they contained opposing views on specific, significant issues. In this and the following sections I discuss those differences with the aim of highlighting disparities among those working on women and gender in engineering education research. I also discuss other topics related to the changes described in the previous section.

Reviewers had very different opinions regarding the article's level of appropriateness for *JEE* and its contribution to EER. While both reviewers commented on the level of analysis and its contribution to the field, they held directly opposing views on the subject.[26] These comments thus raise questions about what it means to contribute new knowledge to engineering education. Reviewer 1 commented that the paper was:

> A pleasure to read both in content and composition. Clear, concise construction, not jargon laden, very appropriate for intended audience. Coupled with Riley, Pawley, Tucker and Catalano (NWSA Vol. 21, #2, 2009) this publication would contribute to a synergistic moment in engineering education research. I applaud all your efforts to bring feminist theory out of the closet and into main stream discussion in engineering education research.

However, Reviewer 3 (R3) began their comments by stating:

> I was very interested when I saw the title and abstract for this paper and had high expectations. These expectations were unfortunately not fully met; in general I found the paper a bit superficial and I am not sure it is adding much new to the literature in its current form. For example, the authors quote in several points an editorial from a 2002 IJEE special issue in Women & Engineering; it is worth reading this editorial and then judging what the present paper is offering that goes beyond that editorial. At this stage my judgement is that the answer is 'not much'.

[25] At the time, *JEE* only conducted single-blind reviews. They recently switched to double-blind. *EJEE* and *AJEE* are double-blind, but *IJEE* is single-blind. I do not have any reason to believe that the single-blind process affected my reviews for either *JEE* or *IJEE,* but I mention this as a difference between fields.

[26] Reviewer 2's comments were not directly relevant to the topics I am focusing on here.

Many of the changes described above that I made in preparing to submit to *JEE* were intended to produce precisely the features that R1 appreciated. And yet, it seemed that many of those features led R3 to see it as superficial. Such disagreements surely pose challenges for a developing field, for authors, and for readers when an article is assessed by one reviewer as "very appropriate" and contributing to a "synergistic moment in engineering education research" and another sees it as "superficial" and contributing "not much" to the field. Such issues are explored in the Conclusion.

The Associate Editor was in agreement with R3, as evidenced by the Major Revision decision and comments that:

> As evident in the reviews, there is divergence in opinion as to the readiness of this article for publication. One reviewer has little to say and assigns an "accept as written", while on the other end, a reviewer asks for more in-depth analysis that would push the work further so as to make contributions back to the field of feminist studies. We encourage the authors to take these latter comments seriously so that the article will both challenge the JEE community while potentially serving as a vehicle for motivating non-engineering education folks to engage with issues faced in the field.

In other words, both the AE and R3 wanted the paper to be deeper and to contribute not only to EER but to women's studies as well.

Additionally, R3 did not like the placement of the discussion of each different branch of feminist theory, (the literature review pieces), in the Findings section. This is an instance where an effort to make the paper accessible to everyone were not appreciated by a reviewer. The AE agreed with this and in the next phase insisted that I move those pieces to the Literature Review section.

There were many indications in Reviewer 3's extensive comments that made me believe that reviewer was not familiar with EER and the current state of research on women and gender therein, and likely someone with a women's studies background who knew about feminist STS work as well.[27] Many of the changes R3 suggested went against *JEE* precedent. Furthermore, at the time, I felt that the expectation that the first *JEE* paper devoted to feminist theory should both be accessible to the entire audience and advance both their knowledge and advance or contribute to women's studies unreasonable. R3 seemed to believe that there had been a lot more work done in this area, and/or that the work that had been done was much more engaged with feminist theory than my research had discovered, but the reviewer did not point to any specific literature to support her impressions. (Unfortunately, I never did come to understand why Reviewer 3 had such a different belief about the existing work than the other reviewers and myself.) Therefore, I made the small change that Reviewer 2 requested and the changes from R3 that I thought were reasonable. In the response letter, I responded to each comment of R3 explaining when a change was not made why I believed that it went against *JEE* precedent and/or reflected a lack of familiarity with EER. I submitted Revision 1 in November 2009.

IV. The Second Set of Revisions

In February 2010, I received another letter from the AE and a second set of reviews, this time from four reviewers. Reviewers 1 and 3 were the same as in first reviews. It was unclear if

[27] R3 would later state that this was not the case and that she had been working in engineering education for a long time.

Reviewer 2 was the same as before and just chose to write much more this time, or if it was a new reviewer. Reviewer 4 was new, added after the last Phase, and it seems had access to the original, the revision, the other reviews, and our response letter. Again there was disagreement over the appropriateness and contribution of the article, and in addition to the reviewer who thought the article was "very accessible" and the one who thought it was "superficial," I now had an additional reviewer who thought it needed to be "more accessible" and less in a "tone of a feminist theorist." In other words, R2 was recommending changes that went in the opposite direction of R3:

> I agree with the authors that the topic of this paper is of great import to engineering education and the development of the engineering education discipline. I think it is important that this information be made available to the engineering education community. However, I do not think the paper is yet ready to be published. The authors need to make the information more assessable to the typical reader of JEE.... If we could really define such a reader! ;-)
>
> The authors have taken on a difficult task. They are doing more than just reviewing the literature. They are trying to:
> 1. Educate the engineering education community about feminist theory
> 2. Critically review the engineering education literature for topics of feminist theory using a feminist theory lens.
> 3. Provide suggestions of future research in engineering education using a feminist theory framework.
> 4. Write their article in a style that is has more of a tone of a feminist theorist and less of an engineering educator.
>
> Please note that No. 2 is the main point of the paper. However, I think the other aspects of the paper sometimes get in the way of providing a critical review. The tone of the writing sometimes reflects No. 1 and/or No. 4 too much and not enough No. 2. I am having difficulty suggesting how to improve the paper.

These comments from R2 (along with events described below) reveal that among reviewers, the AE, and myself, there were competing ideas about the goal of the paper, communities it could and should engage, and who the members of those communities were.

Furthermore, another tension was that comments from R3 revealed that the reviewer had interpreted our aim to make the paper accessible as tantamount to claiming that the *JEE* audience was unable to understand sophisticated social science scholarship, thus revealing very different interpretations of both the meaning and goal of "accessibility" within the engineering education community. I saw these conflicting assessments, and the expectation to make the article go in two divergent directions, unreasonable. Maura suggested that we arrange a call with the Editor to discuss revisions. The Editor referred us to the AE. We therefore arranged a call with the Associate Editor in order to help us understand which of the conflicting reviews to follow.[28]

There were five outcomes from that call that are particularly relevant. First, concerning the level of accessibility and analysis, the AE agreed with Reviewer 3 – not the other two – and insisted that I meet the demands of that one reviewer. The AE did not explain why he/she agreed with R3 and not the others, but in doing so the AE shifted from being an arbiter to an active participant in

[28] Conflicting reviews are common in engineering education, so this article is not unique in that regard.

accepting or resisting the brokering move. Second, as two reviewers had suggested at that point, the literature review pieces we had included in the Findings section were moved to the Literature Review section. Third, many of the most critical – or "snipey" – sentences in the paper were removed due to this comment from Reviewer 2:

> At times, the authors use an example to draw out how a paper did not use or missed the main point of a theoretical framework. I think it is difficult to present such examples without coming across "snipey". I list some examples below. I do not have a suggestion here for improvement, rather I encourage the authors to carefully choose their words (which I am sure they already did!). My fear is that the reader will be distracted by the "snipeyness" and not hear the take home message of the example. But I think the examples should remain.
>
> EXAMPLES FROM PAPER "Unfortunately, no such caution is taken with "gender" in this article." Or "(However, given the lack of traction such conceptions of gender have gained within the dataset analyzed here, when discussing particular articles, we will continue to use the term "gender" as the authors themselves do in their work." Or "While it may be the case that an increase in women engineers results in fun and family benefits for some, basing arguments for diversity on women's entertainment value ("fun") and heteronormative assumptions ("family-life balance" for heterosexual couples) is a questionable strategy. These aspects of her well-intentioned intervention clearly highlight the important role that feminist theory, and masculinity studies in particular, could play in the development of similar initiatives to ensure that they do not undermine the ideals they seek to enact."

Maura had made similar suggestions prior to this, and I believed I had already toned down the paper a lot, but I removed the sentences mentioned by R2. I wondered how you are supposed to deeply analyze each article, getting deeper into feminist theory, as R3 wanted, without also critiquing the papers? I saw this removal of the most critical parts as contradictory to the level of analysis R3 wanted. Note that R2 did not actually suggest removing them, and in fact said the examples should stay. But like that reviewer, I did not know how to tone down those critiques, and I was very frustrated at that point, so I just removed them.

Fourth, at the suggestion of reviewers 2 and 4, who wanted to know how many papers fell in each category, the AE insisted that we put each in one (or more) category and count them. This is part of what it means to do "rigorous" research in EER. To that point, I had not added each paper into a category. Rather, I had pulled out the best examples to discuss for each branch. I found the expectation to code the papers very problematic because the papers themselves did not usually clearly engage one or two branches, and often different branches were most relevant to different parts of a single paper. It was also difficult because I wanted to discuss how a theory could improve a paper even if that paper did not engage a theory itself.

I wrote a long paragraph about why such coding was problematic, citing STS literature such as *Sorting Things Out*, *After Method*, and *Complexities* (Bowker & Star, 1999; Law, 2004; Law & Mol, 2002). I had to cut the paragraph down twice, first based on feedback from Maura and again based on one reviewer in the next Phase. I was worried that authors in the dataset would be upset that I had placed them in one category and not another and that readers would focus on that rather than the larger point of the paper. Against my wishes, I created the appendix and visually represented the categorization scheme by putting each article in one or more boxes. This graphic

representation is not a coincidence because I very much felt like I was "putting them in boxes," in the negative and confining sense of the term.

This illustrates another significant feature of EER, a hyper-focus on methods, and perceptions of rigorous methods, as a hallmark of quality scholarship.[29] As became clear after the review of my second article, however, such a hyper-focus on methods characterizes *JEE* more so than *IJEE*. Perhaps hints of this difference can be found in *JEE*'s manuscript requirements statement that "The relevant theories should be presented, research design described, limitations acknowledged, and research methods and instruments discussed so as to permit evaluation of the validity and reliability of the evidence offered."[30] "Research validity and reliability or credibility and dependability" are then listed as review criteria.[31] On the other hand, *IJEE* has no similar statements evidencing concern methods. The closest criteria to *JEE* in that regard would be under Content for "conclusions drawn" or General Opinion and Comments for "correctness of the text."[32] More details on the journals' review criteria can be found in the Appendix.

Fifth, the framing of the Introduction needed to change. We had originally written this as an EER methods piece that used feminist theory as an example, while the AE sent it to feminist researchers well versed in the theories and literature who were not necessarily our intended audience of regular JEE readers. Getting the framing right up front was revealed to be a key facet for each of the three articles.

I submitted the revision in July 2010.

V. The Third Set of Revisions

I received a Minor Revision decision letter and another set of reviews in September 2010. Most of the changes requested here were for wording and grammar choices. Reviewers pointed out specific sentences that should be worded differently. Two comments are worth discussing however. The first is moving the appendix to the body of the paper. As discussed, I really was uncomfortable with the categorization and did not want readers focusing on that. Additionally, one reviewer "did not necessarily agree with the categories in which some of the articles had been placed" – as I had worried. I therefore insisted on keeping it as an appendix, which the AE allowed. Second, one reviewer did not like the text I added in the last Phase about the problematic categorization I had done:

> I would also recommend reducing the discussion of the authors' discomfort with rigid categorization as antithetical to feminist theory. It is the authors' choice to do such categorization. One mention is fine (p. 19 although I think the tone becomes complaining) but I think they belabor it by repeating on p. 20.

I shortened the text to the current version, but I found this framing of "choice" problematic. I "chose" to do such a categorization in the sense that my choice was either do it or not publish the

[29] Inspiration for this terminology, hyper-focus on methods, came from Steven Shapin's article (2005) on hyperprofessionalism in the history of science. Like him, I use this prefix to emphasize that there is something problematic about an otherwise laudable ideal when it goes too far and stands in the way of other goals, limiting the field's development.
[30] http://www.jee.org/submissions
[31] http://www.jee.org/submissions/review-criteria
[32] Taken from review sheet I received as an author with my reviews.

paper in *JEE*. Of course, it is likely that the reviewer did not know that AE insisted on categorizing the dataset; however, it does raise questions, which have been raised in science education as well, and which I discuss in the Conclusion, about standardization of articles and editorial authority.

I also mention this to demonstrate, again, a discrepancy among reviewers and between the AE and some reviewers on both the level and accessibility of analysis and the categorization (some thinking publishing the categorization of the dataset necessary and some not). For example, another reviewer (Reviewer 3 in this round, but I believe it was R1 from the first set of reviews), remarking on the level of appropriateness of the final version and the importance of the text on categorization (the lack of traction it might have with some readers) said:

> As I said in the first go-round, this is a timely and important article. You are correct in stating that this article is just the beginning to encourage a deeper, more sophisticated and nuanced relationship between feminist theory and engineering education. For some of us who cut our scholarly teeth in feminsit and critical cultural theory, this article reads like a beginning primer, but having now worked in engineering education research for 5 years I understand just how new and frightening feminists theory is viewed by engin. educa. resarchers, including the female engineers I work with. To their credit they now "get it." I completely understand and support your observation that some of the limited application of fem theory in engr educ research is a result of authors intuitively understanding what would and would not get published in engr. educ. journals. We know our audience, yet because we know our audience (faculty, male, white, middle-class) we must continue to bring discussions such as this to the fore and encourage colleagues to engage feminist theory. STS is far ahead in this engagement but can hopefully be the beacon to follow.
>
> Your article is well laid out and easy to follow for those who are not familiar with fem theory. I appreciate that you did not use a lot of jargon. I agree that while the use of liberal feminist theory is a start, it is not sufficient and indeed can be damaging if we do not go beyond to a more critical analysis of the structures of power in engr and engr educ … a site for the construction of that power. While I do not necessarily agree with the categories in which some of the articles have been placed, I do agree with your assessment that they are necessary for analysis. Ah, but would all researchers (quantitative especially) acknowledge the necessary external imposition of organizing categories!

I submitted the final version in October 2010.

Before moving on, a material consideration is worth mentioning here. Unlike the leading STS journals, some engineering education journals (*JEE* and *IJEE*) have page charges. This is another reflection of influences from academic engineering work on the field of engineering education. Future brokers should be aware of this difference, especially given another big difference between STS/Women's Studies and engineering education: engineering education researchers have usually received large (in comparison to social science and humanities) grants to conduct their research (in the US, and to a lesser extent in Europe and Australia as well), and they are able to use those funds to cover the costs of publishing their articles. *JEE* has a $60 page charge. I requested a waiver based on the fact that I was a graduate student and although I had a co-author who was a faculty member with grants, the work had not been part of any of those grants so there were no obvious funds to pay the fee. The editor agreed to waive the fee, which I greatly appreciated. It should be noted though that it was only because I was working with Maura that I

knew I could email the editor to request a waiver. Someone who did not know the editor as well or who did not for whatever reason feel they could or should ask for it would be disadvantaged by page charges. Indeed, during my interviews (the subject of Chapter 4), one of my participants mentioned that when she was beginning her career, the page charges kept her from submitting to *JEE* because she did not have the funds to pay the page charges and did not realize she could - or feel empowered enough to - ask for a waiver. She believes that women faculty are disadvantaged in this regard because of socialized gender roles in which women are taught not to be demanding or ask for things.[33]

VI. Emergent Practices of Brokering

In the process of getting this article published in the *Journal of Engineering Education*, I made decisions and modifications that informed my emergent understandings of what brokering between STS and engineering education means. These understandings were then used to develop the next article. The practices of brokering that emerged from this process were: identifying differences between audiences, aligning with current conversations in the field, and adhering to the norms and expectations of the field in which I was trying to introduce new ideas.

Identifying differences between the audiences – or communities – between which I was brokering involved realizing that what was appropriate and accessible in STS was not necessarily so in EER. Making my article on feminist theory appropriate and accessible in EER required consideration of how and if to introduce certain concepts (and their associated terms) to the *JEE* audience, and attempting to achieve the right tone and level of criticism. These practices were important because of the aim to have the article be clear and of value to that audience while not offending any of them, particularly those researchers in the dataset and others doing similar work.

Adhering to the norms and expectations of EER involved following the typical article layout, attempting to provide concrete recommendations and implications for practice, and satisfying criteria for "rigorous" methods. This was all necessary to meet the status quo that would allow the article to pass through peer review and be published.

Aligning with current conversations in EER involved figuring out how to frame the Introduction to the article and selecting a journal. Figuring out how to frame the article in the Introduction was important given that I was trying to introduce new ideas and thus needed to convince readers (including in the first place editors and reviewers) to read the article because it was important and related to things they cared about. Selecting a journal was important because different journals have different requirements, traditions, and expectations. While selecting the best journal for one's purposes is important to all authors, when trying to introduce new ideas to a field, as in brokering, selecting the right journal is even more important.

Each of these broad categories of brokering practices was also employed for the next article; however, some differences did emerge for the second article. Furthermore, as discussed, these brokering practices were not without challenges and did not produce unequivocal success – at least not initially. After a more complete picture of brokering emerges through discussion of all three articles, the challenges are elaborated upon in the Conclusion.

[33] There is literature that supports her statement. See, for example, Babcock & Laschever, 2003.

The following appears in *Journal of Engineering Education* 100, 2: 281-303 (Beddoes & Borrego, 2011). It is reprinted here with permission from ASEE and *JEE*.

Feminist Theory in Three Engineering Education Journals: 1995-2008

Abstract

Background: Women remain underrepresented in engineering despite decades of effort. Feminist theory may explain why some well-intentioned efforts actually reinforce the very conditions they seek to change.

Purpose (Hypothesis): Our purpose is to understand and advance the use of feminist theory in engineering education research towards the goals of increasing gender diversity and equity in engineering. Specifically, we seek to address the following questions: How has feminist theory been engaged within engineering education scholarship? And what opportunities exist for further engagement?

Design/Method: We analyzed articles from *Journal of Engineering Education (JEE), European Journal of Engineering (EJEE),* and *International Journal of Engineering Education (IJEE)* that had women or gender as a central part of their study. Titles, keywords, and abstracts for every article in the journals were reviewed for the years 1995-2008. The 88 articles directly addressing gender or women in engineering were analyzed to determine their level of engagement with feminist theory.

Results: Feminist theory is not widely engaged or systematically developed in this scholarship. Most work rests upon implicitly liberal and standpoint feminist theories, but a minority of articles point to intersectional, interactional, and masculinity studies approaches. We identified several ways in which deeper engagement with a wider range of feminist theories can benefit engineering education scholarship.

Conclusions: Feminist theory is underutilized within engineering education scholarship. Further engagement with, and systematic development of, feminist theory could be one beneficial way to move the field forward.

Keywords: feminist theory, gender, women in engineering

I. Introduction

Despite a 30-year history of initiatives and interventions to recruit and retain female engineering students, women remain a minority in engineering in many parts of the world (J. Gill, R. Sharp, J. E. Mills, & S. Franzway, 2008b), and enrollments of female engineering students in Australia and the US have declined (Grose, 2006; Mills, Ayre, & Gill, 2008). Clearly, current strategies alone are not enough. In this article, we seek to explore how deeper engagement with feminist theory would help to explain the complex problem of underrepresentation and suggest a promising path forward.

Theories which have been used to study women in engineering include self-efficacy, communities of practice and situated cognition/learning, mentoring, career choice, team functions, identity formation, critical cultural theory, cultural capital, and structuralism. Many of these are common throughout the broader engineering education literature. Although such theories are yielding valuable explanations, we argue that explicitly feminist theories are also

needed to illuminate deep-rooted gender issues in engineering education. For example, self-efficacy, as applied to studies of engineering students, acknowledges the experiences of women as worthy of study but risks essentializing these experiences as similar for all women engineering students and risks perpetuating negative views of women as overly sensitive or emotional. Indeed the tendency in prior research has been to "cast women in a deficit role, aggregating them into one category, and viewing them as 'other'…" (Godfrey, 2003, p. 13). Even when authors do not explicitly discuss the feminist theory that informs their work, there can be embedded assumptions and limitations in their approaches that a discussion of feminist theory can help identify and illuminate. As we discuss in the Literature Review, there is evidence of growing interest in integrating feminist perspectives into engineering education, but the use of feminist theory in mainstream engineering education journals is not widespread. It is a problem if the insights feminist theory provides are not making it into the hands of engineering educators who need to understand and internalize them if we ever hope to address the tremendous challenges to diversity and equity in engineering.

Thus, our purpose is to understand and advance the use of feminist theory in engineering education research towards the goals of increasing gender diversity and equity in engineering. Specifically, we seek to address the following questions:

1. How has feminist theory been engaged within engineering education scholarship?
2. What opportunities exist for further engagement with feminist theories?

As a content analysis (or a detailed and systematic examination of texts to identify patterns and themes (Leedy & Ormrod, 2005, p. 142), this paper advances current knowledge on the state of feminist theory in engineering education research; however we also intend for the literature review to contribute an overview of pertinent feminist thought for the broader engineering education community.

This analysis brings together two distinct lines of inquiry within and around the field of engineering education. First, it is a synthesis of relevant literature on women in engineering, comprising both a broader literature review of feminist theory and a systematic analysis of women in engineering articles. Second, it is yet another publication analysis to appear in *Journal of Engineering Education* (Borrego, 2007b; Koro-Ljungberg & Douglas, 2008a; Wankat, 1999; Whitin & Sheppard, 2004) highlighting opportunities to improve the quality of engineering education research through engagement with methods, theory, and literature from social sciences. We note that in analyzing an international sample of 88 articles in three journals over 14 years, we are advancing the rigor of this line of inquiry. Additionally, in providing substantive recommendations for engaging women in engineering literature with feminist theory, we seek to critique and advance that line of research—and ultimately the status of women in engineering as well.

We begin by briefly discussing the use of theory in engineering education, feminist theory in other fields, and features of engineering that pose a challenge to incorporation of feminist theory, based on the histories of other fields. We then discuss five branches of feminist theory that are related to the articles in our dataset: liberal, standpoint, intersectional, interactional, and masculinity studies. Our content analysis methods are presented in detail, followed by results describing the use of the five branches of feminist theory in engineering education articles. We demonstrate, as others have argued (Nelson & Pawley, 2010), that several key branches of feminist thought are underutilized within engineering education scholarship and argue that deeper engagement with a wide range of feminist theories is one way forward for

those concerned with increasing the participation of women in engineering and changing the cultures of engineering education.

II. Literature Review

A. The importance of theory in engineering education research

The importance of theoretically sound and consistent studies is increasingly recognized within education research (Shavelson & Towne, 2002). Theoretically grounded work connects researchers, allows generalizations across studies, and advances the field of engineering education by avoiding re-inventing the wheel. Moreover, as theory is intended to be transferable it is a potentially important link between engineering educators and gender studies scholars, thus promoting interdisciplinary scholarship in the complex research topic of women in engineering. Yet, as Borrego (2007a) and Koro-Ljungberg and Douglas (2008a) have demonstrated, much engineering education scholarship is still characterized by a lack of explicit and consistent theoretical engagement. Specific to research on women in engineering, Jawitz and Case argue that "feminist perspectives have much to offer in providing an explanation of women's experiences in engineering and the resistance of the status quo to substantial change" (2002, p. 390), and Nelson and Pawley recommend the inclusion and testing of more gender theories in engineering education research (2010).

B. Feminist theory in academic disciplines

Many scholars have studied feminist theory's influence on a wide range of other fields and disciplines (Gelsthorpe & Morris, 1988; Hutchings, 2008; Paludi & Steuernagel, 1990; N. Riley, 1999; Schiebinger, 2001; Spender, 1981; Stacey & Thorne, 1985; Stanton & Stewart, 1998; Strathern, 1987). The established line of inquiry on the relationship between feminist theory and disciplinary development can provide a link to complementary perspectives and expertise that inform the present study and may ultimately improve the status of women in engineering. It should be noted that while Women's Studies and Gender Studies can be considered fields in their own right, with established journals, departments, degrees, etc., feminist theory is a collection of thought that encompasses a larger intellectual space, existing inside other fields as well.

C. Specific challenges in engineering (education)

Factors that limit engagement with feminist theory within a discipline have been identified by Stacey & Thorne (1985) and Riley (1999). Post-positivist epistemologies, aversion to social theory, and quantitative research traditions inhibit the reach of feminist theory into a discipline, while interpretive epistemologies, inclination toward social theory, and qualitative research support it (N. Riley, 1999; Stacey & Thorne, 1985). Engineering education has to date been characterized by the former traits (Borrego, 2007a; Douglas, Koro-Ljungberg, & Borrego, 2010b; Koro-Ljungberg & Douglas, 2008a). Moreover, it has been argued that the closer a field is to national interests, the less impact feminist theory will have (Burawoy, 1996), and as engineering is closely aligned with national economic, political, and military interests (Downey & Lucena, 2004; Lucena, 2005; D. Riley, 2008) that proximity is likely another inhibiting factor in engineering education.

On the other hand, there are encouraging signs that some within engineering education are already advocating engagement with feminist theory. In the U.S., for instance, papers and

special sessions at the annual Frontiers in Education (FIE) Conference, as well as recent journal articles on *feminisms in engineering education* and *feminist engineering* are promising (Eschenbach, et al., 2005; Lord, et al., 2005; Lord, et al., 2004; Pawley, et al., 2009; D. Riley, et al., 2007; D. Riley, Pawley, Tucker, & Catalano, 2009; Tucker, et al., 2008; Udén, 2009; Waller, 2005a, 2005b). In fact, the first special session on feminism at FIE in 2004 (Lord, et al., 2004) won the Helen Plants Award for best non-traditional session. In both the US and Australia there are now feminist engineering education research groups (Mills, et al., 2009; Pawley, 2010). And in Europe, the 1st European Conference on Gender and Diversity in Engineering and Science was held in September 2009, with the aim of bringing "arguments from the gender sciences" to an engineering audience (VDI, 2009).

In sum, there are specific characteristics of engineering and engineering education that suggest engagement with feminist theory will pose a challenge. Nonetheless, there are clear signs of interest in engaging engineering educators and engineering education researchers with feminist theory. To help understand and advance these efforts, we describe feminist theories generally and then present empirical analysis of how they have been used in engineering education publications.

D. Five branches of feminist thought

Feminist theory is far from a monolithic enterprise (Flax, 1987). Different branches of feminist theory – which are not mutually exclusive lines of thought, but, rather, are characterized by overlap and interplay—approach and answer questions of gender construction and interactions differently. A summary of the theories discussed in this paper is presented in Table 1. These are by no means the only kinds of feminist thought that exist, nor are they the only ones with the potential to benefit engineering (education); Riley et al., for instance, discuss others (2009). However, we suggest that the theories in Table 1 are currently the most relevant to women in engineering research, as evidenced by their use in the articles in our dataset.

Table 1. Overview of Branches of Feminist Theory Discussed in this Analysis

Branch	**Characteristics**	**Examples**	**References for further reading**
Liberal feminism	Strives for equal treatment, rights, and opportunities for women	Women in engineering initiatives that focus only on women without addressing the biases and limitations of the broader culture	Lorber (2001, pp. 26-44), Tong (2009, pp. 11-47), Zalewski (2000, pp. 5-10)
Standpoint feminism	Because men and women have different experiences in our society, they also have different knowledge and ways of knowing	Studies of women's experiences as legitimate scholarship, not necessarily in contrast to men's	Harding (2001), Hartsock (1997), Lorber (2001, pp. 176-194), McCann & Kim (2003, pp. 292-361), Tanesini (1999, pp. 138-159), Zalewski (2000, pp. 50-54)
Intersectional	Gender must be understood in relation to other identities or hierarchies that form complex intertwinings of identity and oppression	Studies of how engineering experiences are influenced by multiple identities (e.g., race, class, ethnicity, sexual orientation, nationality)	Barkley Brown (1997), Berger & Guidroz (2009), Fenstermaker et al. (1991), Lorber (2001, pp. 195-198), McCann & Kim (2003, pp. 148-277), West & Fenstermaker (1995)
Interactional	Concerned with how gender as a social hierarchy is (re)produced in daily, face to face interactions	Studies of how men's and women's everyday interactions serve to reinforce gender stereotypes	Lloyd (2007), Lorber (2001, pp. 264-265), Zalewski (2000)
Masculinity studies	Stresses the need to focus on men and masculinity, not just women, in order to understand how gender operates	Studies of the ways in which engineering perpetuates a masculine image	Adams & Savran (2002), Connell (2005), Gardiner (2002), Lorber (2001, pp. 163-177)

1. Liberal Feminist Theory

Liberal feminism seeks to ensure the equal rights, opportunities and treatment of women (Lorber, 2001, pp. 26-27; Zalewski, 2000, pp. 5-7). In other words, "first, to make sure the rules of the game are fair, and second, to make certain that none of the runners in the race for society's goods and services is systematically disadvantaged" (Tong, 2009, p. 2). The gendered division of labor, stereotyped jobs, unequal pay, workplace discrimination, and glass ceilings have all been targeted for reform by liberal feminists. The liberal tradition can be traced back to the 19th and 20th centuries in struggles for equal rights, but emerged in the U.S. most strongly in the 1960s and 1970s, while the other branches generally emerged later in the 1980s and 1990s (Lorber, 2001).

Liberal approaches can certainly be valuable; however, scholars should be aware of their limitations, particularly that they do not necessarily deconstruct problematic hierarchical social categories and tends to universalize white, western, middle class women. For example, critics of liberal feminism would contend that Women in Engineering initiatives that focus only on attracting women to (and retaining them in) the current masculine culture of engineering are problematic if they do not address the biases and limitations of that culture. As readers will see, the vast majority of publications in the dataset are (implicitly) in the liberal tradition.

2. Standpoint Feminist Theory

Standpoint feminism takes patriarchy, or the subordination of women by men, as an integral component of Western culture—one that permeates its ideology, values and institutions (Lorber, 2001, pp. 176-194). Because our institutions are patriarchal, then, standpoint feminism is needed as a corrective. The underlying belief is that knowledge is rooted in experience, and because men and women live different experiences, and have different realities, they also have different knowledge and ways of knowing. Standpoint feminism is unique in its explicit ties to science. It maintains that scientific knowledge in a "gender-stratified society" has marginalized women's experiences and has therefore produced knowledge biased by male interests and perspectives. In standpoint theory, women's experiences are "distinctive resources, which are not used by conventional researchers, that enable feminism to produce empirically more accurate descriptions and theoretically richer explanations" (Harding, 2001, p. 145). The key merits of standpoint feminism are ways to name and study aspects of women's experiences that are typically hidden and ignored as legitimate sites of knowledge.

However, standpoint theory has been criticized for its tendency to universalize white, western, middle class women, to essentialize all women, and to omit other identity markers (Lorber, 2001, pp. 184-190; Tanesini, 1999, pp. 144-149). For example, the "experiences of female engineering students" may be presented monolithically, implying that all women experience engineering in the same ways. Another issue that researchers should be aware of is that the problems identified during standpoint research can be perceived as problems with women rather than problems with engineering education (or any other research setting). (Locating the problem with women rather than engineering education often happens in with the liberal approach as well.) The site of reform is then women themselves, with recommendations such as measures to improve self-efficacy, for instance, which is a problem if larger structural and cultural problems are never challenged.

3. Intersectional feminist theory

Some of the potential problems with standpoint theory can be addressed by attention to intersectional gender theories (sometimes called "multicultural"). Intersectional feminism seeks to understand gender in relation to other identities or hierarchies such as race, class, ethnicity, sexual orientation, and nationality that form complex intertwinings of identity and oppression of marginalized groups. According to intersectional thought, gender alone is neither a total identity nor universally experienced. Therefore, it is problematic to talk about women as a universal group because doing so erases the complexities of identity and tends to privilege a dominant group as representative of all women. Intersectional approaches draw on influential bodies on scholarship on Black feminism and Chicana feminism, for example (Berger & Guidroz, 2009; Collins, 1997, 2000; García, 1997; Moraga & Anzaldua, 1983; The Combahee River Collective, 1997). Riley discusses several notable intersectional studies in engineering education (D. Riley, 2008, pp. 84-85). In Science and Technology Studies more specifically, Harding's work on multicultural science is an example of how intersectional approaches reveal otherwise hidden aspects of the ways in which gender biases interact with other cultural biases to shape science (Harding, 2006).

4. Interactional Feminist theory

Interactional feminism is concerned with the processes in everyday life that create and re-create gender. The contribution of theorists such as West, Fenstermaker, Zimmerman, and Butler has been to emphasize the role that daily actions and interpersonal interactions play in gender construction and maintenance (Fenstermaker, et al., 1991; Lloyd, 2007; Lorber, 2001; West & Fenstermaker, 1995). The social construction of gender not only produces the differences between men's and women's characteristics and behavior, it also produces gender inequality by building dominance and subordination into gendered relationships. Interactional theories could point to everyday behaviors and interactions that are problematic and produce new explanations as to *how and why* masculine biases persist in engineering education. Examples of everyday behaviors to pay attention to could include tasks that are split along gender lines in engineering classrooms or labs (e.g., when men work with equipment and women write group reports), and subtle instances of discrimination. One limitation of interactional approaches is that they have the potential to hide larger structural factors, such as those highlighted by masculinity studies.

Interactional feminist theory is an example of post-structural or postmodern theorizing. Postmodern feminisms challenge fixed and binary gender identities and categories. Postmodern feminist theorists like Judith Butler and Joan Scott argue that gender does not exist as any original referent; it exists only in the ways in which society continually (re)produces it, only as a sign. A central feature of postmodern theorizing is that it is anti-foundational and deconstructive (Zalewski, 2000, p. 22). Rather than take certain categories or identities—including gender—as given, postmodernists interrogate those categories and attempt to understand how they are produced and how they acquire values and meanings so that they can be remade or resignified. Much work in masculinity studies is similarly anti-foundational.

5. Masculinity studies

Many gender theorists have highlighted the need to focus on masculinity as a much-needed corrective to the tendency in gender studies to focus on women. Masculinity studies shifts the attention from women to men and recognizes multiple masculinities. However, it is also recognized that masculinity and femininity are co-created so that knowledge about

femininity is also being produced. Scholars discuss multiple masculinities to identify the traits that are most valued by patriarchal society. Like intersectional feminism, masculinity studies recognizes that privilege also accrues along racial, ethnic, class, and sexuality lines. Masculine characteristics of engineering include competitive (as opposed to collaborative) classroom environments and design projects that are decontextualized or have military- or weapons-related applications only. To the extent that masculinity studies approach is concerned with *how* gender is (re)produced, it too can be considered a postmodern approach.

Many of the contributions of STS have been in documenting and elucidating how Western science and technology came to be gendered masculine. STS scholarship focuses on using historical, philosophical, anthropological, and sociological methods to challenge easy and common assumptions about the social neutrality of science and technology. For example, Oldenziel documents the work that went into solidifying engineering and technology as white, middle-class, male enterprises (1999), while Wajcman demonstrates how gendered social relationships both influence and in turn are shaped by the technologies we create (1991). Others also critically examine the connections between masculinity and western science (Bordo, 1987; Haraway, 1989; Harding, 2006; Keller, 1985). Indeed, the usefulness of STS insights is demonstrated by the fact that the articles in our dataset that fall in our masculinity studies category tend to also engage STS scholarship such as the work cited above. Despite these connections, however, STS knowledge has not made wide-spread inroads into engineering education as denials of biases are still the norm (Mills & Gill, 2009; D. Riley, 2008). Engineering educators and the students Mills and Gill surveyed maintained that engineering was gender-neutral. Therefore, research focused on men and masculinity holds much untapped promise for engineering education research agendas. Perhaps the most valuable insight it offers is that we should study how engineering (education) itself gets (re)produced with masculine biases, rather than focusing exclusively on women. Advocates of masculinity studies would also emphasize the need to understand the role that sexual orientation plays in engineering education, which is an area where there is a dearth of scholarship (Cech & Waidzunas, 2009, 2011; D. Riley, 2008) .

III. Methods

A. Data Sources

This study was a content analysis (Leedy & Ormrod, 2005) of publications from three leading English-language engineering education journals: *Journal of Engineering Education (JEE)*, *European Journal of Engineering Education (EJEE)*, and *International Journal of Engineering Education (IJEE)*. For the years 1995-2008, each journal was systematically reviewed to identify articles with a focus on either women or gender. The time frame was selected for practical reasons; it offers a large but manageable number of articles.

Titles, keywords and abstracts for all articles were reviewed and those determined to have women or gender as a central subject—as indicated by the presence of select terms such as *gender, women, female, girl, underrepresentation, minority, diversity, feminine, masculine, recruitment, retention*—were collected and entered into an EndNote database. Some articles that were originally included were later excluded when a full reading of the article revealed that women or gender was not a central focus of the study. For example, we originally included articles with keywords and titles like "minority engineering programs," and

"underrepresentation," but if the body of an article was only about racial or ethnic minorities, it was later excluded. Articles that used gender as a variable and only compared male and female students as one part of a larger study were also excluded (but we note that these would have been classified as liberal feminism). Table 2 lists the resulting number of articles per journal per year.

Table 2. Number of publications on women and/or gender per journal per year

	JEE		*EJEE*		*IJEE*	
Year	#	% of total	#	% of total	#	% of total
1995	5	10.2	0	0	0	0
1996	4	8.5	0	0	0	0
1997	0	0	0	0	0	0
1998	5	7.0	0	0	0	0
1999	2	2.8	0	0	0	0
2000	3	4.8	0	0	2	3.2
2001	3	3.1	0	0	0	0
2002	2	3.4	0	0	10*	11.5
2003	4	10.0	2	6.1	1	0.9
2004	2	6.1	0	0	2	1.7
2005	2	5.7	4*	8.9	3	2.4
2006	3	11.5	5*	9.3	1	0.7
2007	7	25.0	1	1.6	5	3.8
2008	5	14.3	4	7.8	1	0.8

JEE = Journal of Engineering Education
EJEE = European Journal of Engineering Education
IJEE = International Journal of Engineering Education
* Special issue on women or gender

Table 3 presents a summary of the countries and disciplines represented in the dataset. Included in the country and regions counts below are the 7 international collaborations found in the dataset: Finland and the UK; Norway and Sweden; US and Canada; US and Thailand; Palestine and Germany; and US and Germany, with the same collaborators having two articles. Identifying disciplinary affiliations proved challenging given the unequal attention paid to listing them in each journal, the international differences in disciplinary structures and terminology, and the non-standardized ways in which biographies are written across the journals. Within these constraints, we identified as accurately as possible the disciplinary affiliations based upon academic training and current employment. While we acknowledge that authors' current departmental and organizational affiliations cannot be taken as absolute indicators of the disciplinary training they have received, we nonetheless suggest that they still largely correspond to general trends in either STEM (science, technology, engineering, and mathematics) or social science backgrounds.

Table 3. Geographic and disciplinary distribution of publications

Region	# of papers*	Disciplines represented
N. AMERICA	**57**	
US	49	Engineering, Education, Physical sciences/math/statistics, Psychology, Human development, Anthropology, Communication, Computer science, Political science, Sociology, Science and Technology Studies, Women's studies
Canada	8	Engineering, Computer science, Psychology, Sociology
EUROPE	**25**	
UK	6	Engineering, Education, History, Social sciences
Germany	6	Engineering, Computer science, Political science, STS, Sociology, Social sciences
Sweden	3	Engineering, Education
France	2	Anthropology, History/philosophy, Humanities. Social sciences
Netherlands	2	Social science, Ethics
Norway	2	Engineering, Physical science, Education
Denmark	1	Engineering education
Finland	1	Engineering
Greece	1	Engineering
Turkey	1	Engineering, Gender studies, Sociology
AUSTRALASIA	**4**	
Australia	3	Engineering, Economics, Education, Gender studies and Sociology
New Zealand	1	Engineering, Education
MIDDLE EAST	**4**	
Kuwait	2	Engineering, Language science
Israel	1	Physical sciences/math, Education
Palestine	1	Engineering
AFRICA	**2**	
South Africa	2	Philosophy, Education, Physical science, Psychology
ASIA	**2**	
India	1	Engineering
Singapore	1	Physical sciences, Education

*including international collaborations

B. Data Analysis

Qualifying publications from each journal were read in their entirety and analyzed to determine the theoretical framework(s) used by the author(s). Those articles found to engage feminist theoretical frameworks were reviewed in greater detail to ascertain the type of feminist theory engaged, either implicitly or explicitly. One author read each article and determined if it fell within one of our feminist theory categories based upon a) any explicitly stated theoretical framework, b) implicit theoretical foundations, and/or c) direct relevance to one of the branches

of feminist theory. A second author categorized a subset (n = 12), and inconsistencies were discussed until agreement was reached. Since few publications explicitly labeled feminist theories and perspectives, and because of overlap between the branches themselves, some articles were considered to be examples of multiple branches of feminist theory. Disciplinary and geographic affiliations of authors were then compared to determine if any trends or relationships could be identified between the use of different feminist theories and discipline, region, or date of publication, but no trends were found.

During data analysis, we encountered a key tension in our interdisciplinary work. Strict categorization of such a large number of articles is unusual in the feminist literature. Rather, a few specific articles would be used as examples to discuss the current uses of feminist theory in engineering education research. However, norms of engineering education dictate that in order to make credible claims, we must present a rigorous accounting of our categorization results and procedures. Therefore, in the Appendix we list the number of articles we put in each category along with several examples from each category. Problematic aspects of this approach are discussed in the next section.

C. Limitations

We recognize the limitations of our dataset, including that there is much relevant work published in conference proceedings, in non-English language sources, in national and in regional outlets. We maintain that the large timeframe (14 years) of this study as well as the fact that journals represent more significant and long-term work justifies the exclusion of conference proceedings. Although we recognize that engineering education researchers do publish in *Journal of Women and Minorities in Science and Engineering* and other journals focused on women's studies, we chose not to include these journals. First and foremost, we are interested in engineering education specifically (and more generally as an emergent research field) operationally defined as having engineering academics as the primary audience. Our argument is that while feminist thought is being increasingly applied to study engineering settings, these perspectives have not yet penetrated mainstream engineering education discourse.

A related limitation of the dataset is that bounding it necessarily required interpretation regarding which publications to include. Often, this came down to a matter of how the authors themselves chose to frame their article. Because the goal was to look for feminist theory, we could exclude those initial articles that only dealt with comparing men and women as a convenient variable peripheral to the primary research questions.

Next, anyone familiar with the body of literature represented in this dataset or with the intricacies of feminist theories will understand the inherent difficulties of grouping articles into tidy categories as other analyses (e.g., Koro-Ljungberg & Douglas, 2008a) have done. As Koro-Ljungberg and Douglas document, reference lists and literature reviews are insufficient for determining whether or how a study actually engages theory in its process and analysis. Also similar to their study, we found significant differences in the depth and extent of literature reviews, theory, methods, and discussion sections as well as inconsistencies between various sections within a given article. We had a large, unwieldy dataset, the content of which we could not control. Social science necessarily involves ordering the messy and complex and into legible, stable, and understandable boundaries, patterns, and schemes (Bowker & Star, 1999; Law, 2004; Law & Mol, 2002).

Finally, readers should separate the work represented in our dataset from the skills of the researchers themselves or the field as a whole and take it as evidence of what the authors could

successfully publish in engineering education journals. As with any empirical study, we had to define a manageable scope. However, we argue that our dataset is large enough and broad enough to represent trends and opportunities in women in engineering research in engineering education. We hope that the limitations of our study point to fruitful research areas for others. This study is meant to start a conversation, not to finish one.

IV. Findings

A. Liberal Feminist Theory

The majority of articles in our dataset implicitly accept a liberal feminist conceptualization of gender and of women's underrepresentation in engineering, i.e. we can take the categories of men and women as givens, and that we can study women, often by comparison to male students, to better understand their underrepresentation. Yet there is no discussion of liberal feminist theory and no explicit recognition that they are engaging liberal feminist thought. In general, the major concerns of the liberal articles include: comparing differences between men's and women's academic achievements; documenting recruitment and retention rates; describing and assessing an intervention aimed at women; and understanding why women enter and leave engineering programs, including the effects of pre-college preparation and admissions policies.

Within this group of articles, however, the use of theory varies greatly. The studies range from large-scale quantitative work that engages no discernible theory whatsoever, to qualitative work that systematically begins a study with a theory and carries it through the analysis, such as Hutchison-Green et al. (2008).

B. Standpoint Feminist Theory

In our dataset, those that studied women students' experiences and beliefs, thereby asserting women's experiences and perspectives as valuable and worthy of study, suggest recognition of the core tenet of standpoint theory. For example, Foor et al., suggest a standpoint framework:

> As an outsider, she offers a view that can be painful for those inside to hear. According to LeCompte [4], the words of the silenced shine a sometimes unflattering light on existing social and institutional structures and hierarchies of power that are invisible to those in the mainstream. Her voice, and others like her, can be muted by the disenfranchisement that comes from inexperience with the culture of academia (Foor, Walden, & Trytten, 2007, p. 103).

Speaking similarly of her research subjects, Ingram states, "As women, actively engaged in a male-dominated profession for two decades, they have a unique perspective on what barriers as well as opportunities exist for women in this field over time" (Ingram, 2007, p. 954). And Ambrose et al. explain that conversations with women are needed to fill in gaps left by statistics in order to guide actions aimed at retaining more women (Ambrose, Lazarus, & Nair, 1998, p. 363). However, only McLoughlin explicitly discusses standpoint theory as part of the methodology itself and explains its importance (McLoughlin, 2005).

These studies are cited as examples that explicitly explain researchers' choices to listen to women's voices. It could be argued that any of the studies that aim to understand women's

experiences engage standpoint feminism to some extent. Yet the theoretical and methodological differences between the articles in this category are significant, and they mean that the extent to which they capture women's voices and unique experiences varies greatly. We were uncomfortable with demarcating this category too narrowly, for reasons discussed below, but feel it is important to note that there is a broad spectrum represented here, with work such as McLoughlin's at one end and quantitative surveys at the other. McLoughlin's paper demonstrates that such an approach is useful in obtaining insights not gained when research begins with too many assumptions about women's experiences or needs. A distinguishing characteristic of standpoint theories is that women's experiences should be the starting point for future research agendas. Harding explains that,

> For a position to count as a standpoint…we must insist on an objective location – women's lives - as the place from which feminist research should begin…*But it is not the experiences or the speech that provide the grounds for feminist claims; it is rather the subsequently articulated observations of and theory about the rest of nature and social relations* – observations and theory that start out from, that look at the world from the perspective of, women's lives (Harding, 2001, p. 147) (italics added).

Therefore, a measure of the value of using standpoint theory can be the extent to which the findings then are used to challenge existing power relations and guide future research. Because studying standpoints largely involves interpretation and intention, we felt the need to be most inclusive with this category.

C. Intersectional Feminist Theory

Articles in this category are characterized by having an underlying intersectional approach to their study, by presenting intersectional statistics, or by discussing the importance of intersectional studies even if they themselves did not conduct one. Foor et al. conducted an in-depth interview with a "multiminority" student to explore the relationship between her socioeconomic and racial/ethnic heritage and her experiences as a female engineering student. The authors argue that educational institutions are a "major force in the construction and transmission of gender, race, and class" (Foor, et al., 2007, p. 104). Repeatedly, they emphasize that engineering is not dominated only by men, but by white, western, middle class men. They recognize that their interviewee foregrounds her identity in her racial heritage rather than her gender. Similarly, Trenor et al. explored the relationship between female students' ethnicity and their perceptions and experiences in engineering to investigate relations between environmental, behavioral and cognitive variables and characteristics such as race and gender (Trenor, Yu, Waight, Zerda, & Sha, 2008). Varma and Hahn, in both of their articles (2007, 2008), also address the lack of studies on women from diverse racial and ethnic backgrounds in engineering education, noting a common problematic assumption that, "what applies to white women…also applies to minority women" (2007, p. 361). To fill this gap in knowledge, they conducted interviews with computer science and computer engineering students at seven minority serving institutions. Gallaher and Pearson considered ethnicity differences as one variable in their survey of women's perceptions' of engineering technology programs (2000).

These intersectional articles represent an important contribution to engineering education by highlighting the need to study gender in connection with other identity markers and the limitations of universalizing "female students." Yet further grounding the work in intersectional

feminist theory could illuminate and extend the existing and future studies by explaining other aspects of the data, contributing new research questions and interventions, and calling attention to previously unexplored aspects of the relationship between gender – as a hierarchical social construct— and other facets of identity and engineering.

D. Interactional Feminist Theory

Articles in this category involved researchers studying –and more specifically, *observing* – the (inter)actions of men and women. Perhaps not surprisingly, given that much work has documented the masculine culture of engineering (education), we observed that the interactional studies could also be considered masculinity studies because they are concerned with exploring how masculinity is (re)produced in the cultures of engineering education. Laeser et al. observed a semester-long design course and studied how gender composition of teams affected the quality of work and the team members' interactions. They conclude that one implication of their findings,

…is that engineering educators may not be able to rely upon the general research that has been completed concerning gender interactions to inform their classroom decision making with respect to teamwork. Instead, research that specifically targets the interactions of male and female engineering students is needed (Laeser, Moskal, Knecht, & Lasich, 2003).

Similarly, Du analyzed constructions of identity in male and female students and states that, "This study sees the construction of masculinity and femininity as a negotiation of gendered meaning through interaction in a social context" (2006, p. 40). And Ingram explicitly uses interactional theory as one of her frameworks in her analysis of women engineers' careers across three decades and emphasizes the need to understand gender as a system of relations of power (2006).

Tonso recognized that there is a research gap in engineering education that interactional studies can fill, stating that, "the ways that a 'masculine' discipline is created or maintained in the everyday, face-to-face interactions and activities of undergraduate engineering education are not well understood" (Tonso, 1996a, p. 217). Like Laeser and colleagues, she observed teams in a design course and produced three articles based on her ethnographic observations. She grounds her 2006 article in a "situated learning perspective" that allows her to explore how gendered identities emerge as "hierarchical power relations" or things that are produced, not just property of individuals. She explains that, "trying to understand why some teams work and others don't requires understanding power relations among men in engineering, as well as those between women and men…Similarly, women's circumstances could not be explained merely by the fact that they were women…" (K. L. Tonso, 2006, p. 34). Rather, their (inter)actions can be understood in the context of the larger campus culture and as inherently tied to power differentials in that culture. And she goes on to conclude that in engineering education "face-to-face interactions are rarely studied in enough detail to provide explanatory power" and recommends there is much to be gained from collaborating with social scientists who are trained ethnographers (K. L. Tonso, 2006, p. 35). Importantly, both Ingram and Tonso link individuals' actions back to structures and forces in the broader cultural context.

E. Masculinity Studies

The articles in this category are characterized most notably by explicit discussion of

masculinity or by a concern with exploring the process of *how* masculinities are constructed and maintained. Articles that simply noted the existence of a masculine engineering culture in passing, however, were not included. Godfroy-Genin & Pinault studied images of masculinity and femininity as part of the European WOMENG project (2006). Sagebiel and Dahmen studied femininity and masculinity in organizational cultures in Europe (2006). Du examined the ways in which engineering identity formation is different for female and male students owing to various ways in which engineering is masculine (2006). Similarly, Phipps states of her work,

> My analysis is also informed by the postmodernist reluctance to view any cultural product as a natural phenomenon, and posits that instead of defining engineering practices and institutions as essentially male, an investigation of the field's masculine exterior may be more pertinent in terms of the underrepresentation of female practitioners (2002, p. 409).

She explores how the *image* of engineering is gendered. Stonyer uses a post-structural discursive theory to identify dominant engineering discourses and to explain the ways in which they contribute to the creation of gendered identities in which masculinity and femininity always exist as a binary relationship (2002). Zengin-Arslan examines the differences between engineering subfields' masculinity and femininity and their relative appeal to female students (2002). Employing Cockburn (1988) and Wajcman's (1991) work on the interrelationship of masculinity and technology, her article demonstrates the importance of examining constructions of femininity and masculinity to understand why female students have higher representation in some engineering fields than others. Tonso's discourse analysis also focuses on how masculine facets of engineering education such as weed-out "ordeals," sexual humor, and violent metaphors are part of how one learns to become an engineer (Tonso, 1996a). The articles in this category demonstrate that masculinity studies can benefit engineering education by highlighting engineering education itself as problematic and in need of change, thus potentially enabling broader cultural shifts that many of the authors advocate.

V. Discussion

We analyzed 88 articles in three journals over 14 years, but we found no systematic or consistent development of feminist theory within any of the three journals. Of the minority of articles that use any theoretical framework at all, even fewer actively engage with feminist theory in their methods or discussions.

Research on other disciplines provides insights that can help us understand the lack of engagement with feminist theory in engineering education. Most disciplines begin (and often end) their relationship with feminist theory by recognizing that women are traditionally ignored within the discipline. Adhering to traditional scientific norms, scholars then attempt to correct this omission (and eliminate prejudice or bias) by bringing women into their studies (Harding, 1991; N. Riley, 1999). A multitude of criticisms have been levied against this practice, labeled *feminist empiricism*, which, to a large extent, aligns with liberal feminist approaches. Nancy Riley explains that as a research approach, feminist empiricism treats gender as a binary characteristic of individuals and, thus, assumes that we can learn about gender through the beliefs and behaviors of individuals separately from the context. Our study supports prior work asserting that most women in engineering research is in this vein (Godfrey, 2003; Pawley, 2007; D. Riley, et al., 2009). Riley argues further that gender can only be understood as part of

institutions and power (N. Riley, 1999). According to some scholars, working at a higher theoretical level means recognizing gender as a complex and fluid social construct and an organizational principle of society (Hutchings, 2008; N. Riley, 1999). They maintain that gender is not a simple male/female binary, but rather constructed categories whose values and meanings are shaped by societal norms, the study of which is facilitated through theory. And yet, as science studies scholar Bartsch reflects,

> I have come to discover that it is not unusual for people to simplify issues of "feminism in science" to those of "women in science." It is far less difficult to understand the factors that have limited women's accomplishments in the sciences than it is to engage in the cultural deconstruction of science that feminism demands (Bartsch, 2001, p. 30).

The ways in which engineering strives to be scientific, objective, and quantitative resist discussion and deconstruction of power and politics that are inherently part of feminist theory and gender studies. Feminist scholars argue that to have any hope of improving the situation, it is better to acknowledge and explore political dimensions of research on gender than to feign objectivity (N. Riley, 1999). As Ingram states in her study of women engineers, "An understanding of a culture…is incomplete without a corresponding knowledge of the relations of power which provide its foundation. Thus, in describing a culture's values, norms and styles of discourse, one must also examine how it is a function of larger relations of domination" (Ingram, 2006, p. 291). The disconnect – between common myths about engineering's neutrality and the critical essence of feminist theory - could cause tension between those who see issues of power as relevant for gender research (and thus engineering education research), and those who do not.

Additionally, in some journals and conferences, research on women in engineering tends to be confined. Nearly one-quarter of the articles we analyzed (22%, 19 of 88) appeared in special issues of *IJEE* and *EJEE.* Special issues could be viewed as a promising sign of progress; however, they also evidence a trend of marginalization, rather than integration into mainstream engineering education literature. Such isolation may be problematic if it perpetuates the notion that gender studies are only for women, or that they are not an important part of the field as a whole. Similarly, research on women and gender is most often confined to special sessions at engineering education conferences as well. We made a conscious decision to focus on engineering education journals with engineering academic staff (faculty members) as their primary audience to draw attention to these issues.

It is understandable that much of the engineering education research on women implicitly supports a liberal feminist stance. The liberal work can be an important first step to identifying the problem and creating a sense of urgency around it. There is much complexity and subtlety embedded in the liberal work that we do not mean to minimize. The use of feminist theory can help to both identify specific actions and attitudes that perpetuate inequalities and therefore need to change, as well as link specific details to broad trends in society and social systems of which engineering is just a part. Women in engineering researchers should be aware of the feminist stance they take, even when they do not explicitly name one. Without this awareness, they risk perpetuating the very conditions they seek to change.

VI. Implications for Future Research

Based upon our findings, we can put forth several recommendations for the development of feminist theory in engineering education research. First, collaboration with researchers formally trained in women's studies, STS, anthropology, and related social sciences provides

easier access to these literatures, perspectives, and methodologies. In this data set, there is a strong connection between interdisciplinarity and engagement with theory. Articles that engaged feminist theory outside of the liberal tradition (implicitly or explicitly) and/or engaged STS tended to have one or more authors who were trained in fields other than engineering. (This includes individual authors with degrees in both engineering and another field.) Access to relevant theories is one very direct benefit of interdisciplinary collaboration more broadly advocated for engineering education research (Borrego, Beddoes, & Jesiek, 2009).

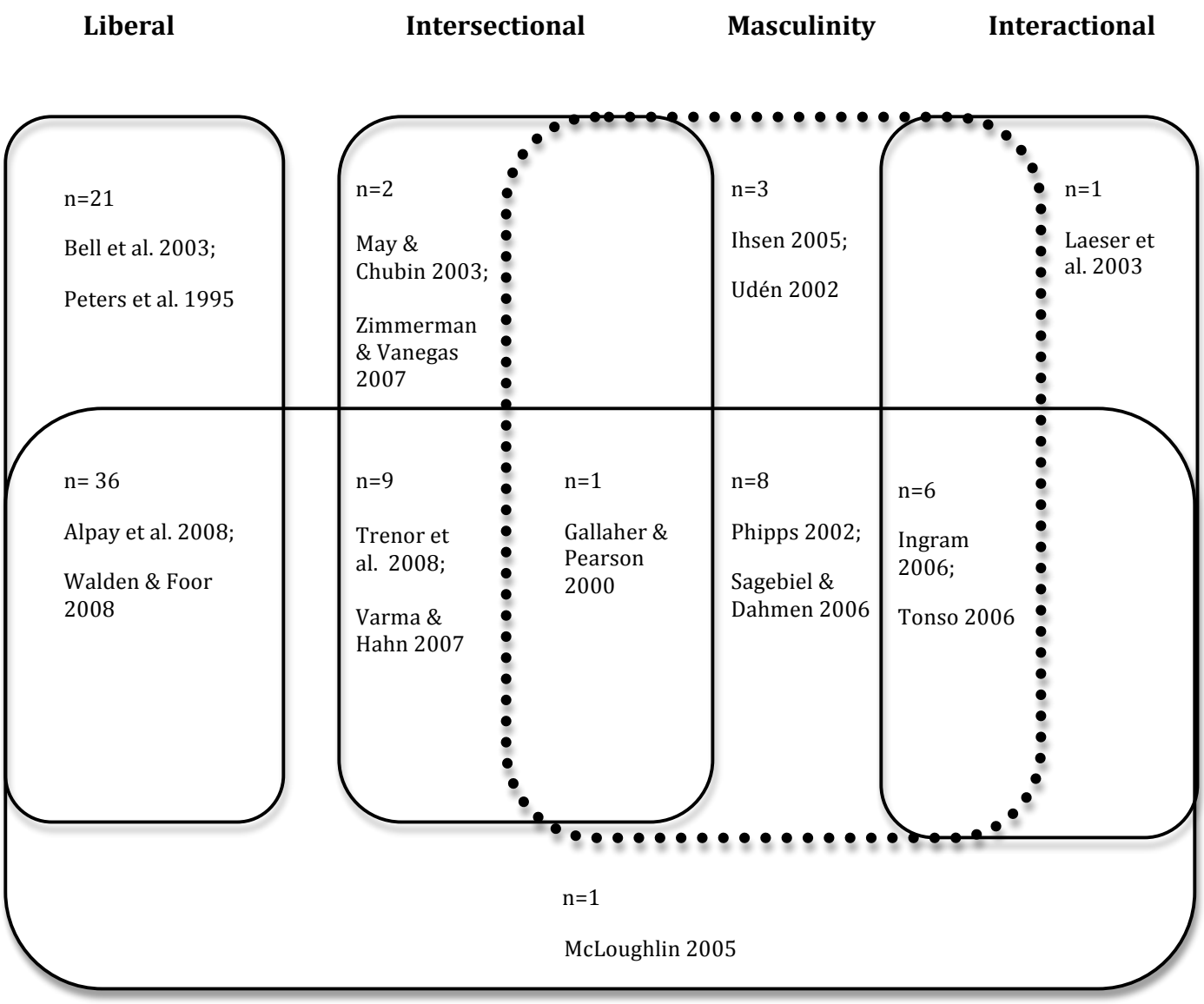
Second, feminist theory can be combined with learning-related theories to deepen understanding. As noted, one of the strengths of feminist theory is that it works alongside and through other theoretical frameworks, and thus, can be used to extend those other frameworks. For example, identity is often used in engineering education to study students' development of identity as (future) engineers. Interactional, intersectional, and masculinity studies feminist theories could all be used to better understand the processes of identity formation that occur in engineering education. Du's (2006) and Tonso's (Tonso, 1996b; K. L. Tonso, 2006) articles are examples of how feminist theory can work through identity theory. Similarly, teams research is often applied in engineering education to understand which combinations of personalities, work styles, and roles (including training students in these categorizations) impact learning and team productivity. Feminist theories such as masculinity studies and interactional perspectives can help explain how and why team roles aligned to gender lines are perpetuated in engineering student teams.

Ultimately, we advocate for variety among the use of feminist thought in engineering education. However, we note an abundance of articles in the liberal feminist tradition and argue that the research area is sufficiently developed to warrant more sophisticated engagement with other branches. There is much rhetoric and some practical efforts around marketing engineering as an exciting career that helps people (e.g., Committee on Public Understanding of Engineering Messages, 2008). These efforts may be seen as an initial step to acknowledging and deconstructing the masculine image of engineering and the gender roles it perpetuates. Jawitz and Case argue that, "Instead of the traditional activities which try to persuade women that they should try engineering and then help them fit into the culture,…we need to create a new engineering culture" (Jawitz & Case, 2002, p. 390). In other words, the time has come to thoroughly examine and deconstruct how cultures of engineering education both reinforce masculine biases and (re)produce gendered identities. As we have tried to show in this article, the research frontiers opened by feminist theory can help us understand many aspects of engineering education and suggest new approaches to increasing diversity.

VII. Acknowledgements

We would like to thank Matthew Goodrum and Cora Olson for the supportive feedback they provided on previous drafts of this paper, as well as our anonymous reviewers for their enthusiasm and suggestions. We also greatly appreciate the feedback and support provided by Brent Jesiek during the process.

Appendix: Categorization of dataset with examples



Chapter 3 - Problematizations of Underrepresentation for *International Journal of Engineering Education*

I. Overview

The article that appears in this chapter was published in the *International Journal of Engineering Education* (*IJEE*) in October 2011. It analyzes recent engineering education scholarship to identify the reasons given to explain why underrepresentation is a problem, in other words, using Foucault's terminology, how underrepresentation is problematized in this body of literature. The aim was to bring insights from STS literature into engineering education discussions of women's underrepresentation to advance those discussions beyond economic competitiveness and essentialist arguments, demonstrating that the framing of the problem affects how people go about solving it and that this is important because despite decades of efforts, underrepresentation persists. In other words, it aims to name and unpack stories around the question of why underrepresentation is a problem, thus offering them up for much needed, yet largely absent, discussion and analysis within the engineering education community. The article begins by introducing this type of discourse analysis as an established theoretical framework in other fields and citing the persistence of underrepresentation as evidence of the need to critically reflect on how the problem is framed. Next, the *Theoretical Perspective* section explains the concept of discourse analysis I am using. The three-part literature review then: identifies examples of discourse analysis in EER on women and gender; summarizes prior studies of problematizations of underrepresentation in STS, business, and EER; and identifies common problematizations or themes that emerge from those studies and explains existing critiques of those problematizations. The common problematizations identified are: economic competitiveness, benefits to a field's contents and practices, and social justice and equality. After describing the Methods, the Findings are laid out in four subsections, one for each of the problematization categories I identified in the dataset. They are: economic competitiveness, professional service and representativeness, women's attributes, and social justice Each of these categories is mapped onto one of the common problematizations identified in the Literature Review. Next, the Discussion section reminds readers of the limitations of each problematization, which had been explained in the Literature Review, and lays out several reasons why further reflection and discussion of the topic of problematization is warranted. The Conclusion is a very short summary of the findings.

Preparing this article included a process similar to the first article in which I submitted several drafts to Maura until she thought it was ready for an engineering education audience. She was less familiar with this journal than with *JEE*, and referred me back to other articles on gender that had been published in *IJEE* to obtain a better sense for the tone, framing, and level of detail of those articles. Because I had already learned a lot about what was expected from the first article, as well as from other engineering education research I had done in the mean time, the process was much shorter and required fewer changes this time around.

During the writing and revision of the first article, I had learned that brokering for the *Journal of Engineering Education* required making the tone and level of analysis appropriate for the journal, adhering to the field's standard organizational structure for articles, putting forth specific recommendations or implications for practice, and ensuring that my methods met the level of "rigor." However, as discussed, these practices were challenging owing to the lack of consensus among reviewers and an Associate Editor, and to differences between norms of women's studies/STS and engineering education. Writing the second article further solidified the importance of most of these practices, but it also revealed new practices and suggested that the choice of journal influences the extent to which some practices were required. Again, by "required" I mean what was necessary to get the paper to a point where my advisor, a successful faculty member at the core of engineering education, thought it was ready for an engineering education journal. As with the first article, I wanted this article to be of interest and use to different stakeholders and any reader, not only those working in the gender sphere.

II. Selecting a Journal and Preparing to Submit

One important aspect of developing this article was selecting the best journal in which I could discuss STS literature to the extent needed and felt free to extend the discussion or raise issues beyond what directly pertained to the data, as is more common in STS but not always accepted in engineering education. For example, I wanted to discuss how my study related to the boundaries of engineering education curriculum and the importance of reflexivity, even though these things were not strictly a part of the research questions or data. In contrast to STS writing, engineering education articles are more confined to discussing only points that were revealed by the findings. The *Journal of Engineering Education* was ruled out because we believed that the methodological (e.g. strict categorization and quantification of the dataset) and analytical (e.g. expectation to limit discussion to data) norms of that journal would be too confining for the type of article I wanted to write.[34] After the first article's review process, I was also not optimistic about the prospects of submitting this article there. The *European Journal of Engineering Education* (*EJEE*) was considered, but ultimately ruled out for length concerns because they have a 4000-word limit. There was also a concern that the most likely Associate Editor had literature in the dataset of this article. There is also an *Australasian Journal of Engineering Education* (*AJEE*), but at that point it was not being published regularly or was only publishing a few articles a year, and it is less widely read outside of Australia than *IJEE*.[35] *IJEE* therefore seemed like the best fit. There is precedent for publishing articles most similar to mine in that journal. The only other critical discourse analysis I have seen in the engineering education journals was published in *IJEE* in 2002 (Stonyer, 2002). It is a (self-labeled) post-structural study that identifies three common discourses about what engineering is or should be (scientific, managerial, and liberal education discourses) and uses those discourses to discuss engineering student identities. Moreover, that article was part of a special issue on gender in which the guest editors asserted the need to move beyond statistical analyses of underrepresentation and descriptions of initiatives, to advance the status quo of EER on women and gender in

[34] See Conclusion for a discussion of an issue previously raised in science education literature. Scholars in that field have asserted that it is a problem that some journals are (or are perceived to be) gatekeepers and others advance the frontiers of what is accepted scholarship, particularly when those types of journals do not cite the other, or are not in conversation with one another. In other work in progress, Brent Jesiek and I are exploring the question of citation among engineering education journals vis-à-vis scholarship on diversity.

[35] http://aaee.com.au/

engineering, and more deeply engage feminist theory and new perspectives on underrepresentation. I mentioned both of these points in my cover letter to the Editor. Additionally, *IJEE* does not have length limits.

Under different circumstances, I certainly could have considered other gender and science or gender and education journals such as the *Journal of Women and Minorities in Science and Engineering* (*JWMSE*); however because the focus of my dissertation is brokering between STS and engineering education, it was important to select an engineering education journal. This is true for my third article, discussed in Chapter 4, as well. Additionally, it is worth noting here that the availability of such journals, also including *Gender and Education*, *The International Journal of Gender, Science, and Technology*, and now *Engineering Studies*, for instance, has an effect on what ends up in engineering education journals, as my interview participants discussed. They have many options that are perceived to be more open to greater engagement with feminist theory, so often do not even try to get that work published in engineering education journals.[36]

Another new requirement for this article was that I had to establish up front that problematization was a legitimate topic of academic study – in any field, not even EER specifically. Because studies such as mine are very uncommon (I found only one publication on the topic and it was a non-empirical conference paper: Pfatteicher & Tongue, 2002) in the engineering education literature, and many in that community would not think that the way underrepresentation is framed is something one can study, it was important to frame the Introduction to establish that problematization of underrepresentation was a real thing that real academics in other fields actually do study. As Maura explained to me,

> There are all kinds of ways you are talking about the problem and your analysis of it that readers may not be equipped or prepared to deal with. The very idea that economic competitiveness arguments are socially constructed and not completely factually unbiased can be scandalous! It is absolutely imperative you decide who your audience is before you proceed. Is it engineers (IJEE, etc.)? Your approach is very similar to the previous paper on feminist theory, and many of the same changes would need to be made.

Secondly, as with the *JEE* article, this article required translating STS concepts – and the language used to convey them – into more accessible terms or explaining what taken for granted terms meant, and adding illustrative examples for uncommon ideas. It is important to note here again the importance of working with someone from engineering education without a background in STS because Maura was able point out ideas and terms that were unclear or assumptions and leaps I had made that I could not recognize on my own. "Problematization" needed to be carefully explained, for instance. "Discourse" also needed to be carefully explained, because, as Maura's comment above indicates, the concept – and particularly this post-structural version of it - is not common in engineering education. A case where an illustrative example was needed was after this quote from Hall. Thus the final version said that discourse:

[36] Standards such as double-blind review, a topic mentioned earlier, also affected participants' decisions over where to submit their work. It is also worth noting here that in its first years of publication, *Engineering Studies* published a greater percentage of gender-related articles than is typical of engineering education journals. In ongoing work, some of which has been published (Ihsen et al., 2010), Brent Jesiek and colleagues found that in 2009 the percentage of papers that engaged gender themes in *Engineering Studies* was 45.5%, and for 2009 and 2010 together it was 29%. Engineering education journals, on the other hand, averaged 10% or less for 2005-2009.

> …governs the way a topic can be meaningfully talked about and reasoned about. It also influences how ideas are put into practice and used to regulate the conduct of others. Just as a discourse 'rules in' certain ways of talking about a topic…so also, by definition, it 'rules out', limits or restricts other ways of talking, of conducting ourselves in relation to the topic or constructing knowledge about it [28, p.72].
>
> For example, if it is thought that more women are not attracted to engineering because they simply are not aware of it or because they do not know what work engineers do, then efforts will of course focus on outreach and informing girls and women of the opportunities engineering careers offer them. However, by thinking about the problem in this way, the field itself is unexamined and unchanged because discourses that locate the causes as masculine biases within engineering itself are not considered.

I believe the challenge in introducing and explaining these concepts lies in the fact that they are about raising issues and questions and pointing out problems, not necessarily identifying solutions, which as discussed, is more in line with expectations in engineering education.

Third, as with the JEE paper, this article needed to be about more than just critiquing the dataset: it needed to have reconstructive aims. As Maura said, it should not be "critique for critiques sake." Consequently, I tried to use the Literature Review and Discussion sections to explain why problematization mattered and make one overarching argument – or recommendation – for the article. I was not recommending any one problematization over another, but rather a more general suggestion that this was important and should be taken more seriously than it currently is.

Related to the aim of reconstruction, there were issues similar to the tone of the *JEE* article. I needed to make it more constructive and remember that my readers would be those I was discussing. So, when I wrote in a draft, "Those concerned with this issue do not have the luxury of not thinking deeply about how they problematize the issue and what the long-term effects of their rhetoric will be," Maura commented that it was "written more critically of your authors than speaking to them – who is your audience?"

Finally, the organizational structure was important. In an early draft I had a lot of the discussion of critiques of the various discourse in the Discussion section and the Literature Review sections did not map neatly on to the Findings and Discussion sections. As noted in the prior chapter, there is a standard organization for engineering education articles, unlike women's studies and STS literature. On top of that, there is more of an expectation that subsections of the Literature Review and Findings and Discussion map directly on to one another. Maura thought the paper would be more readable and clearer if I could systematically map Literature Review (sub)sections on to my Findings and Discussion.

I submitted the article in January 2011.

III. The First - And Only - Set of Revisions

I received a minor revision acceptance letter in May 2011. The article had two reviews, both of which were quite positive. One reviewer commented on the importance of the paper in bringing

these discussions out in a formal venue. The comments provide insight into the current state of EER on women and gender and what reviewers found of value in the article:

> Paper is innovative in drawing out in detail, with evidence from the literature, how underrepresentation is problematized in engineering. While the casual and anecdotal observation that this is so has been around in conversation with many peers for some time now, no one to my knowledge has yet done the work to formalize the argument and disseminate these ideas to a wider audience. While the methodology of literature review and meta-analysis is not particularly novel, the addition of discourse analysis with a grounding in feminist theory is quite original and still rare in engineering education.

The suggestion that formalizing this argument and introducing it to a wider audience outside of a small group of feminist engineering educators highlights one way in which brokering can benefit a field. By bringing in discourse analysis as a theoretical frame to argue that the topic can be analyzed, it opens up for analysis a topic that had largely not been discussed in print because it did not fit into the field's norms. The significance of formalizing it is that it has potential to advance the discussions among a wider audience than a small group who happen to discuss these issues informally.

One reviewer took issue with the way that I had conflated social justice and equality, eliding differences between them, namely that "equal treatment is not necessarily just treatment." I had done this because that level of discussion had not seemed necessary to me and because the authors themselves are never clear what they mean by those terms. But I revised the relevant subsection headings from *Social Justice* to *Social Justice and Equality* to emphasize the distinction. I also added text to explain why they had been included in the same section despite their differences.

Another concern was that I had made assertions without evidence, although no specific examples were pointed to. I interpret this to be related a point mentioned earlier – that I wanted to be able to raise points and questions beyond the scope of my research questions and data. I handled the reviewer's concern by adding references in some cases, deleting text in others, and explaining why I believed that now that many of the points were in the Discussion section they were appropriate and framed as questions or points of discussion, not assertions.

Aside from such content and theoretical issues, both reviewers requested the addition of tables to clarify and summarize the literature review and findings. This may seem trivial, but I have found that the issue of tables has revealed a difficulty of brokering. In engineering education articles it is often expected that you summarize your key points or findings in table form. In fact, as seen in the Appendix, review criteria for engineering education journals often explicitly mention tables and figures. Reviewers of my *JEE* article also requested the addition of tables. I raise this point not because that simple difference is interesting in and of itself, but because of the reactions I have received when I have tried to bring that norm, which I find quite helpful usually, back into STS. Two times I have suggested that an STS person or an historian of engineering should add a table to increase the readability of their paper. One time the suggestion met with dismissal and scorn – as if it were ridiculous and below an STS scholar to do that. The other time, it was met with confusion and doubt about why such a thing would be at all helpful, because everything in the table was already in the article. Obviously it does not feel good to have colleagues in one field doubt your intelligence for suggesting something that is normal in another field. Wenger

has identified some emotional or psychological difficulties that befall brokers. I provide this as one specific example of what happened when I tried to take something from engineering education back into STS.

I submitted the revision in June 2011, and received proofs in July 2011. I do not know if the revision was sent back to reviewers to approve or if an editor reviewed it without sending it back to reviewers. Like *JEE*, *IJEE* has page charges ($65 per page). I requested a waiver based on the fact that I was a graduate student, with no faculty co-author, who had not received any funding to do this work, and the journal agreed to waive the charge.

While it is likely not news to those working in engineering education research that the review process for *IJEE* was less onerous than that of *JEE*, my experiences do raise questions, as has been discussed in science education, about what is good EER and what the role of journals should be in the development of the field. This is discussed further in the Conclusion. One important point to consider along with this analysis of my experiences is that *IJEE* publishes many more articles per year than does *JEE*. In recent years *IJEE* has published approximately 120-150 articles per year while *JEE* has only published approximately 24-36 articles. This difference likely contributes to the higher level of "gatekeeping" done by *JEE*.

IV. Reinforced Categories of Brokering Practices with New Considerations

The practices of brokering for this article can fit into the same broad categories that emerged from the first article. However, within those categories there were several new practices as well as some that were not as important for *IJEE* as they were for *JEE*. Each of these is discussed in turn below, revealing points of difference within the field of engineering education.

This time, aligning with current conversations had to begin by establishing problematization and discourse analysis as legitimate academic approaches, because many in EER would not have been exposed to them before. It also meant formalizing something that was already being discussed informally, but had not yet been analyzed formally in a publication. I was able to do this by employing the theoretical lens of discourse analysis. Selecting the right journal was again important, and, as discussed, *IJEE* was selected for the freedom and breadth of discussion I believed it would allow, and because I believed there would be less of a hyper-focus on methods, among other things. These features of *IJEE* proved important for the other two categories of brokering practices.

Identifying differences between audiences again meant attempting to make the article's concepts, terms, and tone appropriate and accessible. However, because there was some precedent in *IJEE* for poststructural discourse analysis and for advocating pushing the boundaries of existing scholarship, I felt more freedom. Nonetheless, I still tried to explain what would likely be new concepts for most readers, not use unnecessary jargon, and maintain a tone that would not come across as too critical. As with the first article, differences between reviewers surfaced in terms of what was appropriate and accessible, although to a much lesser extent. The fact that one reviewer wanted me to draw out the distinction between equality and social justice reinforced the finding that determining what is appropriate and accessible is difficult in an emerging field with scholars with very diverse backgrounds and knowledge of gender issues. I had chosen to simplify something that the reviewer thought was important not to simplify.

Adhering to norms and expectations again meant sticking to the typical layout, making recommendations for reconstruction, and meeting criteria for methods. However, the latter two were less important this time. No quantification of my data was required and no *implications for practice* section was needed. The reconstructive aim was met by suggesting reasons why further exploration of this topic was important for moving beyond current conversations, and reviewers were satisfied with my methods when I added a table presenting the types of terms I had included in each category. Thus, *JEE*'s hyper-focus on rigorous methods or quantifying data does not seem to characterize all outlets in engineering education. As discussed in Chapter 2, the journals' differing review criteria vaguely suggest such differences between the journals.

This more positive and less difficult experience with *IJEE* increased my confidence in the brokering practices that I had employed, and therefore they made writing my third article relatively easy compared to the first two.

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Engineering Education Discourses on Underrepresentation:

Why Problematization Matters

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Abstract: Despite decades of research on and efforts to increase the low numbers of women in engineering in many parts of the world, underrepresentation persists. This paper analyzes recent engineering education scholarship to determine what reasons are given to explain why underrepresentation is a problem, in other words, how underrepresentation is problematized. Using discourse analysis as the theoretical lens, and drawing on prior research that employed similar methods and theoretical perspectives, this paper examines an international dataset of engineering education journal articles and conference proceedings from 1995-2008. Four categories of problematizations are identified and discussed in order to advance critical reflection that could be beneficial in moving discussions about underrepresentation forward.

1. Introduction

In 1952, an article in the *Journal of Engineering Education* stated,

> Since it seems the shortage of engineers may jeopardize our national welfare, the next question is what we can do about it…Women have certain inherent characteristics which stand them in good stead. For instance, they are conscientious, they know how to use their hands, they are careful about detail, and quite important, they are not adverse to

> trying something new. Witness, for example, their proclivity to change the furniture around in the house about every three days to see if they can find a more efficient arrangement [1, p.174-75].

In 2006, an article in the *European Journal of Engineering Education* stated,

> Diversity is an important issue in globalization and competitiveness of institutions and corporate entities... Women need to love their work and be 'crusaders', meaning they need to have dedication, courage and drive. If those traits are combined with female qualities of intuitiveness, flexibility and people skills this obviously brings great value to the profession. … Women are physically different, think differently and can be more emotional. Hence they contribute another dimension to the male workforce [2, p.661, 63, 67].

These quotations, published over 50 years apart, reveal both a long-standing interest in recruiting more women into engineering as well as a long history of explanations as to how engineering will benefit from their presence. The quotations are striking both for their similarities as well as for the different traits they ascribe to women. The aim of this paper is to explore the current ways in which women's underrepresentation in engineering is framed in engineering education research and to suggest that the persistence of underrepresentation, despite decades of attention, may be related to those framings and how they are articulated.

There is now a large body of international literature documenting women's underrepresentation in engineering in many, but not all, parts of the world [3-9] and proposing a broad range of explanations for and solutions to it. Moreover, increasing diversity within engineering has been cited as one of the major drivers behind the growing international interest in engineering education research [10]. However, despite the fact that concerns about women's underrepresentation in engineering are shared among a group of engineering educators around the globe - and have been discussed for decades - the extent to which their concerns are shared by the engineering education community as a whole is unknown, and there are indications that recognition of and interest in underrepresentation and gender biases in the field are not widespread and are considered to be outside of the real concerns of engineering [4, 11-13]. Therefore, a critical look at the arguments being put forth to explain why underrepresentation is a problem is warranted.

Within this literature on underrepresentation, some authors have demonstrated how engineering and engineering education are socially constructed enterprises. As such, post-structural feminist and discourse analysis approaches can provide insights about their construction [14, 15]. These approaches hold that engineering is situated in certain historical, social, political, and cultural milieu—which vary over space and time—and that this milieu, which includes beliefs about gender, affects how engineering is conceptualized and discussed. These conceptualizations and discussions of the field in turn affect how underrepresentation is conceptualized and discussed. Building on their approaches, as well as other work discussed below, this paper identifies and analyzes the varieties of justifications given for needing to increase women's participation in engineering. Understanding the justifications as discursive formations will shed light on their historical construction and allow for critical examination. One benefit of discourse analysis is that it opens up for discussion topics that were previously understood as unquestionable facts not worthy of academic study. So, although it has not yet been common in engineering education

research to theorize about how underrepresentation is framed, such theorizing has been established in Science and Technology Studies and the field of business [16-18], and there are several prior examples of similar work from engineering education [19, 20].

The purpose of this paper is to name and unpack stories around the question of why underrepresentation is a problem, thus offering them up for much needed, yet largely absent, discussion and analysis within the engineering education community. It is important to name the narratives we use to discuss the engineering profession, and the assumptions therein, because doing so opens up those narratives for critical analysis and reflection [21-23]. As Pawley explains, "If we as engineering educators fail to name and unpack our own stories, we risk carrying on the way 'it's always been done,' maintaining the discipline upon its historical and arguably exclusive foundation" [21, p.317]. Prior scholarship has explored similar questions in other contexts and data sources and has discussed changing justifications over time [16-18, 24]. Similar discourse analysis methods have also been used to study historical trends in justifications for international engineering education initiatives [25].

Building upon this prior work, this paper addresses the following questions: 1. What justifications or motivations do authors give to explain why underrepresentation is a problem? 2. What critical perspectives on those justifications exist? Or, what does each justification potentially hide? While I focus on a dataset of research on women and gender, this analysis has implications for broader understandings of diversity as well.

2. Theoretical Perspective

The theoretical basis of this analysis is post-structural discourse analysis in which, "discourses constitute symbolic systems and social orders, and the task of discourse analysis is to examine their historical and political construction and functioning" [26, p.5]. This approach, allows for an examination of problematization – or how problems are conceptualized and discussed - and aims to show that those problematizations are not simply the Truth, but rather are the result of the social and political milieu in which they exist [26]. "Ideas that do not draw on or interact with available discourses will be dismissed as strange or irrelevant" [27, p.83]. In other words, discourse,

> …governs the way a topic can be meaningfully talked about and reasoned about. It also influences how ideas are put into practice and used to regulate the conduct of others. Just as a discourse 'rules in' certain ways of talking about a topic…so also, by definition, it 'rules out', limits or restricts other ways of talking, of conducting ourselves in relation to the topic or constructing knowledge about it [28, p.72].

For example, if it is thought that more women are not attracted to engineering because they simply are not aware of it or because they do not know what work engineers do, then efforts will of course focus on outreach and informing girls and women of the opportunities engineering careers offer them. However, by thinking about the problem in this way, the field itself is unexamined and unchanged because discourses that locate the causes as masculine biases within engineering itself are not considered.

Therefore, the goals of discourse analysis include examining and deconstructing the problematic assumptions that exist within a discourse [26]; and understanding how the framing of a problem

makes some facets of it appear normal, fixed, or appropriate and other facets appear inappropriate [29]. To put it another way, it is a fact that there are fewer women engineers than men engineers in some parts of the world; however, the meanings and interpretations we give to that fact can be studied through discourse analysis. And, moreover, if that fact is taken to be a problem, then how we frame the problem matters for the solutions we imagine. This process of identifying a problem as such is called *problematization* [30].

The problematizations of underrepresentation found in the engineering education literature are parts of larger *discursive formations* [28] and *discursive economies* [31]. These terms refer to the fact that discourse is never just one isolated statement, text, or action; rather, it occurs across multiple sites, statements, texts, and actions [28] and derives power (or weakness) from its location within broader discourses in society. Thus, the isolated statements in engineering education articles are indicative of larger discourses and meanings, calling attention to their historical, social and political dimensions.

3. Literature Review

3.1. Uses of Discourse Analysis in Engineering Education Research

Discourse analysis has been successfully employed in engineering education research. In particular, the importance of discourse to how we think about recruitment and retention is recognized in the work of Pawley [12] and Watson and Froyd [32]. They have demonstrated that the ways in which underrepresentation is commonly described and conceptualized is limited and misguided. Pawley, for example, argues that the pipeline and chilly climate metaphors are problematic because, "they leave uninterrogated both how we define 'engineering' and how we use 'gender' as a category to understand women's underrepresentation in engineering" [12, p.1]. She proposes that a boundary metaphor would better allow,

> …both "gender" and "engineering" [to] become interrogated categories of analysis…[helping to] make visible the gendered nature of engineering. Ultimately, the act of recognizing and making explicit the metaphors that we use -- often unconsciously -- can help us think about how we construct both "problems," and "solutions" [12, p.5-6].

Watson and Froyd also critique the pipeline discourse stating that the "mental model oversimplifies complexities of the underlying processes, focuses interventions at points of unwanted leakage, and suggests that leaks need to be plugged instead of systems renewed" [32, p.19].

In addition to critiquing metaphors, discourse analysis has been utilized in other ways that illuminate gendered facets of engineering, including to analyze ethnographic data [4, 15, 33-37]. For instance, Stonyer identifies three engineering discourses that shape the identities of engineers: scientist, servant, and citizen. She argues that it is important to understand these discourses because,

> Engineering education is… not a 'given'. Rather it is a constructed response—'an invention'—of the tensions and contradictions, the different points of view and the fundamental assumptions in each discourse. These discourses exercise 'power' to justify and legitimate particular actions… [15, p.393].

In other words, the contents and practices of engineering education are the result of broader discourses in which engineering exists, and what is possible or considered legitimate within engineering education acquires that status through certain discourses, which could be different and can be changed. This scholarship has successfully demonstrated the ways in which discourse analysis offers insights into engineering education and how we conceptualize and go about solving problems of underrepresentation.

3.2. Prior Studies on Problematizations of Underrepresentation and Diversity

Prior studies have critically examined diversity discourses and initiatives in science, engineering, and business, documenting both historic and current trends while demonstrating the need to understand the history and the implications of how we think and talk about diversity and underrepresentation [16-20]. Still others have noted in passing that there have been shifts in the discourse over time [24, 38]. In this section of the literature review these prior studies are discussed, and in the following section, 3.3, their findings are synthesized to draw out common themes that exist across the studies. Critical perspectives on each theme are then presented and used to discuss what each discourse risks hiding - an approach to studying different aspects of engineering that has long been used in the work of Downey [39-41]. Although, many of the studies discussed below focus on US history, parallels can be seen in work focused on Europe and Australia [24, 38]. The point of this review is not to provide a history of any one country, but rather, to show that these issues have been studied and have advanced understandings of underrepresentation and diversity. The dataset is international, representing authors from around the world, and detailed histories of the discourse in each country is beyond the scope of this paper.

Lucena studied U.S. National Science Foundation (NSF) policy aimed at increasing STEM participation and found that shifts in national preoccupations over the last five decades shaped changes in NSF STEM (education) policies and initiatives [17]. He shows that, beginning with the 1960s, each decade had a different dominant discourse that defined the *limits of the sayable* in policymaking. In the 1960s, the launch of Sputnik sparked a new concern with producing scientists for the Cold War. This changed in the 1970s when some policymakers began to see scientists and engineers as solutions to domestic energy, environmental, and social inequality problems. It was during this decade that minorities became a "category of statistical significance" and underrepresentation was established as a problem for the NSF to address. Advocates argued that minorities were good for science because their different cultural backgrounds would benefit science by subjecting its values and assumptions to scrutiny. National concerns changed again in the 1980s when technological threats from Japan led to a discourse of economic competitiveness. And in the 1990s those concerns were replaced with a focus on flexibility and global competitiveness as the technological and economic threats first felt from Japan expanded to include other Asian countries as well as the European Union. By identifying rhetorical strategies and models used by the NSF and situating them within the broader historic and cultural context, Lucena aims to help current policy makers and educators locate themselves and understand the history of policymaking.

Slaton's study is similar to Lucena's, but it focuses more specifically on engineering in particular and efforts to recruit and retain African American students at individual universities over the last fifty years [16]. She identified three types of arguments that have been used to advocate for initiatives designed to increase the participation of African American students: legal arguments,

economic arguments, and social justice arguments. However, in her study she focuses only on the latter two. The popularity of the various types of arguments has risen and fallen over time with broader economic, social, political, and cultural changes in society. Yet, national economic and corporate economic competitiveness arguments have consistently been more common than have social justice arguments. She contends that an examination of the justifications is important because the framing of the problem shapes how we think about inequality. Similar arguments have been made elsewhere [19]. Furthermore, Slaton suggests, social justice rationales may "lead to a more profound understanding of race-based inequalities in STEM fields" [16, p.9]. For example, her case study of the Texas A&M University system reveals that the limited understandings and discussion of social justice in regard to opportunity structures mean that even Minority Education Programs can unintentionally reinforce unjust social and educational structures as well as narrow conceptions of merit.

Within engineering education specifically no such detailed historical or large-scale research has been done. However, there are several conference papers worth noting. Pfatteicher and Tongue identify and raise important issues about "six potential drivers for diversity": regulatory requirements, educational equity, workforce deficiencies, workplace demands, social justice, and professional development [19]. They organized the drivers on a spectrum from external to internal sources of motivation; however, they do not present data on how those drivers have actually been used in engineering education. Hørby et al. briefly discuss three "waves" of underrepresentation concerns in Denmark, all of which evidence labor market concerns, and the effect of each wave on engineering education [20]. They also discuss the most recent trend of linking diversity to innovation. Finally, Nelson and Pawley state that one of the questions they are exploring in their on-going study of gender in the *Journal of Engineering Education* concerns the goals, rationales, and motivations of gender researchers [42].

In addition to these studies of STEM and STEM education fields, scholars in the field of business have also studied how diversity is conceptualized and discussed [18]. Writing in the mid-1990s, Thomas and Ely asserted that to date diversity initiatives in business organizations had tended to fall into one of two, what they term, "paradigms." The *discrimination and fairness paradigm* is characterized by a focus on equality and fairness to overcome prejudice and unfair advantages. The *access and legitimacy paradigm*, which emerged in the competitive business climate of the 1980s and 1990s, is characterized by an "acceptance and celebration of differences" in order to help business "understand and serve…customers better and to gain legitimacy with them" [18, p.83]. In addition to the two paradigms that had prevailed thus far, they argued that a new third paradigm was beginning to emerge. The *learning and effectiveness paradigm* is characterized by integration of diversity into an organization and its work processes, and is a combination of the other two paradigms.

Taken together, these studies establish the following:

1. Precedence for, and value in, studying the ways in which diversity and underrepresentation are conceptualized and discussed;

2. That those conceptualizations and discussions are located in specific historical and social contexts that shape their emergence, popularity, and outcomes or effects, and that, therefore;

3. No problematization should be taken as given, as "common sense," or as beyond analysis,

and;

4. That common themes can be identified across the varying contexts of these studies.

In the next section, I pull out those themes and bring in literature that both further elucidates their historic and social situatedness and raises important questions about their use.

3.3. Common Problematizations and Critiques Thereof

Three common discourses can be identified across the studies discussed above. They are summarized in Table 1.

Table 1: Common discourses and critiques

Discourse	Description	Critiques
Economic competitiveness	Nations and businesses need both more and more diverse engineers to be economically competitive	▪ Hides critiques of ties to military and industrial systems ▪ Hides important aspects of engineers' relationships to their work ▪ Places a superficial emphasis on diversity ▪ Underrepresentation a problem only because more engineers are wanted
Benefits to the field	Diversity directly benefits the contents, practices, and perspectives of science and engineering	▪ Universalizes and essentializes groups of people ▪ Attributes ascribed to women reinforce gender hierarchies ▪ Features of engineering prevent diversity from being expressed in ways that could benefit the field
Social justice and equality	Features of engineering that systematically benefit some groups and disadvantage others are inherently wrong	▪ Equal treatment not necessarily just ▪ Equality can be narrowly construed to mean only equal numbers of students from various groups or to require "sameness"

3.3.1. Economic competitiveness

Economic competitiveness— both for the nation and individual businesses, which are not wholly separable—has been used to argue the need for both more engineers generally, no matter who they are, and for a more diverse population of engineers. As discussed, Lucena and Slaton both identified economic competitiveness justifications in their historical studies of STEM (education) discourses. Pfatteicher and Tongue include similar issues in their "workforce deficiencies" driver, and in the field of business, Thomas and Ely also identified economic competitiveness justifications in their *access and legitimacy paradigm.* This literature demonstrates that the discourse of economic competitiveness is historically and politically contingent, and should not

be treated as a "given," as necessary, or as beyond question. Economic competitiveness arguments may seem to be "givens," however, because capitalist discourse has long been one to which people can appeal because it is credible, non-confrontational to widely-held economic and political beliefs, and makes sense to many [27]. It has been observed that advocates of international engineering education often couch their rhetoric in terms of economic competitiveness to acquire funding and support while their true motivations lie elsewhere [41]. It is possible that advocates for diversity do the same. Indeed, in a recent engineering education publication, Julie Martin Trenor and Alice Pawley contemplated whether "we have had to diminish the social justice issue to get attention from funders to study race, class and gender in engineering education? What have we sacrificed (or what people are not participating) if we make that bargain with funders to support out work?" [43, p.71]. Interviews with engineering educators revealed similar concerns and a higher value placed on social justice [44].

Despite its credibility and status as "common sense" for a large part of the population, advocates framing underrepresentation in terms of economic competitiveness should be aware of what this discourse potentially hides. First, it can hide the fact that engineering's relationships to those systems of economic and military competitiveness and the ways in which economic imperatives shape engineering have been subject to critique [13, 15, 16, 39]. For example, the research agendas that shape engineering have been critiqued for being implicated in exploitative economic structures and for narrowing the scope of problems that the profession addresses [13, 15, 16]. Second, conceptualizing engineering work solely in terms of competitiveness means that important facets of our understanding of engineers' relationships to their work are not seen [39]. Third, it hides its own underlying logic; namely, that if nations and corporations were *not* perceived to need more engineers, then underrepresentation would not be a problem – a proposition that many would not agree with. Fourth, in business environments, economic competitiveness justifications for diversity have been critiqued for placing superficial emphasis on cultural diversity without a deep appreciation for or understanding of what those differences mean for the work itself and for hiding the fact that it often stems from a "very immediate and often crisis oriented needs for access and legitimacy in markets" and almost only works in companies *threatened* by a diversifying customer base [18, p.84]. Therefore, scholars using the economic competitiveness discourse should be aware, in the first place, that it *is* a discourse, and in the second place, that it has been critiqued.

3.3.2. Benefits to a field's contents and practices

A second common discourse can be expressed as the notion that the presence of diversity directly benefits the contents and practices of science, engineering, and business. While this theme is not always completely separable from the first theme of economic competitiveness, especially in the case of engineering, it does deserve its own discussion. The notion of diversity as beneficial to contents and practices emerges in Lucena's study in the 1970s with arguments that diverse individuals were actually good for science because their fresh perspective would lead them to question aspects of science that were taken for granted by others. The theme also emerges in Thomas and Ely's *access and legitimacy* and *learning and effectiveness* paradigms with the beliefs that diverse cultural and language skills help businesses understand and serve their customers and diverse perspectives should be learned from and incorporated into an organization's practices. Pfatteicher and Tongue's "professional development" driver likewise evidences this theme.

As with economic competitiveness, there have been critiques of the idea that increasing the number of women will *necessarily* change a field [14-16, 18, 45-47]. Generally, these critiques recognize that increased diversity *could* improve the contents and practices of those fields, but there are reasons that increasing the numbers of women does not automatically do so. First, this discourse hides the ways in which engineering's control by corporate or commercial interests circumscribes the work that engineers actually do [15], and that "It is not necessarily the absence of diverse personnel that has led to the social narrowness of research agendas in engineering. Rather, it may be the narrowness of the social interests" of those in control of programs and funds for research and eligibility [16, p.214]. As one illustrative example, Slaton describes how the interests of business became dominant and marginalized research to address urban social problems in Chicago during the 1960s and 1970s. It is certainly true that scholars have demonstrated that technologies bear the sociopolitical and cultural stamps of their producers – including gendered dimensions [48-54]. For example, many household and office technologies actually do not benefit women in the ways they are assumed to and also reinforce gendered divisions of labor [50, 53]. And stories abound about women engineers solving problems that remained unseen or unaddressed by male engineers; however, the fact that social, cultural and political dimensions are built into technologies is not *only* a factor of the demographic categories of the individuals producing them. Rather, there are larger belief systems that shape science and technology and simply having more women will not necessarily change that [14, 45-47]. In fact, it has been argued that women who succeed in engineering, do so precisely because they fit the existing norm, not because they challenge it [47].

Another issue is that this discourse hides the concerns that have been raised over ascribing attributes to underrepresented groups. One concern is that this discourse universalizes and essentializes groups of people, or takes social stereotypes as natural and ideal attributes that apply to all women [14, 16, 22, 52]. A related concern is that the attributes ascribed to women reinforce women's subordination to men because the idealized masculine and feminine traits are valued differently [52]. Udén explains that, "the tendency to overestimate the range of 'different' values and practices among women is easily explained, as it creates an account of reality that at the same time confirms ideology compatible to ruling gender orders and strengthens the case of women in the struggle for gender equality" [14, p.463]. Scholarship on gender roles has explored how the links between genders and certain traits came to be and has highlighted problems that association with feminine traits can cause for women [55]. As the epigraph at the beginning of this article demonstrates, attributing certain desirable traits to women is not a new strategy in engineering education—although, evidently these "female qualities" have changed since the 1950s. We need to consider current discourses with the same critical reflection that we may view statements from the 1950s, and consider that, as Jolly argues, essentialism that portrays women as "more socially and environmentally sensitive with greater communication and teamwork skills than men" may be related to the failure of many standard interventions [22, p.1].

3.3.3. Social justice and equality

A third common discourse that emerges from the literature frames underrepresentation as an issue of social justice, equality, morality, or fairness. While these terms can have different meanings for different people, generally this theme can be summarized as the notion that any structural or cultural features of engineering that favor the success of some groups while

hindering the success of other groups need to be corrected because intentional and unintentional biases are inherently wrong. It is also important to note that *equality* and *justice* should not be conflated because equal treatment is not necessarily *just* treatment. However, for the purposes of this paper, those terms are included in the same section. As discussed, Lucena shows how concerns with social inequality shaped the discourse of the 1970s NSF policies. Slaton also identified social justice as one of three justifications used to recruit and retain African American engineers. Thomas and Ely's *discrimination and fairness paradigm* likewise expresses the idea that minority exclusion is an issue of fairness and social justice, and Pfatteicher and Tongue discuss "educational equity" and "social justice" as potential drivers of diversity.

There are not as many critiques of the social justice discourse as there are of the other two themes, and critiques of equality or equity tend to focus on certain, limited, interpretations of those terms. One critique comes from Thomas and Ely who say that the *discrimination and fairness paradigm* operates under the assumption that all individuals are the same and that differences do not count [18]. However, this issue, the insistence on sameness as a requisite for equality, has been resolved in the minds of many other scholars who have concluded that equality does not require sameness [56]. Thus, the way that paradigm has operated in the past is not necessarily how it must operate: there is nothing inherent in arguing for fairness, or social justice, that necessitates the emphasis on sameness to the detriment of validating differences. Regarding equity specifically, Pfatteicher and Tongue argue that if equity is conceptualized only as greater numbers of people from different social categories, then the status quo is maintained, a "diversity of learning styles" is not incorporated, and "interactions between privileged and target groups" remain the same [19, p.3]. However, equity can have much broader meanings, including extending to those issues they identify. Additionally, there have been instances of engineering educators arguing that there are better ways to think of diversity than in terms of morality and fairness [32, 57, 58], but they do not articulate any specific critiques; they merely imply that there are better problematizations.

It is significant that the discourse of social justice has lost traction as economic competitiveness arguments have become dominant. Lucena found that economic competitiveness replaced social justice arguments in NSF discourse in the 1980s, and Slaton similarly found that as economic discourses increased, the popularity and resonance of social justice discourse declined. Similar shifts in focus from equity to competitive advantage and productivity have occurred in Europe [38]. And Australian scholars have also noted the discourse of underrepresentation shifting away from social justice and equity after the 1980s [24].

4. Methods and Sources

The dataset for this content analysis [59] consists of engineering education journal articles and conference papers from the years 1995-2008. Other facets of these sources have been analyzed in prior work [60, 61]. For 2005-2008, empirical articles and editorials from the following journals and conference proceedings were included: *Australasian Journal of Engineering Education (AJEE), European Society for Engineering Education Annual Conference (SEFI),* and ASEE *Global Colloquia*. The *Australasian Association for Engineering Education Annual Conference (AAEE)* was included for 2006-2008. For 1995-2008 all articles in the following journals were included: *European Journal of Engineering Education* (*EJEE), International Journal of Engineering Education (IJEE), and Journal of Engineering Education (JEE)*.

All *IJEE*, *EJEE*, and *JEE* papers and editorials, as well as papers that contained empirical data from *AJEE*, *AAEE*, *SEFI*, and the *Global Colloquia*, that had women or gender as their primary focus were read and instances of a problematization were noted. From this list of problematizations, four general themes emerged that were based upon similarities among statements, allowing the dataset to be coded into the categories that emerged from the data, which are described below. For each category, I provide several examples of the statements included therein. The statements are from North America, Europe, Australasia, Turkey, and India.

Several limitations of this study should be noted. First, only English language publications were included although there is much engineering education research in non-English language outlets as well as in regional outlets around the world. Second, some important English-language outlets, such as Frontiers in Education, were not included because of the need for a manageable size dataset, the already large number of papers from the US, and the aim of incorporating more international sources. Third, the themes identified necessarily involved simplifying what are complex concepts in order to create clear and manageable categories. Such simplification is an inherent part of social research [62]. For instance, as discussed above, *equality*, *justice, morality,* and *fairness* are all treated as one theme. In part, this simplification is also justified by the data because the meanings of those terms are not usually delineated in the publications.

5. Findings

In this section, I identify four categories of problematizations found in the dataset. Briefly, they are: economic competitiveness, professional service and representativeness, women's attributes, and social justice. As readers will see, the first three are highly intertwined, yet distinct enough to allow differentiation and separate discussion. Although I have separated them in this paper, it was often the case that several problematizations were found within one paper. These statements appear almost exclusively in the introductions of the papers. The categories identified in this dataset largely align with those themes identified in the literature review. One difference is that instead of one general theme regarding the benefits to STEM fields, two distinct but related categories emerged from the dataset, those of professional service and representativeness, and women's attributes. Both of these categories express the belief that women benefit the profession, but in the interest of a more thorough and nuanced description, I divided them into separate categories. These findings are summarized in Table 2 along with key terms that were found in the data for each category. It is also worth noting that no significant geographic differences were found in the use of any one problematization; each category contains statements from several different regions. When it is not otherwise clear from the sentence which country a statement is from, I include the country of origin (based on institutional affiliation) in parentheses.

Table 2. Problematizations in the dataset: key terms and alignment with literature review

Problematization/Discourse	Relevant literature review theme	Key terms from data
Economic competitiveness	Economic competitiveness	Economic/economy Competitive(ness) Market Gross national product Industry/industrial
Professional service and representativeness	Benefits to the field	Customers Populations People-centered Clientele Users Good engineering design Solutions Socio-technical challenges
Women's attributes	Benefits to the field	Flavor Intuitiveness/intuition Flexibility People skills Communication skills Creativity Beauty
Social justice and equality	Social justice and equality	Social justice Social need Equal opportunity Moral(ly) Unjust Segregation Women's quality of life

5.1. Economic Competitiveness

One category of problematizations concerns economic competitiveness and expresses notions similar to those described in the literature review. For instance, Trenor et al. write that, "For the U.S. to remain competitive in today's global economy, it is essential to attract and retain more

women— from all backgrounds—in the field of engineering" [63, p.450]. Likewise, Ihsen writes that discussions of women in engineering are important for "economic success and social stability in Germany. Today the country has to cope with more complex requirements because of changing global markets" [6, p.488]. Paloheimo et al. assert that women's underrepresentation in technical fields in Finland is a problem because of the potential for "decelerated Gross National Product" [64, p.1]. Dengiz and Smith (Turkey and US) cite concerns over the "world economy" more generally needing engineers: "The reliance of the world economy on advanced technology is increasing and will be highly dependent on the quantity and quality of a well-educated and skilled engineering workforce. Hence, *all available talent* should be cultivated carefully" [italics added] [65, p.1]. Zimmerman and Vanegas (US) state that, "Engaging women and underrepresented groups in SET will build additional capacity in these fields that are critical to advancing economic, environmental and societal goals" [66, p.243]. Lastly, Watson and Froyd (US) cite former President of the U.S. National Academy of Engineering, William A. Wulf's contention that the lack of diversity is "simply unacceptable and will become increasingly unacceptable to industries that need diversity among their engineers in order to compete in a global market" [32, p.19].

5.2. Professional Service and Representativeness

Another problematization, which is distinct yet related to economic competitiveness and often seen in the same articles, is that as a profession engineering needs to be more representative of the clients and customers it serves so as to better understand and meet their needs or to produce better solutions and designs. Because the clients and customers are diverse, and increasingly so with globalization, then, the engineering workforce should reflect this diversity. The arguments in this category are most similar to the second theme identified in the literature review: diverse people benefit engineering because they bring new perspectives and experiences to the contents and practices of the profession.

For example, Ihsen (Germany) states that,

> Today the mostly *homogeneous* male engineering teams are no longer able to deal with the more and more diverse customer wishes. Thus, within the issue of diversity, the issue *of women in engineering* is achieving more and more economic and political relevance. But there are not enough female engineers who are used to translate the wishes of the more or less unknown female customers into new or more appropriate products [6, p.487].

Similarly, Gill et al., (Australia) write that, "While the engineering profession continues to be comprised of a narrow range of people – far narrower than the populations it serves – its potential to develop innovative and people-centred solutions is going to be limited" [4, p.391-92]. Chubin et al., (US) state, "Engineering has a 'diversity' problem. Like all professions, it must narrow the gap between practitioners on the one hand, and their clientele on the other" [57, p.73]. And, as Daudt and Salgado (Netherlands) explain, "For bridging the gap between technology and users of technology, [creating a woman friendly culture] is not only desirable but also necessary" [67, p.465]. Additionally, Foor et al. (US) expressed a similar sentiment when they cited William A. Wulf, former President of the U.S. National Academy of Engineering, stating that the capability of the engineering profession to produce "elegant solutions" is dependent on the individual diversity making up the "gene pool" of engineers [68, p.103].

Watson and Froyd (US) also cite Wulf, arguing that diverse perspectives and life experiences "bear directly on good engineering design" because they allow engineers to "effectively address current, complex socio-technical challenges" [32, p.19].

5.3. Women's Attributes

A third category of problematizations, again related but distinguishable from the first two, centers around the desirable skills, traits, or abilities that women bring to engineering. It was distinguished from *professional service and representativeness* by the identification of specific skills or traits that were often related more to the internal relationships and practices of engineering, as opposed to external relationships with clients and customers or engineering products. This category is most similar to the second theme identified in the literature review: diversity benefits the contents and practices of engineering.

Some in this category are vague statements such as, "Women bring a much needed and different flavor to engineering and we cannot afford to lose them" [69, p.9] (Australia). Others are more specific and explicitly identify the traits and skills they believe women bring. For example, "Female qualities of intuitiveness, flexibility and people skills…[bring] great value to the profession" [2, p.3] (UK). And, "Women provide invaluable input to engineering teams where their intuition and communication abilities can make a change to the positive in the design and manufacture and supervision of engineering products and tasks" [70, p.389] (Ireland). Also,

> …*female* engineering students in Germany…remain interested in aspects of creativity and beauty in engineering activities more strongly than their male peers. Against this background, female students may continue to support change processes in engineering education towards involving more creativity and beauty into engineering education… [emphasis in original][6, p.491].

Thus, female students are perceived to bring a range of different traits to engineering.

5.4. Social Justice and Equality

The final category of problematization concerns social justice and equality. As readers will see, the social justice problematizations are always accompanied by another justification, usually economic. This category of justifications is the only one that does not appear to stand on its own. For example, Walden and Foor (US) comment on, "the current climate of declining STEM enrollments and the *social*[37] and economic need to diversify participation in STEM…" [36, p.202]. Similarly, Felder et al. (US) state that, "For a variety of practical and *moral* reasons, steps must be taken to attract and retain more women in engineering curricula" [71, p.151]. And Beraud (France) says that, "…the number of women involved in Engineering in Europe is increasing very slowly—too slowly!... From the point of view of *social justic*e and efficiency such a situation appears unacceptable" [73, p.435]. Trautner and colleagues (US) state that, "It is *unjust* and against equal opportunity laws when women are not equally recruited and retained in engineering" and that it is "*morall*y and economically sensible to have women engineering faculty" [74, p.46, 50]. Paloheimo et al. (Finland) explain that underrepresentation "produces problems in terms of *labour market segregation*…and potential decelerated Gross National

[37] Italics added to statements in this paragraph because of the ways in which the sentences overlap with other categories.

Product" [64, p.1]. Labour market segregation could be interpreted as a social justice concern. Lastly, an article from India states, "Participation of women in the engineering profession is important from the viewpoint of national development. It is also an important factor in *improving the quality of life of women themselves*" [75, p.631].

6. Discussion

Four categories of problematizations were found in the dataset: economic competitiveness, professional service and representativeness, women's attributes, and social justice. As discussed in the literature review, economic competitiveness has been a common and compelling framing of the problem of underrepresentation and lack of diversity in both STEM fields and business more broadly, so it is not surprising to find that this discourse is popular in engineering education research as well. However, the popularity of such arguments does not mean that they can be thought of as purely facts not deserving of critical reflection. Given the connections between how underrepresentation is framed and actual changes that can and have occurred in engineering education [16, 20, 22], and given that economic competitiveness arguments have been used since the 1980s yet underrepresentation persists and many in the profession are not concerned about it [4, 11], it would seem that examinations of and reflections upon the accomplishments and critiques of this discourse are warranted. In fact, challenges to this discourse may actually be making their way into engineering education research, as seen in Ihsen's assertion that although discussions of underrepresentation have thus far been fueled by economic needs, it is imperative to move beyond that conceptualization of the problem [6].

Likewise, the literature has pointed out potential problems with statements in the *professional service and representativeness* category. Namely, we cannot assume that simply adding women to the profession will necessarily result in change and that if changes are to occur, attention will need to be paid to identifying facets of the culture that serve to maintain the status quo or inhibit the stated benefits of diversity from being realized. The statements in the *women's attributes* category also deserve further reflection. Unreflectively ascribing certain traits to women has been thoroughly critiqued [14, 16, 22, 52, 55]. Awareness of those critiques could help prevent the unintentional reinforcement of gender stereotypes that contribute to the problem and thus undermine efforts to correct it. It is also worth noting that these arguments are related to so-called "soft skills," or social dimensions, which engineers themselves often consider to lie outside the technical heart of real engineering work [16, 22, 76, 77]. Female students often have negative experiences in collaborative work despite the assumptions that it is something they enjoy [78]. Therefore, if engineering educators believe that such traits and skills are desirable, they have a stake in asserting that these skills and traits are both important for all students and capable of being cultivated in all students. They should not rely on enrolling new populations, whether or not they embody those traits, as a mechanism for changing the profession. As Jolly explains, "if the profession could find ways to value what it actually does over a stereotyped narrow vision of itself, it may well bring about changes that would ultimately attract a more diverse workforce" [22, p.5].

Perhaps it is not surprising that social justice arguments are not found on their own, given the findings in prior literature that discourses of social justice or fairness have lost favor to economic competitiveness arguments [16, 17] and prior literature documenting beliefs in engineering's

neutrality (lack of biases) that limit the reach of social justice concerns in engineering [11, 13, 79]. While this may worry those who do consider underrepresentation a social justice issue, the importance granted or not granted to social justice problematizations should also concern those who would like to see both more and broader social justice and ethics issues in engineering curricula, beyond the specific situation of women's underrepresentation. To the extent that arguments for social justice, ethics, and fairness are not acceptable or persuasive problematizations of underrepresentation, how can we expect those same discourses to hold sway within engineering education curricula itself? Indeed, it has recently been argued that social justice outcomes should be placed above or equal to economic ones and that if engineers became more sensitive to fairness and democracy it will positively affect their work [16]. Thus, the boundaries of discourses of underrepresentation have implications for boundaries of engineering and engineering education more broadly. Finally, the social justice category is the only category that frames underrepresentation as a problem for women themselves – because they are subject to unjust, unfair, unethical, or immoral barriers that prevent them from entering engineering in equal numbers. In the other discourses, underrepresentation is a problem for entities such as nations, businesses, or women as consumers. The conceptualization of whom underrepresentation is a problem *for* matters because the conceptualization of a problem shapes what questions are asked, what actions are possible, and who really benefits from those actions [16, 19, 22, 45, 80].

Given that the issue of underrepresentation –and diversity more broadly - is a complex problem with many different stakeholders, the range of arguments is likely needed because different problematizations will appeal to different people. Using a variety of arguments could be a sound strategy to appeal to as broad an audience as possible. At the same time, reflexivity and critical analysis of those arguments could help ensure that the discourses engaged do not perpetuate the very problem they are intended to correct. Reflexivity means identifying, questioning, and reflecting upon one's assumptions, preconceptions, and behaviors, and it is necessary for changing and challenging established ways of acting and thinking [23, 81]. Because a feature of discourse is the way in which it makes certain problematizations (perhaps most notably economic ones) appear as normal and unproblematic – thus compelling scholars to frame their arguments in certain ways – reflexivity about those framings can be difficult. In this regard, engineering education scholars could benefit from work in other fields that has already grappled with these discourses and identified their potential pitfalls.

We now have the benefit of looking back over the many decades in which underrepresentation has been discussed. We can see how the popularity of certain discourses is a product of history, not any Truth inherent within them. Moreover, we can examine what, if any, change a given discourse has actually helped accomplish. In what ways or in what settings has it been successful? If it seems that a specific discourse has not led to desired changes, then it would make sense to reflect upon how it could be more extensively or better articulated to others and/or to question its continued use. This is not to suggest that everyone need agree upon a problematization, or that there is one correct or *true* problematization. However, to avoid perpetuating a discourse that undermines one's long-term goals for change, awareness of the critiques and implications of our discourse is needed. It is worth recalling here that, "New discourses may alter existing cognitive commitment and thus influence the values and beliefs of actors…discourse constrains action but also…opens ways to recreate society…specific solidified

discursive commitments can be dissolved and social change can be brought about" [29, p.263-64].

7. Conclusion

Four categories of problematizations of underrepresentation were found in the engineering education literature from 1995-2008: economic competitiveness, professional service and representativeness, women's attributes, and social justice and equality. Often, more than one problematization was used in the same article. These categories emerged through interpretation of the data and this analysis does not claim to be *the* definitive categorization scheme; rather, it is intended to begin a conversation around these issues in engineering education. Prior literature demonstrates that these discourses have histories and that scholars have highlighted limitations of each. Thus, wider awareness, and further discussion of, the limitations of each discourse and what each risks hiding could be an important part of both understanding and addressing underrepresentation and other gender biases in the field.

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Chapter 4 - Feminist Methodologies for *European Journal of Engineering Education*

I. Overview

Before discussing the third article, I begin this chapter with a brief overview of the interviews I conducted as part of my dissertation research. Given my findings from the first two articles (i.e. the lack of feminist theory and feminist science studies in EER) and the review process for the first article, I wanted to learn more about the experiences of those who worked on feminist initiatives and why there was not more engagement with feminist theory and feminist science studies in engineering education. A better understanding of the challenges within the field of engineering education would, I believed, be helpful to me as well as to future brokers who wanted to further the development of feminist theory within the field. I also wanted to promote or support the work they were doing and I saw studying it as a way of bringing attention and legitimacy to feminist EER – as something worth studying.[39] I therefore conducted interviews with feminist engineering education researchers and feminist engineering educators and asked them about topics such as: how they became interested in women and gender in engineering (education); why it was a problem that women are underrepresented; what literature influenced them; their research methodologies; challenges and barriers they had encountered; what is needed to overcome those challenges and barriers; and their pedagogical beliefs.

The article discussed in this chapter was submitted to the *European Journal of Engineering Education* (*EJEE*) in July 2011 and is under review. It aims to introduce literature on feminist research methodologies to an engineering education audience via data from my interviews. The Introduction sets up the article as building upon other recent methodology articles in engineering education journals by presenting feminist research methodologies as a concrete engineering education setting in which to explore the connections between epistemology, methodology, and theory. The literature review covers a broad range of topics featured in the literature on feminist methodologies, but necessarily limited to those most pertinent to EER and the data. Importantly, it explains how *all* educational research is value-laden and feminist research should not be seen as less legitimate or less scholarly in that regard. Next, data from the interviews are presented. The ways in which feminist methodologies shape their research topics, questions, frameworks of analysis, methods, practices, and reporting are each discussed. Finally, the Discussion section identifies benefits of further and broader engagement with feminist methodologies within the engineering education community.

[39] Despite this aim of helping, two participants later raised concerns over "knowledge extraction" and ensuring that they get credit for their ideas, as I discuss briefly in this article. The particular brokering work I was doing meant that I was in competition with my interview subjects for research and publishing opportunities; however this is not necessarily or inherently part of brokering.

II. Selecting a Journal and Preparing to Submit

As with the *IJEE* article, the process for this article required selecting the most appropriate engineering education journal. I chose *EJEE* for several reasons. First, there was recent precedent for publishing an article about methodology there, and specifically calls to expand the methodologies valued in EER (Douglas, Koro-Ljungberg, & Borrego, 2010a).[40] Maura was optimistic about the journal being open to more work on this topic. Furthermore, they have published several special issues on gender and have an associate editor who works in gender studies. Lastly, there was simply personal curiosity and professional interest in having an article go through review at each of the three leading journals to see what, if anything, could be generalized across the field and what interesting points of comparison and contrast would arise and provide insight into the field. My only hesitation about selecting *EJEE* came from their 4000-word limit: there was so much literature that I wanted to discuss that I knew the length limit would feel very confining. I believe *IJEE* would also have been receptive to this article. Understanding current conversations and norms/expectations, and differences between journals in such regards, made me more confident with these initial brokering steps this time around.

It is significant that *EJEE* is the only one of the three journals that specifically mentions methodology in its aims and scope. The website states that the journal is a forum in which researchers can "discuss methodology" and it "welcomes research papers as well as position papers and review articles that debate and explore strategic, theoretical and methodological issues, methodological approaches (assessed best practice), and substantive topics."[41] Although I did not look at the aims and scope before submitting, as mentioned, I was aware of precedent for methodology papers in the journal.

As discussed, brokering requires understanding current conversations in the field. To frame this article in the Introduction, I attempted to set up feminist methodologies as a continuation of methodology conversations already underway and as a concrete case through which to illuminate the connections between theory, methods, and epistemology that others had mentioned, but not discussed at length, in *JEE* and *EJEE*. In other words, I was trying to introduce literature on feminist research methodologies by framing it as a logical extension of work published previously in *EJEE*, even though that work was not on feminist methodologies specifically.

There are parallels between this article and the *JEE* article in that brokering here entailed bringing a massive body of scholarship to an audience probably largely unfamiliar with it, in a clear way they might find useful or valuable. Not only was it unfamiliar, but it also challenges many commonly held beliefs among engineers about what constitutes "good" research (e.g. quantification, objectivity). Therefore, as with the other two articles, this article required providing explanations of uncommon concepts and illustrative examples of uncommon ideas. For instance, when I wrote, "Beyond the issue of particular methods, feminist methodologies involve issues of and attention to relationships with participants, power differentials between researcher and researched, and the potential for exploitation therein," Maura asked for a concrete

[40] The same could be said of *JEE* with: Case, Jennifer M. and Gregory Light. 2011. Emerging Methodologies in Engineering Education Research. *Journal of Engineering Education* 100, 1: 186-210. However, this article was part of a special 100th anniversary issue that contained several atypical articles that would likely not have been published in any other issue because they did not meet the criteria of empirical educational research. Readers interested in seeing a typical *JEE* article should not look at this issue, incidentally.

[41] http://www.tandf.co.uk/journals/tf/03043797.html

example of how a research subject might be exploited. Similarly, I felt it was necessary to include a paragraph explaining how all research, not just feminist research, can be considered value-laden, because this is not commonly acknowledged in engineering education research. I note again though that without someone who knows one field but not the other well, it is difficult to identify which concepts require explanation to facilitate successful brokering.

Finally, this article also had reconstructive aims in the form of recommendations or implications for practice. I tried to move beyond pointing out problems to providing recommendations on how researchers could overcome those problems in their own research. I did not have the space in the Literature Review to go into the ways that specific practices and methods can be employed so as to mitigate the problems that feminist researchers have identified. However, there are books that do precisely this, and I mention them for readers who want more concrete recommendations on specific actions they can take to enact feminist methodologies. I then tried to use the Discussion section to make an argument for how such recommendations or practices could benefit EER. Having learned that this was an important brokering practice during the first two articles, I was comfortable using the discussion section in this way.

III. Confidence in Brokering Practices

I believe that using what I had learned from writing and revising the first two articles and following similar brokering practices this time made writing this article easier and less doubt-ridden. Of course, it is hard to judge the ultimate success of the brokering practices as I have not yet received reviews. Nonetheless, I can say that the practices I employed this time further reinforced the categories that emerged from writing the first article.

Identifying differences between audiences meant explaining uncommon and challenging concepts, often by providing examples. Aligning with current conversations meant using the Introduction to frame the article as a concrete case through which to explore methodology conversations already begun in engineering education journals. Related to that, it meant selecting a journal in which an article on the topic of increasing methodological diversity has appeared. Finally, adhering to the norms and expectations of the field meant sticking to the typical article layout with analogous subsections in the literature review and findings sections, and moving beyond critique to providing recommendations for research practices. The biggest brokering challenge for this article was attempting to explain a large body of literature that challenges many commonly-held beliefs about research and knowledge in only a couple of pages.

The following was submitted to *European Journal of Engineering Education* in July 2011.

Feminist Methodologies and Engineering Education Research

Abstract: This paper introduces feminist methodologies in the context of engineering education research. It builds upon other recent methodology articles in engineering education journals and presents feminist research methodologies as a concrete engineering education setting in which to

explore the connections between epistemology, methodology, and theory. The paper begins with a literature review that covers a broad range of topics featured in the literature on feminist methodologies. Next, data from interviews with engineering educators and researchers who have engaged with feminist methodologies are presented. The ways in which feminist methodologies shape their research topics, questions, frameworks of analysis, methods, practices, and reporting are each discussed. Finally, the benefits of further and broader engagement with feminist methodologies within the engineering education community are identified.

Keywords: methodology, feminist methodologies, engineering education research, feminist research, gender

Introduction

Engineering education is increasingly moving away from descriptive publications and toward more empirical research, including greater use of qualitative methods (Borrego, 2007b; Case & Light, 2011; Douglas, et al., 2010a). However, the field is still dominated by quantitative and positivist work (Case & Light, 2011; Douglas, et al., 2010a). In response, there have been numerous recent journal articles devoted to broadening and diversifying the epistemologies, methodologies, and theories widely valued among engineering educators (Robin Adams, et al., 2011; Borrego, 2007a; Borrego, Douglas, & Amelink, 2009; Case & Light, 2011; Douglas, et al., 2010a; Jawitz & Case, 2009; Koro-Ljungberg & Douglas, 2008b). These studies contend that as engineering education pushes to become a more scholarly field, its ability to produce new insights will depend upon the use of a greater diversity of methodologies to overcome the limitations of historically dominant approaches.

While a growing number of scholars advocate more diverse methodologies, however, examinations of feminist methodologies remain almost wholly absent from engineering education literature. One notable exception is Waller's (2005b) brief review. That is not to say that elements of feminist methodologies have not been employed and discussed in engineering education publications, even if not labeled as such; however, it is to say that a more in-depth discussion devoted solely to feminist methodologies as a whole – and what they can contribute to engineering education — is a timely and underexplored addition to the methodology conversations already underway. Therefore, the purpose of this paper is to provide an overview of feminist research methodologies and introduce data on how an international sample of 13 scholars have tried to incorporate aspects of those methodologies into their work.

More specifically, this paper extends the current conversations by providing feminist scholarship as a concrete engineering education setting in which to explore the connections between epistemology, methodology, and theory. It has been noted that these elements of research are inseparable, but their connections, and the way they shape the field of engineering education, have not yet been widely debated (Case & Light, 2011; Douglas, et al., 2010a). Because the aim of feminist research is often to highlight issues of power or dominance and to challenge gender inequalities, it is also necessary to consider how dominance and inequality manifest in research epistemologies and methodologies. Doing so can minimize the extent to which researchers unintentionally reinforce the very inequalities they seek to change. By extending conversations about methodology, this analysis demonstrates what could be gained through greater engagement with feminist theories and methodologies that challenge commonly held beliefs about knowledge and social research. It also contributes to the growing, international body of engineering

education scholarship on gender. Thus, it should be noted that the term "gender" in this paper is meant to convey a recognition of complex social categories and their associated norms, with much in-group variation: it aims to resist the facile association of "gender" and "women" that so commonly occurs. (For further reading on different types of masculinity and femininity in engineering see: Kvande, 1999; K. Tonso, 2006)

Literature Review

There are different definitions of methodology, and in engineering education the term has often been used interchangeably with *methods*, despite the fact that it encompasses much more than particular methods (Case & Light, 2011). Following other engineering education scholarship (Beeman & Baillie, 2007), this paper draws on Harding's definition and use the term *methodology* to refer to "a theory and analysis of how research does or should proceed", thus distinguishing it from both *methods* ("techniques for gathering evidence") and *epistemology* ("a theory of knowledge") (1987, pp. 2-3). Rather than offering up strict definitions of feminist methodologies, many scholars prefer to identify characteristic features and practices, which can most generally be described as those grounded in feminist theories (DeVault, 1999; Harding, 1987; Jayaratne & Stewart, 1995; Reinharz, 1992; Sprague, 2005; Waller, 2005b). Feminist research is often contrasted with research termed "traditional" or "mainstream".

Research for social change and equality

One of the distinguishing features of feminist methodologies is the tenet that research should in some way benefit those that it studies and contribute to increased gender equality in social, cultural, political, institutional, etc. systems (Harding, 1987; Harding & Norberg, 2005; Jayaratne & Stewart, 1995; Lather, 1991, 1995; Sprague, 2005; Waller, 2005b). Working toward that end often means producing scholarship that:

- calls attention to gender inequalities or injustices;
- calls attention to biases in research;
- corrects misconceptions about women's lives and social phenomena;
- or demonstrates how women's experiences and perspectives differ from those of men or other groups of women.

Feminist research can also go beyond these aims and try to benefit specific individuals who are part of a particular study, although there is debate over how this can or should occur (Harding & Norberg, 2005; Lather, 1991). Because the goals differ from those of traditional research, the measures of quality, validity, and credibility for feminist research necessarily and legitimately differ as well, just as they do with many other research traditions (Case & Light, 2011; Patton, 2002). Criteria used to assess the quality of feminist research can include:

- the potential to make women's lives better or minimize gender inequalities;
- the potential to catalyze learning and social change among the population studied;
- and recognition or acceptance of the findings by the population studied (Harding, 1987; Lather, 1991, 1995; Sprague, 2005).

The aims of social change have led some traditional researchers to view feminist research as political or biased and to dismiss it as un-objective or unreliable. Therefore, it is important to recognize that *all* research is biased or value-laden – in the sense that it advances some social

positions and interests over others - whether researchers admit it or not (Bredo & Feinberg, 1982; Harding, 2006; Harding & Norberg, 2005; Longino, 1990). In fact, it has been argued that by explicating their objectives for social change, and locating themselves in relation to the work, feminist scholars can actually be *more* objective than traditional researchers who deny social interests and locations (Harding, 1991, 2004). Moreover, the biases, interests, and epistemologies accompanying traditional research have not been haphazard or circumstance. They have tended to favor and advance the interests of dominant groups and institutions (Harding & Norberg, 2005). Because traditional research claims to be, and is assumed by many to be, value-neutral or unbiased, however, methodologies that illuminate those biases are necessary for social scientists who do not want to perpetuate gender inequalities through their scholarship.

Research topics and frameworks of analysis

One of the ways in which inequalities and biases enter research is through choice of research subjects, topics, and questions (Harding, 1987; Sprague, 2005). In most disciplines, engagement with feminist methodologies begins by calling attention to women's absence among the field's research subjects/participants and adding them into traditional research methods and frameworks. This approach, termed *feminist empiricism*, has been critiqued for maintaining the status quo in favoring dominant institutions and social positions (Harding, 1987, 1991; Hutchings, 2008; N. Riley, 1999). One suggested corrective to the shortcomings of feminist empiricism is to generate questions from the perspectives or standpoints of women's experiences rather than asking questions that serve the interests of dominant social positions and institutions (Harding, 1987). Furthermore, there are concerns over "studying down". *Studying down* means studying marginalized groups in ways that make dominant positions, groups, or institutions appear as the norm or as beyond questioning (Harding, 1987; Harding & Norberg, 2005; Sprague, 2005). For instance, in mainstream research, "questions are more likely to explore the deficiencies of those in disadvantaged social positions than of those with social power" (Sprague, 2005, p. 10). Also related to choice of topics and questions is attention to intersectionality between gender and other identity components, such as race, and the inaccuracies or gaps in research that does not attend to it. Intersectional approaches recognize that gender is not an isolated facet of identity and is not universally experienced and enacted by all (Harding, 1987, 2006; Harding & Norberg, 2005; Lorber, 2001; Sprague, 2005).

A related way in which social research can reinforce inequalities and gender biases is through the frameworks of interpretation that are used to analyze observations and data, including what theories, assumptions, gender biases, and epistemologies underpin the analyses (Harding, 1987; Lather, 1991; Martin, 1991; Sprague, 2005). Problematic or incorrect assumptions that are incorporated into traditional research include:

- a tendency to focus on individuals in isolation from the contexts (structures or systems) in which they live;
- and a tendency to take social constructs as natural (and therefore unproblematic).

Both of these hide power dynamics and social inequalities thus making problems appear to be the inadequacies of individuals. For example, in economics, one of the first contributions of feminist researchers was to identify flaws in the fundamental assumptions of the discipline, namely the assumption of rational individuals who operate without gender prejudices (Bergmann, 1987).

Research methods, practices, and reporting

The ways in which researchers carry out their studies (i.e. the methods they use and how they interact with participants) are other ways that social research can reinforce inequalities. Although quantitative methods have been critiqued, some scholars now argue that it is not any particular method that makes research feminist, but rather *how* that method is used and what it is used *for* (Harding, 1987; Kelly, Regan, & Burton, 1995; Sprague, 2005). In fact, some have specifically advocated the need to employ both quantitative and qualitative methods because of the distinct advantages of each and note that many of the critiques of quantitative methods have been critiques of *positivist* quantitative methods (Sprague, 2005). (Readers interested in how particular methods, including quantitative ones, can be practiced from a feminist perspective, should see: Hesse-Biber & Yaiser, 2004; Reinharz, 1992; Sprague, 2005; Waller, 2005b).

Beyond the issue of particular methods, feminist methodologies involve attention to relationships with participants and power differentials therein (Jayaratne & Stewart, 1995; Sprague, 2005). As one example, and as discussed above, when a researcher studies marginalized or minority groups and that work benefits the researcher's career but does not directly benefit their research subjects, some have argued that this is an exploitative relationship. Finally, concerns over how research is done extend to issues of how, where, and with whom the research findings are shared. Many scholars contend that the research should be shared in places and ways that are accessible and useful to the target population and that discuss the researcher's own interests, motivations, choices, and struggles.

Many of these issues have been manifest in the writing of this and other papers based on the interviews. I have tried to be sensitive to the fact that my participants are academics who build careers on their ideas. As several participants pointed out, interviewing them about their ideas introduces issues around citation and who receives credit for an idea. Thus, while I want to promote their ideas, I also am aware of the tensions in doing so. This has meant removing parts of papers with ideas that participants want to ensure they get credit for later, and ensuring that participants felt comfortable with pieces that could potentially make them quite easy to identify. While these specific issues are not commonly discussed power dynamics or points of potential exploitation in feminist literatures, I include them to demonstrate reflexivity about trying to enact the very principles I am writing about.

Methods

To explore these issues within engineering education specifically, semi-structured interviews were conducted with 10 US and 5 Australian participants between April 2009 and December 2010. Participants were primarily identified through their affiliation with a self-labeled "feminist" engineering education initiative and included current and former faculty at all career stages. They had degrees in anthropology, economics, education, engineering, math, psychology, and sociology. Eleven worked in engineering departments, one in sociology, one in economics, and two were educational consultants and former faculty. IRB approval was obtained and potential interviewees were contacted by email. The interviews, conducted via phone/Skype and in person, which had an average length of 49 minutes, were recorded and transcribed by the author. Transcripts were edited for clarity and readability, removing false starts and fillers such as "um" and "you know." Ellipses represent other words removed.

Among other questions, interviewees were asked what feminist scholarship had influenced them and in what ways it had shaped their methodologies. This analysis presents data from 13 participants who discussed some aspect of research methodology specifically. Prior to submission for peer review, the paper was sent to all participants for review. Other findings from the study will be reported elsewhere (Beddoes, 2011b).

Findings

Research topics and frameworks of analysis

Participants described their research questions and topics. In general, responses reflected a desire to question common assumptions and critically examine engineering itself, including constructions of masculinity and definitions of diversity. One theme, discussed by numerous participants, was critically examining engineering's epistemologies. As one elaborated:

> …the issue of gender in engineering is actually one of masculinity. And that is what we would like to see being studied more, not just the fact that it is more men than women but something about the epistemology and ontology of the discipline is very masculinist and it may be that those are the things that are delaying any change in the gender make up of engineering…the fact that gender research has done absolutely nothing in changing the gender ratios makes you think we've been asking the wrong questions.

Others explained that it is vital to examine the ignorance that is produced alongside knowledge in engineering education:

> [We are] going back to what is it methodologically that might be playing a role in limiting our understanding of women and engineering or gender and engineering…We're saying in the process of knowledge [creation]…ignorance is created as well...it's not just [that] you come up with new understandings but in the process you are able to create - in an unintentional or an intentional way - a knowledge where issues like gender and engineering remain invisible.

Another common theme related to research questions and topics was *intersectionality*. Many explained that they chose not to look at gender as an isolated identity marker or phenomenon because of the ways that other identity markers intersect with gender to vary how gender is experienced and expressed across and within groups. One participant highlighted the challenges and importance of large-scale intersectional studies in engineering education:

> [T]here's sort of a camp that looks at gender and a camp that looks at race but there's not much at all that looks at the intersectionality of both, and clearly your experience as a black woman would be very different from your experience as a white woman. But…because the numbers [of women in engineering] are so small, by the time you disaggregate by gender and then you try to disaggregate by race again you have nobody left...There's a much bigger racial component to the differences in graduation rates than there is a gender component.

Additionally, one said she pays "particular attention to reading the silences. What kinds of things can women say about their lives and what can't they say?"

In regard to frameworks of analysis, participants focused on the structures, institutions, systems, and broader social contexts within which issues of gender in engineering exist. For one interviewee, this meant questioning why some groups "ultimately do or don't have positions of power in social organizations" and how "cultural and social systems set up the situation within which people make decisions." This entailed examining why "some people's version of what's going on is the one that sticks. And how is it that they make it stick? How is it that they're put in a position that people have to not challenge their version? What happens if someone challenges that persons version?" For another participant, it meant

> taking into account a holistic approach to people's lives so that we have a feminist analysis of relationships between gender relations and the family as well as gender relationships and the workplace. So we don't only look at what is going on inside the engineering workplace, we look at the wider economic context, the role of the state and globalization…

Yet another spoke of the "gendering of work and how we devalue women's work" and about how examining institutions helps "us think differently about work, engineering, education structures, and so forth." The same participant also discussed the importance of paying attention to how metaphors are used to interpret and analyze data, which is a popular theme in feminist Science and Technology Studies.

Research methods, practices, and reporting

Participants also discussed aspects of how they went about studying these topics and reporting their findings. Participants preferred qualitative and mixed methods over quantitative methods. More specifically, one elaborated on her preference for open-ended questions that facilitate narrative: "that choice has to do with relying on the importance of narrative and allowing the voices of the subjects to really come through in the research." She went on to explain that looking at agency (i.e. beliefs about one's choices, options, possibilities for action) in narratives is revealing because gendered roles emerge from the narratives and female students "don't often ascribe agency to themselves" in discussing their decisions to become engineers. Similarly, another stated,

> [W]hen you take these critical perspectives you make a commitment from the beginning to see the world from the vantage point…of each and every person you are studying, to having a rich enough understanding to allow for there to be diversity of opinions. So that whole postmodernist notion of and the whole cultural anthropological notion of allowing the insiders to speak for themselves, to actually guide you, to tell you what you need to be looking at, to shape how things need to go.

Several participants discussed their use of participatory action research (Patton, 2002) and the belief that research should help participants or share power with students with whom they work. One, who worked at an undergraduate-only institution explained her choices to involve students in research decisions:

> I involve undergrads as researchers in the project and I gave a lot of power to my undergrads in designing these studies…To the point where I actually gave up a lot of things that were conventionally expected about sort of how you write a research protocol

> but those students argued for what they wanted to do and I thought their arguments were reasonable and so we went forward with their choices…And they've led to really interesting findings and it is important for them intellectually to be part of that research, to be…equal members of the team.

Another, who studied minority faculty members, discussed the goal of using research in a way that benefits those faculty:

> [I]f in fact we are trying to share power with our participants who have shared their stories with us, how do we as researchers - who are sort of in this institutionally powerful position to represent their perspectives - how do we actually share that credit with them in a way that might do work for their career as opposed to simply it being another obligation for them?

These participants also discussed critiques of participatory action research and struggles over how to conduct participatory research in ways that overcome the critiques. Additionally, a third participant discussed the ethical difficulties of what it means to "empower" students in a context where doing so could make their lives more difficult. A thorough discussion of these struggles, as well as other challenges related to employing feminist methodologies, is beyond the scope of this paper, but will be discussed in future work.

Finally, in regard to choices about how to report findings, one interviewee explained that,

> I carefully make decisions about whether I'm going to present my work in a fully feminist way or whether I'm going to present my work in a more traditional, or…masculine way, and trade off the issues being heard versus being true to myself.

This likewise touches on the challenges of employing feminist methodologies in engineering education.

Discussion

Participants discussed their research questions, topics, methods and philosophies, data analysis, and reporting of results. There is a large body of literature that supports their choices as valuable for the production of social science that:

- does not inadvertently perpetuate inequalities;
- has the potential to enroll research subjects in mutual processes of learning and benefit;
- produces analyses that illuminate the complex and multifaceted gendered dimensions of engineering.

The ways in which feminist methodologies have shaped the work of these engineering feminist researchers highlight several important frontiers in engineering education research as well as limitations of more traditional research.

First, by studying and interrogating gendered dimensions of engineering itself, as opposed to focusing on women, interviewees engage with a wide variety of theories and understandings of gender. Doing so is important because a wider range of feminist theories is needed to address the problems of underrepresentation and gender biases in engineering education (Beddoes &

Borrego, 2011; Nelson & Pawley, 2010). Second, by discussing intersectionality, participants support a topic that is gaining increased recognition as an important theoretical concept with which engineering education researchers should further engage (Robin Adams, et al., 2011; Beddoes & Borrego, 2011; Foor, et al., 2007; Trenor, et al., 2008). Third, by interpreting and analyzing their results with respect to structures, institutions, and systems, these researchers highlighted an important corrective to the tendency toward individuation that prevents us from seeing and addressing all of the factors that contribute to gendered facets of engineering. Fourth, by reflecting and discussing how research can benefit participants and how and where to report findings, they raise issues that have not been widely discussed in engineering education publications but deserve further attention given the focus on students.

Taken as a whole, then, these choices, and the literature that supports them, can provide increasingly novel and critical insights into multiple gendered dimensions of engineering (education). In fact, many of the concerns seen in feminist literature – including the importance of examining how and why we choose our research topics, questions, study designs, and measures of validity - are also present in engineering education scholarship on methodology more generally (Case & Light, 2011).

Conclusion

This paper suggests that feminist methodologies have much to offer engineering education researchers (even those who do not identify as feminists) interested in advancing the field's scholarship in ways that challenge inequalities built into many social science processes. As many push engineering education to become more rigorous, scientific, or scholarly as a research field, it becomes important to understand the limitations and critiques of features commonly equated with rigor and scientific validity (e.g. quantitative methods, statistical significance, traditional notions of objectivity, standardized measures), including how they can reinforce gender inequality. When the limitations and biases of traditional research are recognized, it becomes clear that feminist methodologies offer alternative paths for improving engineering education research that are no less valid or scholarly. If these and paths are not widely valued or accepted, however, their potential to contribute novel insights, knowledge, and research ideas to all areas of engineering education will be limited.

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Chapter 5 - Conclusion

I. Practices of Brokering

Three categories of practices emerged during this project: identifying differences between audiences, aligning with current conversations, and adhering to the norms and expectations of the field in which you are working. Within these categories the specific practices for each article varied slightly, but by and large these categories were employed while writing and revising each article. In this section I revisit the specific practices and identify challenges associated with each. I situate these practices with respect to the relevant literature first discussed in the Introduction. In addition to brokering literature, this includes Myers study of the publication process for biology articles (1990), Baker et al.'s narrative of their experiences working to build bridges between Women's studies and science faculty (2001), and Downey's work on scalable scholarship (2009). The section concludes with a discussion of affective dimensions of brokering.

A. Identifying Differences Between Audiences

Recognizing that the concepts, terms, tone and level of criticism that are normal in one field will not necessarily be appropriate and accessible in another field is key to successful brokering of new ideas and research approaches. As Wenger stated, "The job of brokering is complex. It involves processes of translation, coordination, and alignment between perspectives" (1998, p. 109). I attempted to make my articles readable and clear by explaining and/or removing many concepts and terms. In many cases, I provided an illustrative example to help explain the concept. I attempted to make the articles non-offensive by rewording and/or removing the parts that came across as criticizing my audience. In many instances, concepts, terms and tone that are appropriate and common in STS and WS made my writing inappropriate and inaccessible for engineering education journals.

Yet, identifying differences between audiences and adjusting your writing accordingly can be challenging for several reasons. First, stepping back and having to explain in every day language what you mean by terms that are usually taken for granted in your field or having to explain concepts that challenge commonly-held beliefs can be a frustrating experience. Second, attempting to identify what is appropriate and accessible is made even more challenging when there is disagreement within an emerging field on these points. The nature of engineering education is such that reviewers, and audiences, have significantly different knowledge backgrounds. Thus, authors are caught between fields and held accountable to reviewers from different fields and should expect divergent opinions over what is appropriate and accessible. This interdisciplinary issue of finding appropriate reviewers, including specifically for feminist scholarship, has also been discussed in science education (Eisenhart, 2002; Roth, 2002b; Scantlebury, 2002).

Third, recognizing when the tone is too critical and figuring out how to re-tone it for another field is challenging when you want to raise critiques without offending anyone – which is

necessary for participation. Myers also found that his authors had trouble establishing a tone that satisfied reviewers (p. 83). In my case, I was trying to say what other STS and WS scholars have said but in a way that does not come across as critical of your audience. The critical tone that is common in much STS/WS writing is not appropriate when writing for an engineering audience if you want to engage and not alienate them. Even after I thought I had considerably had toned down the level of criticisms in the *JEE* article, one reviewer still found it "too snipey." Working with someone at the core of the community in which you are trying to introduce new ideas is invaluable to identifying when a concept, term, or tone is inappropriate or inaccessible, which is a necessary first step. After that, figuring out how to explain, clarify, and re-tone takes patience, time, and creativity.

Accounts of others' experiences with similar initiatives are also useful in helping those trying to work across the boundaries of WS and STEM fields. For instance, as mentioned in the Introduction, Baker et al. provide an in-depth account of their two-way streets project, which aimed to bring together WS and science faculty to start conversations between them (2001). Many of their experiences paralleled mine in this project. They found that much of the language WS faculty used put scientists on the defensive because it was critical of their worldview. They also found the women's studies language "opaque, verbose, manipulative and repetitive" (pp. 159-60). It stands to reason that putting one community on the defensive does not promote successful brokering efforts. Similarly, many of the STS and WS terminology and tone issues that I dealt with when attempting to make the articles appropriate for an engineering education journal were also related to the need to not seem critical of my audience and alienate them by putting them on the defensive. In addition to trying not to offend my audience, I also needed to step back and explain or not include some concepts and terms because they would be unfamiliar to most readers. Baker and colleagues likewise found that scientists were unfamiliar with categories of analysis that feminists took for granted and that terms such as *gender*, *objectivity*, and *critique*, meant different things to the scientists and the WS faculty. Their insight that terminology is not easily disentangled from a discourse community in which it developed helped me understand why in many cases it seemed so difficult to explain a concept and I opted to remove it all together. A third parallel is discussed in the norms and expectations section below. Given the similarities between their experience and mine, it seems that producing more accounts of what actually happens in such interdisciplinary initiatives is important because with more accounts, trends and generalizations will emerge that can help future brokers anticipate and understand challenges they face.

B. Aligning with Current Conversations in the Field

In order to introduce new ideas and approaches into a field it is necessary to convince readers that they should be interested in what you are saying. It makes sense to do this by relating your work to topics that are already present in the field. Downey has made this point about scalable scholarship as well, noting that it was important for him to listen to ongoing struggles in the field of chemical engineering in order to understand how to engage that audience (2009). In all cases, I did this by explaining how my work was a continuation of existing conversations that offered to potentially advance those conversations. The *IJEE* article was slightly different, however, in that it required first establishing my approach as a legitimate academic endeavor. In all cases, aligning with current conversations in the field meant getting the framing of the article in the Introduction right.

Here again, however, this can be challenging because not all reviewers or editors will necessarily agree on what the "right" framing is. As discussed, reviewers and the Associate Editor did not like how we had framed the *JEE* article, and the published Introduction is quite different from what was originally submitted. We had originally written it as an EER methods piece that used feminist theory as an example, while the AE sent it to at least some feminist researchers well versed in feminist theories and literature who were not necessarily our intended audience of regular *JEE* readers.

Another important part of aligning with current conversations is selecting the most appropriate journal for particular work. Factors such as prestige, freedom, length, methodological requirements, and publishing precedent all came into play for me. Figuring out which factors are most important for you for a given article is key to successful brokering. As seen in the Appendix, consulting the journals' aims, scope, and review criteria will provide guidance when attempting to select the "best" journal.

Aligning with current conversations is essentially trying to make readers see value in your work because it contributes to things they are interested in. Myers's study also highlights this as a challenge. His work, combined with mine, suggests that it is perhaps not uncommon for interdisciplinary work to receive polar opposite reviews vis-à-vis an article's contribution to a field. Just as several reviewers of the *JEE* article said it was an important and timely contribution to EER while one said it did not contribute much to the field, reviewers in Myers's study also had opposing opinions on an article's contribution. In his study, "where one reader finds a clever and reasonable hypothesis, the other finds no hypothesis at all." One reviewer thought the claims in the article were already well-known and that the author is "out of touch with current knowledge," while the other reviewer thought the article was an "important contribution," a "valuable service," and a "needed jolt" (pp. 78-79). Brokers should therefore anticipate differing opinions on the value (which stems from how it is perceived to align - or not - with current conversations) of their work, especially in emerging and interdisciplinary fields such as engineering education.

C. Adhering to Norms and Expectations of the Field

I found that in several ways the status quo was strongly enforced and I had to adhere to the norms and expectations for engineering education journal articles. One way in which I had to do so was by following the standard organizational structure for articles. This can be challenging and is potentially problematic because STS/WS knowledge does not necessarily lend itself to easily being discussed in discrete subsections. The lack of a similar uniformity in those fields attests to this fact. It is also potentially problematic if adhering to the norm is valued over clarity and readability. For example, in the *JEE* article, even though Maura and I believed an atypical structure (including the overview of each branch of feminist theory alongside the Findings as opposed to the Literature Review) would make it easier for engineering education readers unfamiliar with feminist theory, we were forced to change the structure to align with the norm for article layout.

Myers found that the authors he studied encountered similar challenges concerning the need to fit new ideas ("claims" in his terms) into old molds. Recall that the articles he studied were also interdisciplinary in nature. He says, "These authors have some difficulty fitting their new interpretations into the form of the research report or the review article, because these forms

demand that the claim fit closely into the structure created by other scientific articles" (p. 68). He goes on to argue that issues such as organizational demands are not trivial matters: they are directly related to the arguments that authors are able to advance and can reveal other norms in a field, around methods, for instance:

> [R]eferees' comments about such matters as length, organization, and style are not just matters of taste; they too help define the status of the claim. As there is a tension in determining the appropriateness of the claim for a particular journal, between assertions of originality and participation in an established structure of knowledge, there is a tension in determining the form of the article, between construction of the idea as the author tells it and the conventional formats of the report or review article…[T]hese formats, though flexible within limits, embody the attitudes of a subspecialty toward claims, methods, and use of the existing literature. (p. 80)

I experienced these tensions over trying to fit STS/WS ideas and approaches into an engineering education form and style. For example, even more generally than the *JEE* example given above, was the challenge of wanting to raise and discuss issues not directly pointed to by the data. This is a style of writing common in STS, but not in engineering education, and it affects the ideas, or claims, one is able to introduce. Recall that one of the reviewers for the *IJEE* paper spoke directly to this tension by stating that I had made claims without evidence, when, from my point of view, I was only trying to raise relevant issues that I thought should be considered.

Another way I had to follow the norms and expectations was by providing concrete recommendations, suggestions, or implications for practice. Unlike STS/WS critique alone was not enough. Answers and solutions are valued and expected in engineering education. The challenge here is that most STS/WS literature that I was drawing on and attempting to introduce into EER did not come with concrete recommendations or solutions of the kind expected in EER. Baker et al. encountered this tension between differing expectations and underlying beliefs as well (2001). The scientists in their group wanted practical and concrete ideas for recruiting and retaining more women. The women's studies faculty, on the other hand, thought it was impossible to address recruitment and retention without first understanding feminist critiques of science, which the scientists perceived as pushing a feminist agenda on them.

Finally, I had to satisfy the field's perceptions of quality research by presenting a rigorous and quantified account of my methods. This norm did vary by journal, however. This expectation presents a challenge to brokers if the knowledge or approach they are trying to introduce does not lend itself to quantification or rigid categorization. I am not faulting EER for the desire to maintain high standards for research methods: the problem arises when what is perceived as the mark of quality and rigor prevents certain kinds of scholarship from being introduced into the field. STS/WS knowledge and analyses that cannot be easily fit into methodological norms may be perceived as low-quality, which will pose a challenge to introducing them into EER. As discussed, I found the expectation to code the papers very problematic because the papers themselves did not usually clearly engage one or two branches, and, often, different branches were most relevant to different parts of a single paper. It was also difficult because I wanted to discuss how a theory could improve a paper even if that paper did not engage a theory itself. Discussing this dataset in a women's studies journal would likely not have required similar quantification and categorization.

D. Affective Challenges of Brokering

I experienced the affective challenges of brokering Wenger identified (1998). I found his analysis helpful in shifting the way I felt about my work, particularly in the beginning with the *JEE* article. Because brokering work does not exist at the center of any one community of practice, and instead operates at the margins of several, that work is often undervalued. Brokers can interpret what are reasonable challenges of taking on the brokering role as personal failure or limitations. He explains,

> Uprootedness is an occupational hazard of brokering. Because communities of practice focus on their own enterprise, boundaries can lack the kind of negotiated understating found at the core of practices about what constitutes competence. That makes it difficult to recognize or assess the value of brokering. As a consequence, brokers sometimes interpret the uprootedness associated with brokering in personal terms of individual adequacy. Reinterpreting their experience in terms of occupational hazards of brokering is useful not only for them and for the communities involved. It can also allow brokers to recognize one another, seek companionship, and perhaps develop shared practices around the enterprise of brokering. (p. 110)

When writing my first article for *JEE*, I felt like I was not producing respectable STS scholarship because it was too simplified, did not use typical STS language, and did not seem to be producing new STS theoretical insights. When I showed it to another STS graduate student in a writing group, I worried that it would reflect poorly on me as an STS scholar. For the same reason, it took a long time for me to be able to show the article to Gary. I experienced the requirements of writing for *JEE* as tensions over my adequacy as an STS scholar. Moreover, concerns over producing respectable STS scholarship are likely compounded among graduate students, as they are learning to live in a culture where intellectual brilliance and production of new knowledge is usually valued over impacting practice or making meaningful connections with other academic fields. Hence, it could be argued that much Ph.D. training discourages brokering work. More established STS scholars may not have experienced these tensions to a similar extent if they already had legitimacy and a demonstrated ability to do work valued by the STS community. Therefore, a broker's location within a community likely affects the tensions and challenges they will face. Concerns about adequacy as an STS scholar occurred to a much lesser extent with the next two articles, perhaps because I was more confident that people would see value in that work after positive feedback on the first article.

A second affective dimension of these experiences is the frustration I felt during revisions of the *JEE* article. The conflicting reviews, quantification requirements, and level of control exercised by the Associate Editor were frustrating at the time and made me question the feasibility, value and wisdom of trying to do what I was. While most authors have likely been frustrated at times by the review and revision process, the frustrations I felt can in large part be attributed to trying to introduce a new topic and approach into a field, I believe.

Third, I experienced annoyance and embarrassment when I tried to bring a practice from engineering education into STS. As recounted in chapter 2, STS scholars scorned and were puzzled by my suggestion to use tables in their papers. Again, this might seem trivial, but I suggest that it raises questions about STS scholars' willingness to consider approaches they view as inferior or unnecessary in order to help readers. This is related to brokering because

readability or accessibility is key to communicating STS ideas to non-STS audiences. If those trying to promote the ideal of scalable scholarship are looked down upon, then potential brokers' willingness or ability to continue that type of work will be hindered.

These tensions and challenges shape brokers' identities. Struggling with experiences, such as those just described, is part of what Wenger terms *reconciliation* between the different parts of oneself that belong to different communities. Elaborating his theory of how reconciliation is tied to identity formation, he explains,

> Reconciling these aspects of competence demands more than just learning the rules of what to do when. It requires the construction of an identity that can include these different meanings and forms of participation into one nexus. Understood as the negotiation of an identity, the process of reconciling different forms of membership is deeper than just discrete choices or beliefs. (p. 160)

He stresses that reconciliation is an on-going process reflecting continued interest in working between communities:

> The work of reconciliation may be the most significant challenge faced by learners who move from one community of practice to another…the nexus resulting from reconciliation work is not necessarily harmonious, and the process is not done once and for all. Multimembership may involve ongoing tensions that are never resolved. But the very presence of tension implies that there is an effort at maintaining some kind of co-existence. By using the term "reconciliation" to describe this process of identity formation, I want to suggest that proceeding with life…entails finding ways to make our various forms of membership co-exist, whether the process of reconciliation leads to successful resolutions or is a constant struggle. (160)

Certainly I have felt and continue to feel a struggle over where and how I want to direct my membership in engineering education an STS. When applied to projects like mine, then, brokering is about developing an interdisciplinary identity. Given escalating calls in some circles for increased interdisciplinarity, it is important to understand what interdisciplinarity truly entails and the experiences of those who have tried to create interdisciplinary identities. For those pursuing interdisciplinarity via brokering, Wenger offers a framework and language to help understand and articulate their experiences.

II. Implications for STS and Women's Studies

As mentioned in the Introduction, one prominent goal of STS scholars has been to have an impact outside of the field. Much of the STS work in that vein focuses on lay people or publics however, rather than on working within other academic fields. I believe this project demonstrates the value in the latter and can provide foundations for others to build upon to do similar work. However, if work of this nature is to become a significant part of STS, it will need to be valued and recognized as legitimate STS work. This raises questions of value and quality in STS.

I see this project as an example of scalable scholarship, albeit for another academic audience, and Big STS, as conceptualized by Downey (2009). As elaborated upon in the Introduction, scalable scholarship is judged on its ability to shape the thoughts and actions of non-STS

audiences. It must therefore recognize and engage audience agency and interests. Each of the three narratives demonstrates how my attempts to produce scholarship that would scale up among engineering education researchers had to respond to existing conversations and interests in that field. They also show how this requirement challenged my own agency as a scholar. A key challenge of scaling up it to make concepts, such as ideology, "be heard as something other than an accusation" (68). Ideally, through successful brokering practices, I have been able to do that with critiques from feminist theory, feminist methodologies, and STS literature on problematizations of underrepresentation. In that regard, it stands in contrast to STS scholarship that is valued for inaccessibility, jargon, and critique alone, judged only by other STS scholars. Such work limits the ability of STS insights to exist outside of our academic silo and has been critiqued by Steven Shapin as "pathological" *hyperprofessionalism* (Shapin, 2005).[42]

Expressing similar concerns about feminist theory, bell hooks has critiqued the development of "theoretical elitism" and "academic elitism" in which the feminist scholarship most valued in the academy is the most convoluted and inaccessible:

> …theory is often employed to promote an academic elitism which embraces traditional structures of domination. Academics who produce theory along these lines often see themselves as superior to those who do not. Oppressive hierarchy is thus reinforced and maintained. Feminist theory is rapidly becoming another sphere of academic elitism, wherein work which is linguistically convoluted, which draws on other such works, is deemed more intellectually sophisticated, in fact is deemed more theoretical (since the stereotype of theory is that is it synonymous with that which is difficult to comprehend, linguistically convoluted) than work which is more accessible. Each time this happens, the radical, subversive potential of feminist scholarship and feminist theory in particular is undermined (hooks, 1989, p. 36).

Institutional structures enforce a hierarchy among feminist scholars in which those seen as less "theoretical or intellectually rigorous" are looked down upon. The problem, she contends, with this hierarchy is that the work that has become the most valuable - that which "does not allow effective communication of ideas" – inhibits the potential of feminism to affect those outside of academic circles (p. 37). hooks thus argues for broader and more diverse understandings and definitions of theory – and of the ways that theory can be developed. "There is a place for theory that uses convoluted language, metalanguage, yet such theory cannot become the groundwork for feminist movement unless it is accessible…Visionary feminist theory must be articulated in a manner that is accessible if it is to have meaningful impact" (p. 39). This is similar to Downey's notion of "dense simplification" in that both advocate the need for simplification, not making scholarship unnecessarily complex, while recognizing that creating simplicity is no simple task. Moreover, it is parallel to Downey's argument that scalable scholarship need not replace all other kinds of other work, just that it needs to be considered and discussed, legitimated, alongside currently dominant modes of academic work. She also calls for examinations of the tensions experienced by those who resist perpetuating that hierarchy and work on less traditionally theoretically elite projects (p. 40). While hooks is expressly concerned with theory and non-academic audiences, her critiques are also germane to projects such as mine that deal with

[42] Shapin is speaking specifically about history of science, but his critiques apply to much other STS scholarship as well.

feminist theory and science/engineering audiences.

As discussed in the Introduction, feminist science scholars have challenged this dominant mode of feminist theorizing with work such as that in *Feminist Science Studies: A New Generation* (Mayberry, et al., 2001b). They have intervened and attempted reconstructive projects in sciences within and outside of the academy. They have written about their efforts, discussing challenges they faced, with the aim of establishing easier pathways for future feminist science scholars who cross the boundaries of disciplines and the academy. Their work, therefore, is an important step in answering hooks calls.

I see my project responding to that call as well, and as identifying new challenges to build on prior feminist science studies work. It aims to avoid theoretical elitism, create accessible feminist theory, and make visible the challenges that come from that, including from resisting theoretical elitism. I experienced tensions stemming from the hierarchy hooks identified. As discussed above, I felt like I was not doing "real" or theoretically advanced enough STS work. I also experienced the limitations of theoretical elitism first hand. When trying to translate some feminist theory into concrete recommendations for research, for example, I experienced much of the literature to be limited in its practicality and applicability. These examples thus support hooks arguments, as well as Wenger's that brokers often internalize the difficulties of brokering as personal inadequacies, and Downey's that "Paying attention to scaling up can generate considerable discomfort for its practitioners" (2009, p. 73). I have learned that there is nothing simple about creating simplicity and there is no reason to think that scalable scholarship is any easier or less challenging than "theoretically elite" work.

III. Other Issues for Engineering Education

This project and my experiences also raise questions about peer review and publishing practices in engineering education that have implications for the field as a whole. In related work, several engineering education researchers have recently begun to examine peer review practices (Jolly, Willey, Tibbits, & Gardner, 2011; Willey, Jolly, Tibbits, & Gardner, 2011a, 2011b). Scholars in science education have also already recognized the importance of openly discussing peer review and publishing practices in their field, including describing their own peer review experiences (Eisenhart, 2002; Osborne & Brady, 2002; Roth, 2002a, 2002b, 2002c, 2004; Scantlebury, 2002; Tobin, 2002). I suggest that several issues raised in that field should be considered by engineering education researchers as well. Moreover, I suggest that engineering education researchers should also be writing about, and publically discussing (perhaps at conference sessions, for example), peer review, especially for underexplored and critical topics such as feminist theory. It has been argued that peer review is hegemonic for minority groups (Tobin, 2002), so openly discussing peer review could potentially further engineering education's engagement with feminist science studies and other STS literature.

First, this project raises questions about the desired role of journal editors and reviewers. Should they be gatekeepers or promoters of new ideas and innovative approaches? What level of editorial authority should they exercise in those roles? Wolff-Michael Roth, a science education scholar, argues that the peer review process should be less gatekeeping and more about helping authors, supporting newcomers to the field, and advancing new ideas. The focus on gatekeeping

as the goal of peer review needs to be rethought if the field of science education is to prosper (2002a). Kenneth Tobin (2002) likewise argues that giving feedback for improvement, not gatekeeping, should be the role of peer reviewers. As engineering education develops, it should also consider this question. Tobin also discusses how he has been made to fit his perspectives to those of reviewers, which parallels my experience with *JEE*. He critiques the standardization and homogenization that such requirements produce. As discussed, I believe the standardization required for the *JEE* article was valued over clarity for readers unfamiliar with feminist theory. The journal's hyper-focus on methods also serves as unnecessary gatekeeping, I would argue.

Engineering education researchers Willey et al. address similar concerns when they begin a recent conference paper by questioning the relationship between diversity and novelty of ideas and peer review:

> What diversity of ideas is able to emerge through the normative practices of setting conference themes, reviewing of papers and the potentially confrontational conference presentation itself? How are neophyte engineering education researchers able to be developed within formal structures that reward the familiar and the well-established?...We wish here to raise questions about one aspect of scholarly practice which we usually take for granted, the peer review system, which might actually work to discriminate against innovation and impede the development of the field. While we acknowledge that there are external pressures which are likely to maintain the need for peer review, we would like to open debate on how we might diversify our practices in productive ways. (2011a, p. 1)

Secondly, does it matter if some journals are perceived to be either one or the other (a gatekeeper or a more innovative/open outlet)? Margaret Eisenhart (2002) has written about the "paradox of peer review" – a paradox in which peer review simultaneously lets in both low quality work and is too strict about enforcing conservative standard. The issue of allowing through low quality work is especially prevalent, she argues, in interdisciplinary fields, like education, where qualified reviews can be hard to identify and engage. She sees the latter – enforcing conservative standards – as a problem because enforcing the status quo, prevents diverse and innovative perspectives, ideas, and approaches from being incorporated into, and helping to advance, a field. Describing the result of this paradox in education and science education, Eisenhart explains:

> What has happened in educational research in the face of this paradox is that journals, publishing houses, and university departments have tended to divide into those that take one side (and proceed accordingly) and those that take the other side…The problem with this situation is that researchers on one side of the divide rarely talk or listen to those on the other side. Those cited in the articles in one journal are not cited in the articles of the other journal (see also Delamont, Coffey & Atkinson, 2000)…and the accumulation of knowledge about important education research questions is threatened. This is a problem for the entire field. (p. 252)

Tobin (2002) has also commented on the differences between science education journals in this regard, noting that some require many changes to satisfy reviewers and have high rejection rates, and are therefore more prestigious, but he has found that he prefers to read the journals are more

accepting and innovative.

I believe my experiences, documented in this dissertation, as well as the publishing records of the journals, and perhaps the journals' formal review criteria, indicate that a similar situation has developed in engineering education. *Journal of Engineering Education* has developed into a gatekeeper of what parts of the community perceive to be rigorous or scholarly work – most often conceived of as rigorous methods and quantification. The fact that I had to quantify my dataset and submit to the demands of one reviewer and an AE attest to this. *International Journal of Engineering Education*, on the other hand, much more readily and quickly accepted a novel theoretical approach and did not demand a thorough recounting of or quantification of my methods. And, yet, I do not believe the *IJEE* paper is any lower quality or less important than the *JEE* paper. Yes, it is the case that *IJEE* publishes many more articles per year, but I do not believe this can account for all of the differences.

Certainly striving to maintain high standards for scholarship is a desirable goal, and certainly not all journals in a field need to have the same goals or review criteria. However, the questions then become: How are high standards, or rigor, conceptualized/defined? What are the implications of that conceptualization for the type of work that is accepted into certain journals? What is the implication of that type of work for the development of a field? And, finally, do the differences between journals in these regards prevent conversations (citing) between the journals, thus inhibiting the development of the field?

If the marks of quality engineering education research are perceived to be rigorous methods and quantification, adherence to the organizational norms, and falling in line with prior scholarship, then work that attempts to bring in new perspectives or approaches that do not easily lend themselves to the norms of the field may be difficult to introduce and develop in the field's literature. For example, the dataset for the *JEE* article did not lend itself well to quantitative categorization, and doing so did not do justice to the uses of feminist theory in the dataset. It also limited the ways I could talk about feminist theory, because discussion had to be limited to articles in that category/section. As further evidence of differences, as discussed, I chose *IJEE* for the discourse analysis paper because I believed I would have more freedom to discuss issues not directly raised by the data.

If one journal tends to publish more innovative papers, but is seen to be inferior because it is not a gatekeeper, then innovative work in that journal may not reaching a broad enough audience and may not be getting cited in the gatekeeping journals. The expectation to adhere to certain norms or standards in some journals could mean that some work, STS and feminist theory for instance, just lend themselves better to the freedom of other journals. It there is not conversation between journals, then, the field's development may be slowed or limited. While I do not have any data on this topic yet, I will be working with Brent Jesiek to examine diversity literature citation patterns among engineering education journals.

Looking at *JEE* and *IJEE*'s stated goals and review criteria reveals that the two journals ostensibly have similar aims regarding new ideas and approaches. Of course the terms they use are open to different interpretations by editors and reviewers. "Degree of novelty or originality"

is one of *IJEE*'s review criteria.[43] *JEE* asks reviewers to explain how an article "contributes to new knowledge" and "presents original ideas."[44] Yet, despite the stated interest in original or new ideas, my experiences suggest that there are features of *JEE*'s review processes that work against some types of "new knowledge" and that that journal exercised a gatekeeping role in many respects.

IV. Final Thoughts

I hope that engineering education readers recognize that these are important questions about peer review and that examining what is allowed into engineering education journals is important for the development of the field. I hope that the project is received in the spirit in which it is intended – to raise questions and promote reflection, not to air dirty laundry or criticize any individual journal, reviewer, or editor.

After conducting his in-depth analysis of biology articles and proposals, Greg Myer's wrote, "I have found that the biologists who read my chapters…were not surprised by what I had to say, and were only surprised by the lengths to which I went to say it…So now I see myself not as revealing what is hidden under biology, but as making explicit what its practitioners know, and perhaps take for granted" (p. xiii). He was surprised by this, but hopes that his project can still "be useful to biologists trying to see why an article or proposal is causing them unusual difficulty, as well as to nonbiologists trying to trace the production of a scientific fact when they see only the last, public stage. That is, the project can be useful to biologists trying to get out of their assumptions, and to nonbiologists trying to get into them" (p. xiii). I do not know if most engineering education researchers would be surprised to read about my experiences. I suspect that like Myers's the value of my project likely lies not in revealing features of my experiences that would surprise most feminist engineering education researchers but mostly in making those experiences publicly available and open for discussion and challenging assumptions about what counts as quality EER on women and gender. In that way I hope that this project opens doors for more feminist and STS scholarship in engineering education journals, makes reviewers and editors reflect upon their own practices and assumptions, and opens the door for further, formal discussions of peer review experiences in engineering education.

In regard to STS and Women's Studies, I hope that my project serves as an example of critical participation, scalable scholarship, and non-theoretically elite theory development. I hope it furthers feminist science studies discussions of the rewards and challenges of working across disciplinary boundaries and *in* the sciences we would like to change. I believe detailed accounts such as this are necessary both for other scholars wanting to follow similar paths as well as for those who study the relationship between feminism and disciplinary development.

[43] Taken from review sheet I received as an author with my reviews.
[44] http://www.jee.org/submissions/review-criteria

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Appendix

Overview of Engineering Education Journals

--Used under fair use guidelines, 2011--

1. *Journal of Engineering Education*

The following is taken from the journal's Submissions website:
http://www.jee.org/submissions

MISSION

The Journal of Engineering Education (JEE) serves to cultivate, disseminate, and archive scholarly research in engineering education.

RESEARCH AREAS

The journal publishes manuscripts in a wide variety of research areas in the field of engineering education. A particularly rich description of research areas in engineering education may be found in the special report, "The Research Agenda for the New Discipline of Engineering Education," *Journal of Engineering Education*, 95 (October 2006) 4, pp. 259-261, which includes: what knowledge and competencies engineers must possess and how they are learned and assessed (*epistemologies and assessment*); how educational methods, materials, infrastructure, and faculty affect learning (learning mechanisms and systems); and how to attract, engage, and retain diverse human talent to engineering (*diversity and inclusiveness*).

MANUSCRIPT REQUIREMENTS

Manuscripts are expected to report original research that significantly extends the body of knowledge in the field of engineering education. Quantitative, qualitative, and mixed methods research designs are accepted. The journal typically publishes two types of manuscripts: research investigations and research reviews.

Research investigations should state the questions addressed and their context relative to the body of knowledge on the subject. The relevant theories should be presented, research design described, limitations acknowledged, and research methods and instruments discussed so as to permit evaluation of the validity and reliability of the evidence offered. Ethical considerations in data collection, analysis, and reporting involving human subjects should be addressed. A description of any statistical analyses, discussion of the uncertainties, and the significance of the results to advancing engineering education research or practice should be provided.

Research reviews should state the propositions addressed in the review and their context relative to the body of knowledge reviewed. A review might include a critical analysis, synthesis, or evaluation of previous research to provide new perspectives, a new knowledge structure, general conclusions or overarching principles, or new research directions. Reviews using meta-analytic approaches are encouraged. An explanation of the significance of the insights gained to advancing engineering education research or practice should be provided.

The following is taken directly from the journal's Review Criteria website: http://www.jee.org/submissions/review-criteria

The journal seeks to obtain at least three reviews on all manuscripts. Reviewers are asked to evaluate manuscripts according to six criteria and to provide a narrative summary of their evaluations. Four criteria relate to the scholarly content and contributions of the manuscript and two to the quality of the composition and presentation. Manuscripts are expected to:

- state clearly the questions or propositions addressed and the significance of the research to engineering education research or practice (*focus and relevance*);
- situate the research within relevant bodies of knowledge and describe how it contributes to new knowledge (*context and contribution*);
- employ research designs, methods, theories, and/or practices appropriate to the research performed (*research validity and reliability or credibility and dependability*);
- present original ideas or results of general significance supported by clear reasoning and compelling evidence (*results and generalizability or transferability*);
- exhibit clear, concise, and precise exposition that appeals to a broad international readership interested in engineering education research and practice (*clarity and readability*); and
- provide tables and figures, as needed, that meaningfully add to the narrative (*useful illustrations*).

JEE is publishes four issues per year. In recent years, each issue has had approximately 6-9 articles.

2. *European Journal of Engineering Education*

The following is taken directly from the journal's Taylor & Francis homepage: http://www.tandf.co.uk/journals/tf/03043797.html

Aims & Scope

European Journal of Engineering Education is published six times a year in print and electronic editions and provides an essential forum for dialogue between researchers and specialists in the field of engineering education, at European and worldwide levels.

European Journal of Engineering Education is the Official Journal of SEFI, the Société Européenne pour la Formation des Ingénieurs (the European Society for Engineering Education). SEFI is a non-governmental organization whose aims are to develop information about engineering education, to improve communication and exchange between professors, researchers and students and to promote cooperation between the various institutions concerned with engineering education.

European Journal of Engineering Education examines the economic, cultural, and social factors which influence the education of engineers in different societies and provides a forum in which teachers and researchers in engineering schools, institutions and industry can share accounts of good practice and discuss methodology. Technological change constantly creates new demands on both engineers and the educational system that produces them. The Journal contributes to the development and improvement of engineering education necessary to meet those demands. While ***European Journal of Engineering Education*** puts a special emphasis on specific European developments in the field of engineering education, the Journal also welcomes papers presenting a worldwide perspective and with an international or intercultural dimension.

In addition to regular issues, from time to time the Journal also publishes special themed issues, each with a specially appointed Guest Editor, which concentrate on a theme that is of general value to everyone involved in engineering education and has particular applications within different engineering disciplines.

The structure and organization of the Journal

The Journal welcomes ***research papers*** *as well as* ***position papers*** and ***review articles*** that debate and explore strategic, theoretical and methodological issues, methodological approaches (assessed best practice), and substantive topics.

Papers may be submitted in English but also in French or German, the three official languages of SEFI.

All published research articles in this journal have undergone rigorous peer review, based on initial editor screening and anonymous refereeing by independent expert referees.

The ***criteria*** used in the reviewing process are:

- Importance of the subject for engineering education and its developments
- Suitability for publication in the Journal according to its editorial policy and scope
- Pertinence of the paper and the ideas developed in relation to the topic
- Originality and innovative potential
- European and/or international or intercultural perspective
- Quality of the scientific evidence presented
- Quality of the literature review
- Readability, format, style and language

As noted, *EJEE* publishes 6 issues per year. In recent years, the approximate number of articles per issue has been 8.

3. *International Journal of Engineering Education*

The following is taken directly from the journal's homepage for Aims and Scope: http://www.ijee.ie/aims.html

> Aims and Scope
>
> The International Journal of Engineering Education (IJEE) is an independent, peer-reviewed journal. It serves as an international archival forum for scholarly research related to engineering education. The journal has recently published in numerous areas of engineering education including:
>
> Electrical Engineering, Mechanical Engineering, Civil Engineering, Chemical Engineering, Computer Engineering, Agricultural Engineering, Aerospace Engineering, Thermodynamics, Structural Engineering, Control Engineering, Robotics, Mechatronics, Fluid Mechanics, Nanotechnology, Simulators, Web-based Learning, Remote Laboratories, Engineering Design Methods, Education Research, Students' Satisfaction and Motivation, Global Projects, and Assessment.

This is the only information (about the aims and scope) for potential authors on their website. Their Guide for Authors (http://www.ijee.ie/GuideForAuthorsNov09.html) contains only formatting and style guidelines. *IJEE* does not publish its review criteria on their website. Their review sheet, which I have seen with my returned reviews, includes the following fields for reviewers to enter their feedback:

- CONTENT (e.g.: Clarity of objective; basis of theory; conclusions drawn; understanding of subject, contribution to engineering education.)
- DEGREE OF NOVELTY OR ORIGINALITY (e.g.: presence of new ideas; innovative contribution; bulk of the material has not been published elsewhere.)
- STRUCTURE OF PAPER (e.g.: general layout; use and number of figures/diagrams, etc.)
- QUALITY OF TEXT (e.g.: Clarity of expression; consistency; readability; number of quotations and references)
- REVIEWER'S GENERAL OPINION AND COMMENTS (e.g.: correctness of the text; applicability of the items included; quality of the paper; scope covered.)
- RECOMMENDATIONS

IJEE publishes six issues a year. In recent years, each issue has had approximately 20-25 articles. The journal very often has special issues.