The Changing Landscape of Mechanical Engineering: Learning to Embrace My Ecofeminist Identity Within the Elitism of Engineering

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Introduction

Mechanical engineering is an essential profession to our world. Mechanical engineers build infrastructure, design robots, develop energy alternatives, and create medical devices. The American Society of Mechanical Engineers (ASME) defines five core new technologies which are current areas of growth within the field: bioengineering, robotics, clean energy, manufacturing, and pressure technology [1]. Although mechanical engineering is often simply defined as the design and use of machines, or the study of objects and systems in motion, this list shows how mechanical engineering is much more than this, and is one of the most diverse and versatile fields of engineering.

So then, we must ask ourselves, what defines someone who identifies as a Mechanical Engineer? Engineering identity has been studied over the past few decades, and there is a general consensus that engineering identity is tied to one's professional identity. Beam et al. define professional identity as "how closely an individual relates to a particular field, profession, or occupation" [2]. Other scholars also emphasize the importance of professional identities considering both how people identify themselves, as well as how they are identified by others within the field [3]. This latter part of identity, where others are making judgments on who fits within the field, often comes from a comparison to the cultural norms that exist within the field [4]. Therefore, through better understanding of the professional and cultural norms of mechanical engineering, we can better understand what defines someone who identifies as a Mechanical Engineer. However, what happens when this identity and the underlying cultural norms are challenged? As we build a more inclusive culture, how do we integrate the core identity of mechanical engineering while also allowing space for a wider variety of identities?

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I am a third-year PhD candidate exploring the concept of the *hidden curriculum* of engineering, which includes the invisible norms, beliefs, attitudes, and values that we all unknowingly conform to, and that are engrained within classroom and professional environments [5, 6]. Specifically, I am applying principles from eco-feminism to support the deconstruction of the hidden curriculum of engineering education. Simply put, ecofeminism recognizes the connections between the oppression of women and the oppression of nature. Further expanding, it "*is the position that there are important connections between how one treats women, people of color, and the underclass on one hand and how one treats the nonhuman natural environment on the other*" [7, p. xi].

Within our society there is higher value and power given to the male–human–culture relationship than to that of the female–biological–nature. For example, our society, particularly within technical contexts such as engineering, values problem-solving with *rational* approaches above *emotional* perspectives. We see technical problems and critical thinking as requiring rational decision-making and there is little value for using emotions and feelings to support this decision making process in engineering [8]. For example, when designing a bridge, rather than just doing a logical data analysis from stakeholder engagement surveys, it would be beneficial to put more value on factors such as previous experience (what feelings have you had on bridges in the past?) and emotional empathy (what sociotechnical considerations should be made for the local communities and ecosystems?). We also tend to associate rationality as one of the qualities that makes humans superior, whereas we see emotions as being a more feminine approach closer linked to nature. This value hierarchy operates as if it is inevitable and logical, when in reality it is an "invented superiority" [9, p. 64]. I believe that it is essential in our engineering classrooms and workplace environments that we deconstruct some of these fabricated value dualisms to promote a stronger integration of the human–nature connection, and nurture humans' ecological connectedness.

Through my work so far, however, I have learned that throwing around words like *ecofeminism* in mechanical engineering brings up a lot of feelings. Some people are excited, curious, and eager to learn more. Others are immediately defensive where they don't understand how social justice concepts such as ecofeminism have anything to do with engineering. They defend their male-dominated, and hierarchical Mechanical Engineering identity and argue that ecofeminism is not a true engineering research topic.

Through this chapter, I explore my PhD journey so far, my past journey of where I came from, my internal journey that brought me to this work, my external journal in the comments and feedback I have received, and my future journey in the importance of continuing to pursue this work. I explore the values that are core to mechanical engineering, and consider how these come into conflict with values which I believe are core to the future of engineering, particularly for addressing challenges such as climate change and achieving the sustainable development goals [10].

This chapter provides a new perspective on engineering and how I believe that through shifting some of the value hierarchies that exist within the culture of mechanical engineering, we will be better equipped to address the challenges of the

future. I have had conversations on these topics with people from across career levels, including graduate students, early-career engineers, to late-career engineers. There is something different to learn from each of these conversations, and I always appreciate the wealth of knowledge and experience that people bring to understanding and uncovering engineering's value systems. Regardless of where you are in your educational journey or in your career, I hope you enjoy reading this chapter. And if you ever feel uncomfortable with my words, I hope that together we can explore where this discomfort is coming from and learn how to challenge and expand the identity that has been deeply engrained within us.

My Past Journey: Where I Came From

My engineering education and career have meandered through many different disciplines and a variety of experiences. I completed my undergraduate degree in Manufacturing Engineering with a Biomedical Specialization; I worked in industry as a Lean Project Manager for 2 years; I went back and did my MSc in Civil Engineering; I worked as a staff member in academia for 3 years as an Engineering Accreditation Specialist; and currently I am pursuing my PhD in Mechanical Engineering. This wandering journey also represents a slow increase in my self-awareness of the engineering identity I was developing.

During my undergraduate degree, I was fairly accepting of the education I was receiving, and I did a lot of "leaning in" to the culture. I knew that I was a woman in engineering and that this was an accomplishment in itself as people often reminded me of this fact, such as family members saying: "Wow, you must be a smarty pants if you're in engineering!" However, I didn't notice the microaggressions and engineering identity that was being embedded within me throughout my undergraduate degree. Thinking back to all my lab groups and design teams, I was rarely with other women. Both in my first year and my final year design team, I was with three male students, and at the time, I didn't notice the subtleties of always being the one responsible for taking meeting minutes, writing up the report documents, and organizing group meetings. I was assigned these tasks instead of the technical design tasks likely due to my gender and an assumption of my skillsets. Even when I was assigned technical tasks, this was typically on top of my more administrative tasks, often with me reassuring the others that it wasn't too much work, "Oh no worries, I'm happy to help!" This lack of awareness is common; research has shown that female students often do not "*question the profession's central narrative about itself*" [11]. I certainly did not question the gendered narrative and work distribution that was perpetuated within my design teams.

The values that I was taught during my undergraduate coursework were core to what I believed engineering to be—these being the masculine, elite, and individualistic narratives that had been promoted through my classes [12, 13]. One of the strongest values that I held core to my belief system when I graduated engineering was that the profession aspired to be *neutral* and *objective* [11]. This presumption

of a neutral and objective engineering culture aligned with my apolitical approach to engineering, believing that the profession existed within a meritocracy where all groups have equal access to success and that the profession was free of politics. The emphasis on problem-solving and the application of the design process, especially, gave me the misguided impression that engineering was based on academic and technical ability in a way that was objective and value-neutral.

Immediately after graduating, I went into industry working at a small manufacturing plant as the Lean Project Manager. In this role, I was responsible for working with the employees who manufactured our products to reduce waste and increase efficiencies in their manufacturing processes. This experience was the beginning of my identity crisis and realization of my discomfort with the elitism that the culture of engineering carries. The manufacturing employees, who were all MUCH more knowledgeable than me on the manufacturing processes, assemblies, and products, often looked to me as their superior. I distinctly remember discussing ordering a new welding arm with the foreman. We were discussing different options, and then he looked at me and said, "You're the boss, whatever you want we will make it work." I felt this frustration that he didn't want to collaborate with me, and he felt that somehow 4 years of engineering education made me the better person to choose a welding arm that he would be using every day, at a company he had worked at for over 20 years. Not to any fault of his, he had also been indoctrinated to believe that I was the elite and superior person, much more knowledgeable and powerful than he would ever be, simply because I had a degree attached to my name. Although I had often doubted my long-term career as an engineer, this was the first time I can remember having a sadness that as an engineer. I would be often doing my work very isolated and it would be assumed that I would need to take an individualistic, hierarchical approach to work.

Although this example highlights my growing identity disconnect with engineering's hidden norms and values, it is not to say that much of my work as lean project manager wasn't with a collaborative approach. In this job, I often was able to truly see the value of working and designing together. For example, I ran daily stand-up meetings with the employees to gather their feedback and ideas for improvements. These meetings were modeled after the Lean Six Sigma approach, with integrated practices from Agile methodologies (specifically, the "daily scrum") [14]. I held the short 10–15-min meetings at the beginning of the day on the "gemba" (work floor), where we all remained standing, and each employee gave a quick update. Typically, the guiding questions asked employees to look back (how did I do yesterday?) and look forward (what will I do today? any issues or concerns?). During these meetings, employees were encouraged to share and discuss their ideas for improvements. Ideas ranged from very small changes such as moving the location of a supply bin so that it was in closer proximity to the work area, to very large changes such as suggesting entire changes to the manufacturing process. I felt that these collaborative discussions, although brief, were always highly valuable to the employees to learn and brainstorm together, and to feel that they were active members of the decision-making team.

At this same organization, I also coordinated a half-day project to work with a group of five employees and redesign the stockroom, where we discussed current processes, outlined challenges, and brainstormed solutions for improving the flow of the stockroom and part ordering. In planning for this brainstorming session, I worked very hard to ensure the process would be bottom-up, and the employees would be empowered to take leadership on the redesign. They made the decisions, and then they helped to implement them and iterate on them. But even in these two situations, there was always a protective bubble that seemed to follow me around, making it difficult for me to truly connect with the manufacturing employees, all of whom were men. They stepped out of my way with a gentle bow of the body, any jokes or laughter stopped when I entered the room, and they always apologized for the one wall that was decorated with magazine cutouts of swimsuit women. Even when working collaboratively with them, I never truly fit in—being a young, female, engineer made me someone different, someone they viewed as both more intellectually elite and powerful, while also being more delicate and sensitive.

After 2 years at this company, I decided that it wasn't for me. I didn't quite know why; I didn't quite have a plan on what I would be doing next, but I just knew I couldn't stay there. When I quit, I felt like a failure and I felt like I hadn't accomplished anything in the job personally or professionally. In retrospect, it was a job I really liked and excelled at, and I wonder if I had had a female mentor if I would have stayed longer. Being able to talk about my experiences with someone else might have helped me to label my feelings more easily. At the time, I didn't understand that my disconnect with the job wasn't about my own ineptitude, but rather it was that my feminine, collaborative, and empathetic identity and leadership style conflicted with the implicit value systems of engineering which emphasize a more individualistic and elitist approach to the workplace.

My Internal Journey: How I Came to This Work

Quitting my engineering job was the beginning of my transition into finding myself, my identity, and my value as an engineer. While I was unemployed, I met up with a professor who was a friend and she had an opportunity I couldn't resist. Although I never saw myself going back to school for a graduate degree, she was specifically interested in finding someone who could research our engineering faculty's leadership program to better understand the impact of the program on students who had been in their career for a few years, which eventually became the focus of my MSc thesis [15]. This field of research, known as "engineering education," was something I had never heard of, but it was a perfect blend of my two strengths: I was able to use my engineering background and the ways of thinking I had been taught through my undergraduate degree, and apply these to investigate and understand engineering education, engineering leadership, and pedagogy.

As I progressed through my master's degree, I truly felt seen and felt I was gaining a better appreciation for my engineering identity. Within engineering identity

research, scholars have used the concept of *figured worlds* to conceptualize engineering identity into three areas of development:

- *Acting as an engineer:* This is the *making of worlds* which describes that through our actions we may shape the world we live in.
- *Others recognizing them as being an engineer:* This is the *positionality* of identity which acknowledges the hierarchy, social positioning, the importance of power in social interactions.
- *Believing themselves to be an engineer:* This is the *space of authoring* which understands how one integrates into the space/culture [4, 16].

For myself, during my MSc, I started to develop within each of these areas. By studying engineering leadership, I truly felt that I was able to *act* and use my engineering knowledge to shape and improve engineering education. As I spoke to more people across a wide variety of roles, including members from industry, professors, and students, I always received positive commentary on the importance of the work I was doing and I truly felt that I was *recognized* as an engineer. And although previously I had struggled to believe that I was a "real" engineer, I felt I had found my place in engineering and *believed* that I could do this work as an engineer. This is not to imply it was not without struggles—in fact, along with peers from across Canada, we conducted research and published a paper on the experience of engineering education graduate students. We found that students in this area often experience an identity crisis due to the epistemological differences between engineering research and educational research. Additionally, we often face critique and judgment when studying these topics from some engineering faculty members who often do not see the work and methods used as "real" engineering research (e.g., qualitative approaches are misunderstood and not valued as an accurate data analysis method by engineers who are only familiar with quantitative approaches) [17].

Fast forward a few years, and after my Master's degree I was now making the decision to continue my graduate studies and begin my PhD with a focus in engineering education (through the department of Mechanical and Manufacturing Engineering). As engineering education is not an official program at my university and there are only a few professors who study in the area, my supervisor did not have a specific focus or topic of study to give me. Rather, unlike my MSc, my area of research was left open-ended for me to choose a topic, as long as I pursued a project which investigated engineering education in some way. In my personal life, my identity was also transforming, where I had recently come out as queer and I was developing my passion for social justice work and grassroots activism. For this reason, I knew that I somehow wanted to bring a social justice or feminist perspective to engineering education in my PhD work.

Feminist thought was first brought into fields such as science and engineering by early scholars in the late 1980s including Haraway [18] and Harding [19]. These critical feminist theories have been powerful in bringing forward the invisible culture of STEM disciplines and many scholars in engineering education continue to build on this early work. Feminist pedagogies can observe the hidden ideologies in our programs and challenge the dominant assumptions of science and engineering

[20]. They make visible *"engineering's gendered boundaries,"* and consider whose identities are excluded from the universal narratives of engineering [21]. However, engineering and other technical fields are often very resistant to feminist discourses because of the presumption that engineering operates as a neutral and meritocratic field of study [11].

Meritocracies assume not to bias any group and assume that all groups have equal access to success. Engineering culture promotes the idea that a meritocracy is possible and we *believe* that engineering operates within a meritocracy. In other words, we see engineering as a value-neutral field where measurement of student success is based on purely objective assessment, and there is a positivistic approach to knowledge where there is one objective truth that we are seeking. However, although societies may aspire to be meritocracies, a purely meritocratic society is not possible, and research has shown over and over again that genetics, social class, upbringing, and just plain luck often play the most significant role in one's success in life [22]. The consequence, though, is that *this belief of meritocracy renders social justice topics irrelevant in engineering*, because any social injustices are unconnected when we believe the most talented and hard-working are rewarded [23].

As I further explored the literature on feminist thought in engineering, I was fascinated by the amount of work that had been done, with Donna Riley publishing a feminist approach to thermodynamics almost 20 years ago [24]. I was inspired and knew there was something I could do within this area of study. However, I also knew it would not be without challenges. Many of the publications talked about the difficulties of getting this kind of work recognized in engineering due to the confrontation with deeply rooted beliefs in engineering culture. For example, Beddoes [25] published an entire thesis which documented and reflected on her efforts to publish three gender-theory informed articles into engineering education journals. While I was still searching for a specific topic that I could research for my PhD, my supervisor introduced me to a professor from our Women's Studies department who teaches a course on *ecofeminism*. During our meeting it hit me like a ton of bricks—engineers have (mostly) adopted the idea of sustainability, and the "eco" lens of ecofeminism would be the perfect gateway for me to be able to talk about feminism in engineering without losing most of my audience.

Simply put, ecofeminism recognizes the connections between the oppression of women and the oppression of nature. More specifically, at its core, "*ecofeminism is the belief that coinciding ecological and feminine repressions are often more than coincidental*" [26]. Ecofeminist perspectives highlight the fact that there is higher value in our society given to masculinity, humanity, and culture as compared to femininity, biology, and nature. One of the biggest risks is that this value hierarchy operates as if it is inevitable and logical, when in reality it is an "invented superiority" [9, p. 64]. Within engineering these value hierarchies are especially prominent. For example, we emphasize the importance of innovation and technological progress. By "progress" we specifically mean that we value human and cultural progress, often with limited consideration for the impact of our progress on nature and the biological ecosystems around us. This value hierarchy is often taken even further, where we value technological solutions so strongly that we solve problems we

have created with further technologyengineering education, and ensure that our future engineers understand the importance of nurturing human's ecological connectedness.

Table 1 summarizes these hierarchized dualisms from ecofeminism and which are most prevalent within engineering culture. These represent maps that have been created through a process of cultural socialization within engineering culture, where we both internalize these maps and project ourselves onto them [9]. The higher value elements on the left side of the table are seen as correlated, and we notice when something is out of alignment. For example, this is why male students are believed to be more rational, and better at technical work, whereas female students are seen within to be more emotional, and to be better at social-oriented work. Additionally, our society sees these dualisms as two extremes, rather than as a spectrum across a scale.

For decades, engineering education scholars have been aware of the technical–social dualism which is prevalent within engineering culture [28]. For example, engineering students and professors will often publicly belittle other faculties, particularly anything related to the liberal arts as they see this as "weak" and strongly in opposition to their technical engineering identity [13]. Both symbolically and in practice, this techno-social dualism is considered mutually exclusive, because "at the core of engineers' identities and engineering practice lies a sense of the technical which specifically excludes the social" [28]. This mutual exclusion not only reinforces a very masculine approach to engineering, but it also promotes a culture of power, elitism, and often arrogance [29]. The gendered techno-social dualism also reinforces the gender binary of two genders that are directly in opposition with each other and hierarchical, with man being valued higher than woman and there being no spectrum between these two discrete genders [30].

Regardless of the dualisms present, it is important to note that engineering practice is fundamentally heterogeneous and needs to integrate across these dualisms. To succeed, engineers must effectively integrate both the technical and the social to meet the needs of society. Often, this heterogeneity of engineering is used to encourage more women to come to engineering, where advertising campaigns emphasize the social elements of the technical work. However, "*the assumption that women will both be more attracted to, and have more to offer to engineering if it is defined in non-technical terms leaves intact the equation of technology and masculinity*"

Table 1 Hierarchized dualisms

Higher value	Lower value
Culture	Nature
Man	Woman
Rational	Emotional
Active	Passive
Technical	Social

Adapted from [9]

[28]. This approach of attracting more women into engineering does not address the deep-rooted educational practices and continues to promote the mutually exclusive techno-social dualism. We need to be aware of how our discourses about engineering reinforce these dualisms and more actively work to deconstruct them.

As I learned more about ecofeminism and I relished the wealth of expertise from feminist engineering scholars, my theoretical framework was coming into view for my PhD thesis. I was now feeling more confident speaking to people about the work that I would be doing. Through these conversations with others, I truly began to understand how my work would be pushing the boundaries and making people feel uncomfortable as I attempted to break down their beliefs about what is core to engineering identity.

My External Journey: What Others Think/Feel About This Work

Generally, I have been very lucky to have mostly positive and inquisitive experiences in response to the work that I am doing. People are often very curious and want to learn more, and typically they have some personal experience that they can relate to my work. Through my workshops and presentations, I have found that people appreciate being able to label their feelings. After a recent conference presentation, one of the attendees connected with me on *LinkedIn*, and talked about her experience of often feeling marginalized at STEM conferences and that my "presentation helped [her] to find the words to articulate what was happening."

Although I have not been met with direct criticism, there is certainly sometimes a feeling of discomfort which comes out in the questions being asked. After a workshop I facilitated for a national organization, one of the participants reached out to me and asked to connect so we could further discuss the topic. In our chat, he admitted to me directly that he believed engineering did exist within a meritocracy and that this was not a bad thing—that we should be rewarding effort and that it is true that not everyone can be an engineer and there are certain capabilities which are required in order to succeed in engineering. We had a productive conversation, and dove into understanding why a meritocracy is not possible, which is why believing in one is dangerous and leads to inequities in our classrooms. It was an insightful discussion for both of us. I am still learning myself how to manage these conversations, and how to articulate my arguments. Luckily this work drums up lots of curiosity in others, so I will have plenty of practice before my final thesis defense!

The biggest wins I have noticed in conversations with others is when I am able to observe small shifts in thought, where someone builds on where they are currently at and moves *slightly* toward a more inclusive lens of engineering or justice work within engineering. For example, I was once in conversation with a professor about feminism and he was arguing that feminism gives off the wrong tone because we should consider more than just the women. During this conversation, I

introduced the idea of intersectionality, which can be defined as "*the interaction between gender, race, and other categories of difference in individual lives, social practices, institutional arrangements, and cultural ideologies and the outcomes of these interactions in terms of power*" [31]. He had never heard this term before, and was so excited to have the words to describe his feelings—which in essence was that much of the diversity work in engineering tends to prioritize white, western, heterosexual, cisnormative, middle-class women [25], without considering other marginalized populations.

As I continue through my PhD it will be important for me to regularly reflect and consider how I can provoke these dialogues that help nudge people to slightly expand their perspectives on what it means to be a mechanical engineer. Keeping in mind that as I continue my journey, each conversation is also a learning opportunity for me, to better understand the identity tensions that exist and to expand my own perspectives.

My Future Journey: Where Do I Go from Here

I believe that through facilitating workshops, engaging in conversations, and following-up on connections across my network, I have been able to make a difference. Although one-on-one conversations are not the most efficient way to make change, this grassroots approach provides me with the opportunity to learn and grow myself. I have been continuously learning from others, and I have been building my own knowledge to be able to better articulate myself. Slowly with time, I am gaining a clearer picture of how to make long-term, sustainable recommendations to change engineering culture. Change is often slow and difficult (especially in academia), but over time I hope I am able to continue making a larger impact, through bigger conversations, publications, and, eventually, systemic, sustainable change. This chapter is just another step in that direction. And systemically I am also making progress— our university is proposing a new program *Sustainable Systems Engineering* and they invited me to sit on the program design committee so that the program could have foundational elements of ecofeminism integrated into the program design [32].

As I continue this work, it's also important for me to consider activism burnout which comes with educational justice work [33]. Activism burnout has been shown to decline the emotional and physical health of individuals, and to cause a loss of hope in some activists. Although my supervisors have been extremely supportive of my PhD work, it is important for me to intentionally seek out mentors who can support me in my activism and feminist approach to engineering education. For every difficult conversation I have, I hope to be able to have triple the number of inspiring conversations to keep my energy and hope for a better future in this (sometimes) overwhelmingly depressing capitalist, white supremacist, and hetero-cis-normative society that we live in.

If this chapter has piqued your interest, you might also be asking yourself, what can you do? I don't expect that every engineering student, faculty member, and

practicing professional become a feminist and social justice advocate in their engineering careers. However, I think we can all start somewhere. We can be more observant of the culture around us and label what we observe. We can see the dualisms that exist in our engineering culture, and break down these hierarchies to bring light to the spectrum of perspectives. We can be honest about why someone might feel a disconnect with engineering, and help them understand that it's not them—it's the system and culture that's making them feel like they are not part of the elite brand of engineering. We can resist changing ourselves to fit into this culture, and bring our own unique perspectives to the table. We can connect with and support each other on our journeys, so that we all feel a little less alone in this crazy world.

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