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# Feminist Theory and the Culture of Scientific Practice: Making Sense of my Experiences as a Female Engineer

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## Introduction

In 1976, 42 students entered a chemical engineering program at the University of California at Davis. I was one of 13 women among those 42 students. In my first few years out of college, I would often hear of my female peers leaving the profession; only knowing of two women who remained in the field after ten years. Data show it is not unique to my class that a higher percentage of women and ethnic minority scientists and engineers leave the field within five years. For example, Frehill reports that within three years of graduation, 71% of men and 61% of women who earned a bachelor's degree in engineering were still in engineering jobs.[1] For chemical engineering majors graduating between 1985 and 1989, 45% of men remained in the chemical engineering workforce, compared to 35% of women. This exodus has led me to wonder why so many qualified women in science choose to leave the field or never seriously consider the field at all.

For me, the decision to leave the profession was partially due to conflicts between engineering and family, but also due to my desire to encourage more young women to pursue science studies, a passion that evolved from connections made through my involvement with the Southern California section of the American Institute of Chemical Engineers. As a young female engineer on the board of our local section, I was often asked to give guest lectures and presentations at high schools. Recognizing my value as a role model, I returned to school to become credentialed as a high school teacher of science and math, and later received a doctorate in science education. However, I found that it was still very difficult to convince my promising female students to consider science majors for college.

As an author and editor for the Report on the Status of Women and Girls in California™ since its 2012 inception, I have noted that the number of women and girls entering the science, technology, engineering and mathematics (STEM) fields in California has remained a small percentage, particularly as one looks at advanced degrees in the physical sciences and engineering. Reports on the Status of Women and Girls in California show that little progress has been made since I enrolled in a bachelor's of science in engineering program.[2] While women are now more likely to obtain a bachelor's degree than men, they are still far less likely to major in STEM fields. In 2013, less than 2% of women across the United States who earned bachelor's degrees majored in engineering. In addition, less than 2% of women earning a degree majored in mathematics, statistics and computer sciences; less than 1% of women earning a bachelor's degree majored in computer sciences. The number of women further decreases when we examine advanced degrees. Less than half of all professional and doctoral degrees are held by women. This is particularly true in the STEM fields. For example, the ratio of men to women earning doctoral degrees in mathematics is nearly 3 to 1 when measured by the percentage of those earning bachelor's degrees continuing to a doctorate.[3]

Before one can suggest any modifications or solutions, we must first understand the obstacles and limitations women face as they attempt to enter, and advance, in the STEM fields. One obstacle is the underrepresentation of female professors in many STEM majors who may serve as mentors and role models. For example, in 1995, Ginorio reported that half of the physics doctoral programs in the United States had no female faculty members.[4] While efforts have been made to improve these numbers, the number of female physics professors at the associate level and beyond remains at less than 18%.[5] This continues to negatively impact female students, as implicit biases held by faculty influence gender dynamics in the classroom.[6] Feder encourages universities to ensure that female faculty at the upper levels also serve on committees to increase their power on editorial boards and with hiring decisions in order to address inequities in the field, such as salary, awarding of grants, laboratory space and promotions.[7] I have often reflected on my decision to leave engineering and the outside influences that led to doing so. The encouragement I received about my science abilities contributed to my decision to enter engineering, and female role models were powerful influences in my early career. However, I did not have female professors or women role models while I was in college, and I wonder whether this absence contributed toward my doubts and frequent feelings of being an outsider in the field.

While many believe that the strides made in the past decades have opened STEM fields to women and other underrepresented groups, little has changed in the culture of scientific practice. Thus, a sense of belonging still has a large effect on whether women will enter and stay in these fields. My experiences in an earlier generation still resonate with the experiences of many women entering these fields today. In exploring how the culture of scientific practice, along with the hegemonic view of science in our society that privileges the value system associated with the scientific revolutionary period of sixteenth and seventeenth century Europe, I seek to challenge the practices that marginalize women's experiences and change the image of who can be a scientist. Framing the work of scientists through a feminist viewpoint, one that asks how the inclusion of women affects scientific practices, goals and outcomes may help to empower future science leaders. In my work as a science educator, I continue to challenge myself and future teachers to consider how their teaching styles and representations of science impact the choices of the women and other underrepresented group members who enter STEM fields. Thus, this paper will frame my own experiences in engineering with findings in the literature regarding role models, societal perceptions of science, and the hegemonic structure of STEM education and practice.

**Lack of role models for women**

The lack of role models and encouragement for women continues as a major obstacle for success.[8] In math, science and engineering courses, the student who believes that she is alone in the struggle to understand a new concept is likely to become discouraged and quit. This lack of role models for women is even more critical in view of the stereotype of a scientist as a male genius. Feminist studies, which aim to contextualize women's experiences and explore how normative gendered assumptions have led to inequities, have challenged these hierarchical ways of knowing about the world. Hughes further discusses the hierarchies of knowledge, describing how as a student of science she was awarded the privileges of being perceived as smarter, and therefore, better than her peers in the humanities.[9] As an engineering student, I also felt pride in studying a major that led others to perceive me as "smart," but also felt like a fraud in that I did not view myself in the same way.

A common perception on the UC Davis campus was that the chemical engineering major held the highest status, and was considered to be the most comprehensive and the most difficult. Thus, even within the engineering community, I received a degree of respect simply by virtue of my major. Similarly, of the pure sciences, many view physics as the most fundamental science, requiring a more advanced level of mathematics and the highest levels of intelligence. With these intimidating views of engineering and physics, women have read the societal signals that it is okay not to know science if you are female.[10]

While I was an undergraduate student, my mother reinforced this thinking by consoling me when I called to tell her of my struggles in class. "Girls don't need to know that much math," she would tell me. "It doesn't matter if you fail." Many of my male classmates would comment that I should just get married and not worry about grades. I also noticed that many of my male classmates had spent their entire lives knowing that they wanted to be scientists. They were competent at working on engines and electronic devices.

They exhibited confidence in their abilities to do lab work and usually took control during group assignments. Perhaps they, too, had heard the societal voices that women do not need to excel in STEM disciplines. While I had grown up with chemistry sets and microscopes and loved spending hours on "research" and explorations, I never really considered myself a scientist.

In talking with many female friends and acquaintances that had successfully entered STEM careers, I found that most believed that a strong influence on their success came from a family member who was a scientist. Chinn discusses this influence in describing a young woman in her study that chose a STEM degree after learning of a role model's career: "Meeting her godmother, an engineer, was a revelation," the young woman said.[11] It struck her that a girl could, indeed, succeed and confirmed for her that she wanted to be an engineer. Several of my female friends told tales about struggling in courses, and noted that their perseverance was possible largely due to hearing family members' assurances that they, too, had struggled and overcome to reach their own positions.

In my own experience, I benefitted from having role models at key times, but also dealt with the negative perceptions of society that limited my science identity. As a high school junior, I wanted to enter the medical profession and was considering training as an x-ray technician. My male chemistry teacher, however, felt that with my abilities and interest in the sciences, I should broaden my goals and consider going to a four-year university. One morning when I showed up for class, he informed me that I would be joining the school's guidance counselor and a small group of female students for a trip to a "Women in Engineering Day" at the local state university. The opportunity enabled me to hear several women talk about how they had overcome obstacles to become engineers. I was intrigued by the jobs that they described. After that, I decided that I would, indeed, pursue an engineering degree.

Role model effects include exposure to potential careers, much like my experience in attending the Women in Engineering conference as a high school student. Bleemer found that the simple arrival of a female physician in the hometown of twentieth century California college students increased the likelihood that a woman would choose a STEM major by 5%.[12] During my university years, I met my mentor, Mary, through my involvement with the American Institute of Chemical Engineers. Mary, about ten years my senior, was a practicing engineer at the engineering/construction company where I would later work. She was actively involved in programs similar to the one that had sparked my initial interest in engineering. Mary, the sole female member of her class at Penn State, was a pioneer for women engineers in many ways. Overcoming many prejudices against her during her schooling did not prepare her for the continued need to prove herself as she pursued her career. When she took her first job in engineering, she was given the title of "secretary" despite her work as an engineer because her peers could not reconcile the job title of engineer with her being a woman. In addition, because she did not receive her deserved title, she was not paid at the same salary scale as her male counterparts. Years later, when women in engineering had become more accepted, she met even more resistance as she tried to convince her employer to increase her salary to reflect her experience as an engineer. When they refused, she found employment elsewhere. Although her new position was considered entry-level despite her more than ten years of experience, she was earning twice the salary of her previous position. As my mentor, Mary's stories of perseverance helped me through difficult times and guided me early in my career.

Recognizing this need for role models, many outreach programs strive to put successful students in positions to share their experiences with younger children. As a graduate student, I was the coordinator for one such outreach program, known as the Physics Circus, that took a performance involving physics demonstrations to local schools. The program was sponsored by the physics department and was staffed primarily by female volunteer faculty and graduate students. While this had many advantages in terms of showing students who physicists are, I wonder if we were truly getting the message to the children that women can be great scientists and engineers. It can sometimes be difficult for science educators to be seen as scientists by their students, who may be more conditioned to view women as teachers or professors. It is part of the science and education communities' responsibility to broaden students' visions of what women can achieve.

**Societal perception of science**

Negative stereotypes about the abilities of women in science can be debilitating to performance and may further explain persistent gender gaps.[13] Haussler and his colleagues found that in physics, for example, women responded positively when the associations to their own experiences or life situations were obvious.[14] Exploring interest in learning physics with motivational factors ranging from a "pure physics" interest to an interest in the social impact of physics, Haussler's study points to gender differences. They found that a majority of women were more interested in the social impact of physics, such as medical applications, while men were motivated when physics was presented as a pure science, or as being highly technical.

Communication styles, too, vary among cultural subgroups, and may also contribute to feelings of belonging. Since science has been dominated by European male culture, members of certain subgroups may feel ill-at-ease. These differences in communication styles may also lead to different ways of participating in scientific meetings, which can be critical to career advancement.[15] Differences in communication styles may have also contributed to the perception of women STEM students that they did not receive enough feedback or affirmation from their science professors.[16] Competitive styles may also disenchant certain subgroups. Students may feel alienated by the culture of the science classroom and find it irrelevant to their everyday life experiences.[17] In my engineering work experiences, I was often told to not speak during meetings, but to voice my questions to my supervisors afterwards. It was many years before I rediscovered that I had a voice.

Part of my own frustration with the field of engineering is related to science as being value-free. While science is said to be objective, I sometimes struggled to see how I could be a caring citizen, concerned with peace and environmental harmony in the world, and yet work in a field that did not appear to prioritize those values. I became frustrated when I tried to be innovative in my designs and include new technologies that I believed would result in less environmental impact from the industrial facilities I was designing — only to be told to simply follow the plans that had been designed 20 years earlier that had been used "successfully." Although these frustrations may not be limited to women, I felt much less conflicted in my years as a professor. I was more comfortable in believing that what I was doing was having a positive effect on society.

In my tenure as an engineer, I received persistent messages, both implicitly and explicitly, that women should not be engineers. Although my mentor had paved the way for me to find success, I often dealt with the fact that my experiences would be different as a woman. One project, designing an oil refinery to be built in Kuwait, was especially interesting. I was given a male administrative assistant, the only one at the time in this company of over 2,000 employees. He was to dictate all of my results to the client, who was not to know that I was female. I recall one day when one of the senior members of our project team came down to my floor and found me in a discussion with my assistant. The team member, assuming that I was the assistant, walked past the young man and handed me a pile of papers to photocopy. Before I could explain his mistake, my boss stormed out of his office and screamed that I was the talented engineer for whom he was looking. I was thankful, at least, to have an immediate supervisor who believed that a woman could do the work. However, even he became very disappointed when I showed him my engagement ring. He responded with his expectation that I would soon have other priorities and would not remain in engineering. Unfortunately, he seemed to take me less seriously after that.

One wonders how far women have come since the writings of Kant that appear in *Changing the Educational Landscape: Philosophy, Women, and Curriculum:*

> "A woman who has a head full of Greek...or carries on fundamental controversies about mechanics ...might as well even have a beard." Therefore, Kant's point was that, insofar as women did master these subjects, we would not be women; we would be men.[18]

In many ways, I felt pressured to be less feminine in order to achieve success, and even wondered if being a female engineer was compatible with being married. I often struggled with the dichotomy of my femininity and my work identity. While in my youth I argued that women were equal to men, I came to understand that ignoring what makes women feminine forces them to forfeit the ability to make unique contributions to science from a feminist perspective. Duran discusses from a philosophical viewpoint the literature related to feminist science.[19] Her writings about Fuller describe the ''post hoc tinkering that frequently occurs in theoretical accounts of science, many of which are designed to heighten the notion that science is a more rational, or in some sense purer, endeavor than it actually is."[20] She also discusses the implications of a singular scientific method, which tends to privilege the physical sciences over the biological due to the differences in methodological approach, and the work of Thomas Kuhn. Citing the work of Evelyn Fox Keller about the research of Barbara McClintock, Duran identifies how the use of alternate methodologies interfered with McClintock's ability to gain consensus within the scientific community. McClintock, trained in the positivist tradition, which views scientific work as purely objective, used methods that were outside of the scientific method. She used intuition and developed an empathetic relationship with the corn plants in her study. Yet her work produced some very revolutionary and important knowledge in the field of genetics.

Women are often socialized out of science due to the view of women portrayed in science. Women are also socialized out of science due to conflicting societal messages about what is expected from women.[21] Girls learn that to be feminine is to be "intuitive and rational." Later comes the conflicting message telling her that to be a scientist, she must think objectively and linearly, traits our society labels as "masculine."[22] These messages have also led to occupations becoming gendered, or segregated by sex. Hochschild described the roles of gender and society's stereotypical roles for men and women, positing that the gender revolution would be viewed as incomplete until males moved into historically female roles at the same rate of females entering male roles.[23] Friedman builds on this argument by noting that popular culture focuses on teaching women to "lean in" and be more like men in order to achieve success in "male occupations," while campaigns continue to exploit the stereotypes that women are nurturers and men are strong.[24] For example, men are encouraged to enter nursing programs with slogans such as, "Are You Man Enough to be a Nurse?" Financial incentives continue to negatively influence parity in movements within gendered professions. For example, nurses generally have lower salaries than physicians in the medical profession.

Past efforts to include more women in science have emphasized improving visuospatial skills, assertiveness training, competitive sports and other mechanisms to help women enter the culture of the white male scientist rather than allowing for adaptions to the culture of science that would make it more female-friendly.[25] Barton argues that reform initiatives in science education need to use the personal experiences of women to help them grasp science more readily and to make it more interesting.[26] In her community college chemistry course, Barton modified her lessons to give value to the ways in which women experienced science. She describes how the hegemonic view of science in our society tends to marginalize women's experiences. Similarly, Martin describes that women tend to choose fields that are at risk of being downgraded in academic standing and resources.[27]

**Hegemonic system (the gatekeepers)**

Even for women who achieve academic success and attain a scientific degree, in some ways, their battle for standing and acceptance in their field of choice is just beginning.[28] The culture of science and science teaching has historically been dominated by the culture of the white male, and that culture aims to tell us what does, and does not, count as science.[29] Scientists use models, metaphors, procedures, technologies and other ideas from older European traditions in defining what we know as science.[30] When metaphors and pedagogies are only understood by a few, they lose their value. This is true in the scientific community, where the use of metaphors has been dominated by male culture and warfare, thus potentially alienating women.[31] For example, ''Nature is Machine" is only valuable to people familiar with mechanical devices.[32] Other discourses used in teaching STEM continue to reinforce existing power structures and do not promote equity in STEM fields.[33]

Another example presented by Martin shows how these teaching descriptions can be demeaning to women. There is a metaphor used in immunology where the feminized, primitive phagocytes kill by engulfing and eating the enemy, whereas the masculinized T cells kill by penetrating or injecting. While both are often killed in the process, the T cells are given heroic deaths — imagery as David taking on a Goliath (the tumor cell). Calabrese-Barton further argues that the language of science can result in the silencing of women's voices within STEM classrooms.[34] Citing issues with the naming conventions of a distillation apparatus related to male and female parts, Calabrese-Barton discusses how the constructs of positionality and feminist liberation education can bring light to the need for scientific language to consider how certain conventions might marginalize groups.

This industry hegemony is kept in place by both the reluctance of outsiders to break the traditional images and by those in positions of power acting as gatekeepers of the status quo. Malcom gives an example of this oppression in her review of a book by Margaret Rossiter that includes a letter from Robert Millikan urging Duke University scientists not to hire a female candidate they were considering because doing so would negatively impact the department's prestige.[35]

Beginning with education in the sciences, competition and teaching styles that do not stress the relevance of the subjects taught tend to marginalize female students. Mayberry suggests that this competitive style of teaching deters many women, stating that "competitive classroom culture appears to facilitate individual achievement for white men, but acts as a significant deterrent to women's achievement."[36] As I began to more critically examine my own teaching practices, contemplating if my use of competition in the classroom counteracted my efforts to be a role model as a female engineer, I wondered if this informed my difficulties in getting my female students to consider science majors in college. After much thought, I tried to present a view of science that included more collaboration and minimized competition. This was a realistic representation of science given my experience in the field.

Competition was present amongst various groups; however, there was also much collaboration and sharing of ideas with outside groups.

Self-esteem issues for women, which may be related to the atmosphere of competition, also contribute to difficulty in finding academic and career success in the sciences. Martin argues that educational equality must go beyond identical education for all:

> "Educational equality between the sexes is still far from having been realized," the [Organization for Economic Co-operation and Development] report says, I fear that as long as women's education is designed on the one hand to develop traits genderized in favor of males and on the other to ignore gender differences related to learning, this finding will continue to hold true. In the name of identical educational treatment, girls and women will experience difficulties and suffer hardships our male counterparts will never know. But if identical treatment is untenable — if, indeed, it gives us the illusion of gender neutrality — when in fact it intensifies the problems of becoming an educated women.[37]

Chandler and Parsons further discussed many self-esteem issues for women.[38] Several girls in the study expressed the opinion that they were not good at math because they had to work at it, and they often asked for help. The girls pointed out that although they got A's in math, they had to work hard to get those grades. The authors also believed that girls were often unable to see the relevance of science and, therefore, did not find it enjoyable to study. Self-esteem issues may explain some of Ginorio's findings that women with college GPAs similar to those of their male peers tended to more negatively evaluate their intelligence, even after college.[39] Self-confidence declined drastically during the first year of college and for most did not improve back to the level of the students prior to beginning their college studies.

This decline of self-esteem actually begins even earlier. Middle school is a time when many girls begin forming a negative view of science and math, and start drifting away from elective courses in those disciplines. In a survey of girls and boys ages 9-15, the dramatic effect of self-esteem for girls is evident. Bailey states that "... during adolescence, both boys and girls experience a significant loss of self-esteem in a variety of areas. However, the loss is much more drastic and long lasting in girls than in boys."[40] The study suggested that there is a complex relationship between self-esteem and choices that students make regarding their future careers.

## Conclusion

We must address the lack of role models, the societal images of scientists and engineers, and the hegemonic system of scientific practice in order for women to feel more accepted in the STEM communities. The challenges to removing obstacles for women in science involve providing more role models for women in science, changing the image of who is considered scientist material and what counts as science. The histories of science that have excluded many of the contributions of female scientists need to be rewritten to help modify the image of a scientist that society tells us about. It must be understood that it is not true that science is purely objective and value-free.

I am hopeful. Feminist theories have broadened my view of what counts as science. I am better able to understand the conflicts that I lived with as I navigated the male-dominated world of engineering. I hope that these lessons will enable me to motivate science teachers into presenting science in more inclusive ways. Eventually, our society may begin more fully to embrace women as scientists. Instead of forcing women to assimilate and take on a masculine orientation to science, the field can make room for new perspectives and insights from women in STEM disciplines. Female scientists can become the heroines for young women who aspire to be STEM professionals.

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## Acknowledgments

Ann McElaney-Johnson, PhD, *president*
Robert Perrins, PhD, *provost and academic vice president*
Stephanie Cubba, DPA, *vice president, institutional advancement*
Kimberly Kenny, *associate vice president, institutional advancement*
Emerald Archer, PhD, *director, center for the advancement of women*
Phillip Jordan, *editing; manager, communications and marketing*
Piper Murakami, *design*
Avni Thakkar, *proofreading*
Geena Davis Institute on Gender in Media at Mount Saint Mary's University

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The Center for the Advancement of Women at Mount Saint Mary's University


**About the Center for the Advancement of Women**
The Center for the Advancement of Women at Mount Saint Mary's University is a hub for gender equity research, advocacy and leadership development. Its vision is to find solutions to persistent gender inequities and work with partners to eradicate those inequities in our lifetime. That goal includes eliminating obstacles that women face in the workplace, in their communities, in the media and beyond to make a positive difference in the lives of women and girls in California and our nation. The Center also creates public programming, research guides and training opportunities to engage more partners in its work. **MSMU.EDU/CAW**

Mount Saint Mary's University LOS ANGELES

**Mount Saint Mary's** is the only women's university in Los Angeles and one of the most diverse in the nation. The University is known nationally for its research on gender equality, its innovative health and science programs, and its commitment to community service. As a leading liberal arts institution, the University provides year round, flexible and online programs at the undergraduate and graduate level. Weekend, evening and graduate programs are offered to both women and men. Mount alums are engaged, active global citizens who use their knowledge and skills to better themselves, their communities and the world. **MSMU.EDU**


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