A Systems Approach to Understanding Gender Inequity in Engineering

by

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University of Texas at Austin, 2013

SUBMITTED TO THE SYSTEM DESIGN AND MANAGEMENT PROGRAM
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN ENGINEERING AND MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SEPTEMBER 2022

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Abstract

Gender inequity is a very difficult topic to grapple with as most existing articles, books, and opinion pieces around the subject like to focus in on one particular problem or issue. Gender inequity in STEM has been a hot topic of conversation for years, with people pointing fingers at certain potential root causes such as a limited talent pipeline, parental planning, lack of retention, and many others. These issues are not single source issues, however, and cannot be thought of as such if meaningful change and progress is to result in the overall STEM workforce. As STEM itself is extremely broad, this thesis seeks to focus on gender inequity in engineering specifically, and to assess and dissect issues and opportunities from a systemic approach.

By leveraging learnings and processes relevant to Systems Management and Systems Design, the research and work enclosed in this thesis intends to pursue multiple lines of inquiry into the system level makeup of the engineering world and how it does or does not support gender equity. This research analyzes existing data sets available for working women in many disciplines, as well as incorporates input from a set of interviewees comprised of female engineers. Defining the relationships between many seemingly separate issues may lend insights into how academic institutions, corporations, and society as a whole may be able to implement some staged solution sets to improve gender parity and equity throughout the engineering field.

Thesis Supervisor: Donna H. Rhodes
Title: Principal Research Scientist, Sociotechnical Systems Research Center

Acknowledgements

I dedicate this thesis to all the women who paved the way for me to be in this position right now. I am still one of very few women in my specific profession, but I am thankful that I rarely have to be the "first" in most situations. I have been the only woman on an offshore vessel, the only woman in an engineering classroom, and the only woman overseeing a field crew in the deserts of West Texas, but I can only imagine what it was like to be the first woman in these places. These female pioneers have enabled significant change in the last two decades alone, and because of their sacrifices both personally and professionally, I feel emboldened to push the envelope and pursue challenges like this thesis.

I never saw myself pursuing a master's degree. Prior to 2020, I saw myself staying put at my previous role for at least another year. My then-supervisor reached out to me to nominate me for a position in Chevron's Digital Scholar program, where I would spend a year in the MIT System Design and Management (SDM) program, and I had frankly not considered it as my then-spouse was unsupportive of me seeking additional schooling. Thankfully, many other factors converged in the perfect storm, or as we call it in systems thinking "an emergence", and I was able to see a new path ahead for me in life that included exiting my unhappy marriage and choosing to enroll at MIT. I could not be more thankful to all of those in my life who have supported me from that point onward. This thesis would not have been possible without their love and support. Thank you to my parents who have continued to encourage me to always think outside the box and explore all opportunities. Thank you to my partner Cory for continually asking me "what did you do on your thesis today?" and for always making sure I had a margarita handy when needed. Thank you to Cory's mother, Janette, for checking in on me weekly and then telling me "Get back to my homework" when we were done chatting. Thank you to all my family and friends in Canada and across the US who so eagerly shared my interview request with their professional and personal networks, many of whom signed up to be interviewed themselves.

A very large and special thank you to my advisor, Donna Rhodes. Donna has been so enthusiastically supportive of my work from the first time we spoke in December of 2021. She not only offered to be my advisor before I could even ask her for myself, but she has routinely leveraged her personal and professional network to send me resources, contacts, and ideas. Her passion for this subject matter, along with her expertise and experience in thesis writing, has proven invaluable. Thank you to Diane Rigos from the MIT Energy Initiative, and Joan Rubin from the Systems Design and Management Program. Both women have provided me with insights and perspectives from the onset of this topic becoming an initial thought back in summer of 2021.

An additional big thank you to everyone back at the Chevron mothership, including Margery Connor, Chris Lewis, Ayo Lawrence, and many others. Margery shared multiple wonderful connections with me at Chevron that will undoubtedly prove useful far beyond this thesis, for which I am eternally grateful.

Finally, my love and thanks to my Chevron SDM cohort. The 14 others on this journey routinely provided moral support, and often a good laugh over a beer. Living in Cambridge alongside them has been wonderful and I could not have survived living alone here without them. They have given me rides to and from the airport, watered my plants while I was away, shared their pets with me for walks, given me hugs when classes have been hard, and overall become some amazing friends that I will cherish for the rest of my life. I am so thankful for this year together and all we have accomplished.

Table of Contents

List of Figures

1 Introduction

Gender Inequity is not a new topic to the world of STEM or even the subset of engineering but examining this tough topic through a systems lens is not something often discussed. The phrasing of inequity was intentionally chosen, as inequity and inequality are often mistaken as being interchangeable but are not. “While the terms equity and equality may sound similar, the implementation of one versus the other can lead to dramatically different outcomes for marginalized people. Equality means each individual or group of people is given the same resources or opportunities. Equity recognizes that each person has different circumstances and allocates the exact resources and opportunities needed to reach an equal outcome” [1]. Equity recognizes that individuals have “unequal access to a system” whereas equality refers to resources being distributed evenly without taking into account a person’s starting point [1], [2]. Inequities can lead to inequality, so to focus on the concerns and issues that can be altered and potentially improved, it is prudent to frame this thesis around such inequities rather than only on the resultant inequality. Naturally, the inequalities at play are also discussed throughout this topic, so defining the difference is crucial up front to ensure thorough understanding of potential outcomes.

In the eyes of system thinking, anything in the world can be assessed as a system. This most frequently relates back to technical systems, such as engineering designs or products. However, the examination of sociotechnical systems is becoming more commonplace, and there are many tools and tactics within system design, system architecture, and systems thinking in general than can be applicable to assessing a sociotechnical system. Much research is being done on team dynamics, knowledge growth as an organization, and other business-related project management concerns in the systems thinking world. There is, however, not much work currently set towards systematically assessing gender issues in the workplace or in engineering roles specifically. Much corporate response presently focuses too narrowly on one or two major root cause issues. Buzzwords such as “talent pipeline”, “leaky bucket” and many others are discussed often by managers as a potential major root cause, but these issues are intricately intertwined, and to look at them all individually and not from a systematic level does not do them justice from a framework of potential solution sets. Given the pressures companies and organizations feel from both external and internal forces to address the issues of gender inequity and gender disparities, this thesis intends to give a systematic review of such considerations for a more organized and holistic approach to addressing these items moving into the future.

1.1 Personal Motivation

I didn't know I wanted to be an engineer growing up. Until late in high school, I didn't have any idea what I was going to be except for that I wanted to pursue something that made good money so I could have financial independence in the future. Doctor, lawyer, businesswoman, any of these would do. At the same time, I felt the stereotypical trope of not wanting to be singled out as a "nerd", and through high school, concerned myself with what most teenagers worry about: trying to fit in. Being a female "nerd" is not the way to do that. As a male, it is perfectly possible to be both nerdy and popular in school. As a female, at least when I was in high school, it was much less plausible. All of this changed as I entered my junior year of high school and joined the Academy of Science and Engineering. I also started taking my first physics course, and suddenly everything clicked. I had always done well at school, but physics was the first class where I couldn't wait to get another homework assignment and solve the next problem set. Projectile calculations were my favorite, as all the forces and resultant actions of them just made perfect sense in my normally jumbled-feeling brain. With this newfound love of physics in hand, I pursued AP Physics courses my senior year and decided to enroll at the University of Texas at Austin as a mechanical engineering student in the fall of 2009.

Another factor that I now reflect on as having been important to my comfort level in taking on an engineering degree: My father is an engineer and was kind enough to take me along to worksites, force me into taking AutoCAD coursework, and convince me to do some unpaid internship work at the company he was working for while I was in high school. These experiences undoubtedly showed me that not only could I be an engineer, but that the eventual outlook of an office job where people are actually doing engineering was not so scary. I recognize that many women do not have this role model. I have been a recruiting team lead at my undergraduate alma mater for the last three years and have noticed a visible correlation between female engineering applications and their having at least one parent who is an engineer. The concept of representation being crucial to showing a woman that they can be an engineer is something I hope to shine some light on in this thesis as a result of this observation.

When entering my engineering courses as a freshman, I quickly noticed how few women there were. At the time of my matriculation, the percentage of females in mechanical engineering coursework at UT Austin was a little under 20%. This meant that for every group project, I was nearly always the only female. Most of my engineering classmates fit the stereotypical engineering mold: white, male, antisocial, difficult to work with. As if the coursework itself wasn't hard enough, working with, and often around, these classmates was a hurdle I was unfamiliar with from my high school days where my classmates matched with the typical demographics of my area and were half male and half female. One

thing that carried over from my high school classmates to my college classmates is that they were nearly all white. Intersectionality is a topic I intend to devote a section of this thesis to, but for now I will focus on my gender-related motivations.

One thing I had going for me throughout my entire time as an engineering undergraduate student was my outright stubbornness. If someone told me I couldn't do something, I took it as a challenge. My freshman year, an advisor told me "Freshmen don't get internships". So, I went to the career fair and secured myself a summer internship, perhaps out of spite, but also to make money to pay for the next year of school. This eventually proved to be the best decision I could have made because it gave me credibility in pursuing a sophomore internship, and then a junior internship, and finally ended up in me getting my dream job upon graduation as a subsea engineer at Chevron. I had interned at three different companies by then to explore the market thoroughly and realized that workplace culture was far more important than the work itself. Chevron fit the bill for a progressively minded company with tough engineering challenges that would give me immense personal and professional satisfaction. Nine years later, I am still employed by Chevron, and they have been generous enough to sponsor me as a student in the MIT System Design and Management (SDM) program. I've been fortunate throughout my time at Chevron that they have encouraged and supported me in gender-related initiatives. I volunteered for an organization through UT Austin called "Elevate ME" where we focused on female matriculation in the Mechanical Engineering department specifically, with a goal of reaching 30% enrollment within 5 years. Despite concerted efforts from many parties, we plateaued around 26% for multiple years and just never seemed to be able to reach that target number of 30%. This was puzzling to me, and the question arose then of "what constitutes critical mass in an organization"? What type of numbers must a subpopulation make up to no longer feel as though they are "other"? As mentioned, I was also leading the recruiting team for facilities engineering at my alma mater, and I began to examine more critically some of the recruiting rhetoric we were discussing with students and did my best to be cognizant of different communication styles and learning styles during presentations and interviews. We were fortunate to have many qualified female candidates apply for our roles, and I can proudly say that many of them came to work at Chevron, however, it personally never felt like enough. I've also observed some of those same women exit the engineering workforce since their time of hire, and I realized I wanted to explore further the means and reasons for these women leaving engineering roles.

Three years ago, I listened to the book "Brotopia" on audiobook and felt deeply inspired, as well as angered, by the content of the book [3]. This book echoed so many of the stories of my own

experience as a female engineer, and I thought to myself, “What can I do to address these issues?”. I knew that the stories in the book would resonate with so many of my female peers, so I recommended it to everyone I could. I also recommended it to my male peers, partially thanks to my employer, Chevron, introducing a program they call “MARC”. MARC stands for Men Advocating for Real Change and is geared towards engaging males in the workforce as allies in the process of increasing gender and racial equity and equality. This organization came into existence around about the same time as I finished reading Brotopia, and the timing couldn’t have been better. I finally felt that I had a safe space to discuss issues that had been burning on my mind for years. It was also through the MARC program that I met a mentor, Brendan, who was leaving that year to attend the MIT SDM program. Brendan was on my mixed-gender MARC team, and I could tell from the onset that he was an ally and wanted to see meaningful change come into the workplace. We remained in touch since that program, and when the time came that I was nominated for joining the SDM program, Brendan and I caught up for lunch. It was a bit forward looking at the time, but Brendan was telling me about the process of writing a thesis for SDM and how it should be a topic that one is personally passionate about and has great cause for pursuing. We then switched gears briefly while I recounted some recent personal struggles in balancing work life and personal life and some of the gender issues at play in those struggles. Brendan’s eyes lit up and he said, “you know, you could write about some of this as a thesis topic”. We both paused and initially laughed it off a little bit, but he told me “Chew on it for a few months and see if it sticks”. As I started my SDM coursework and began to explore the concepts behind systems thinking, it became more and more apparent to me that focusing on a topic I am immensely passionate about would be crucial for my thesis. I realized that there may likely never be another time in my life that I am able to put sole focus towards one topic of my own choosing. My own life experiences have encouraged me to pursue this topic, but the life experiences of my friends and colleagues have been even more inspiring, as many of them have suffered far more egregious affronts during their experiences as female engineers, and I intend to do them justice by putting some of these struggles in writing and bringing these issues to light in a data-driven, systematic manner. I am so thankful to the many generations of women who have come before me and made being a female engineer seem possible. I hope to honor them and their struggles through presenting material that can make it even one iota easier or more bearable for another woman in the future to pursue engineering and then hopefully remain in engineering for years to come.

1.2 Research Objectives and Approach

This research seeks to understand the systemic issues affecting gender inequity in both positive and negative ways. Much of the current research into this topic is focused on solitary issues or combinations of issues in isolation. This research aims to assess the entire system through the lens of a system engineer and architect and work to dissect strengths of relationships between specific issues. These objectives are investigated through the following lines of inquiry:

1. What are the specific individual components of the gender framework with respect to engineering, or in other words, what architectural decomposition does the current system of engineering work hold?
2. How do these individual components interface with one another to make up the overall system of the engineering world?
3. How can academic institutions understand recruitment and retention to better attract and retain female engineering students?
4. How does Intersectionality relate to all these gender-specific topics?
5. How can companies address the systemic issues at play in their own workforce?
6. What future lines of research would be most effective at improving the existing inequities related to gender in engineering?

The first question is addressed through a strategic literature review of research into gender inequity throughout the last two decades. The literature discussed gives statistical insights into the individual aspects at play in gender inequity within engineering. This data is then balanced against interview inputs from current female engineers, who give their own insights into both the first and second questions.

To further understand the systemic nature of the aspects at play, a design structure matrix (DSM) approach is taken to depict the strength of relationships between multiple factors and issues. The DSM is intended to be a reference visual to both demonstrate the issues at hand, as well as demonstrate the complexity of the systemic nature of these issues [4]. Once a system is depicted via this method, the relationships can be discussed in more detail without treating any one issue like a singled-out factor without other contributors or detractors. Effectively measuring the weight of each factor and issue is a very complicated matter, and the objective of system engineering is to help show complexity without it being complicated which the DSM aids in.

The final few questions give readers a potential set of suggestions, or at a minimum, questions to be asking, if they truly want to influence positive change in their organizations. The last question lends to potential future research, or at a minimum is intended to display the multifaceted nature of the issues being discussed and demonstrate that they cannot be views only through a lens of gender and must in reality assess multiple different attributes to effectively engage and assess issues in a complete manner.

1.3 Research Scope

The scope of this thesis focuses on gender issues in general and then narrows to focus on gender issues in engineering specifically. Much of the research currently available is focused on Science, Technology, Engineering, and Math (STEM) in aggregate, and the decision was made to focus solely on Engineering for the crux of this thesis to allow for a deeper understanding of the issues at hand for a set discipline. That said, the scope is not limited to a specific sub-discipline of engineering, which lends to additional breadth of discussion with interview candidates as well as literature assessed. Engineering sub-disciplines vary vastly in their existing percentages of females, and the work scopes between sub-disciplines can also be very broad and thus appeal to different persons, so this is a challenge in this thesis.

Intersectionality between diversity attributes outside of gender is discussed, but the primary focus remains on gendered issues as much as feasible. When selecting interview candidates, there was a concerted effort made to engage candidates of different backgrounds in many categories, so that other factors outside of gender did not unintentionally creep in through an overage of specific categories of interviewees. For instance, multiple ages, races, marital statuses, and parenting statuses were recruited. This allowed the focus to remain on gender specifically and ensure that when results were discussed, they were measured by a variety of experiences.

A very specific decision was made to only keep in scope women that have spent the entirety of their lives as women, and to not include those persons that have transitioned to womanhood during their lives. This was a difficult choice in an effort to never be exclusionary, but the understanding that the breadth of a lived experience is very different as a male versus female led to the need to focus this thesis on those persons with the entirety of their lived experience as a woman. Despite this choice, future work into experiences of all who identify as female at any time in their lives would be recommended to better understand the topics discussed in this thesis.

The scope of this thesis is further narrowed in its focus only on those with the bulk of their work experience and/or university experience in the United States or Canada. This is to allow for focused literature review based on American companies primarily. This also attempts to ensure that cultural norms outside of those in the typical North American, primarily white engineering workforce are not impactful to the experiences of interviewees. Cultural norms related to gender are very different based on countries of origin and this was a factor avoided through the specific scoping of American and Canadian female engineer interviewees.

The scope of literature reviews was initially quite broad, especially as much of it focused on general STEM as mentioned previously. The aspects discussed in the literature review are used to build the framework of the system and discuss the system decomposition of engineering as a sociotechnical system, however, the deep dive into engineering specifically without other STEM disciplines is clearer in the interview driven discussions within this thesis.

1.4 Thesis Structure

This thesis is organized into seven chapters as displayed in Figure 1. **Chapter 1** introduces personal motivations for this research topic, the objectives, and questions on which this thesis focuses, and the narrowed scope of this investigation. **Chapter 2** summarizes the literature review on gender equity across multiple spectrums – the overall corporate workforce, specific subdisciplines, specific industries, and specific focus areas of known inequity. **Chapter 3** describes the foundation of a systems framework of the ecosystem of engineering for a female engineer using inputs from qualitative interviews and scoping conversations from key stakeholders. **Chapter 4** uses a systems-based analysis approach to begin to describe the complex relationships between aspects of the female engineering experience. This analysis includes architectural decomposition and a design structure matrix of interactions. **Chapter 5** discusses the intersectionality of characteristics outside of gender that affect the diversity, equity, and inclusion (DE&I) of an organization as a whole. **Chapter 6** proposes key recommendations for organizations looking to effect meaningful change in driving equity for women in engineering. While these recommendations do not address every issue discussed, they are intended to spur on extensive conversation within an organization about how it can improve. **Chapter 7** summarizes the research, comments on scope limitations, recommends future research opportunities related to tangential topics and deeper focus areas, and provides supplemental resources for readers looking to enhance their organization's understanding and efficacy in improving in these areas.

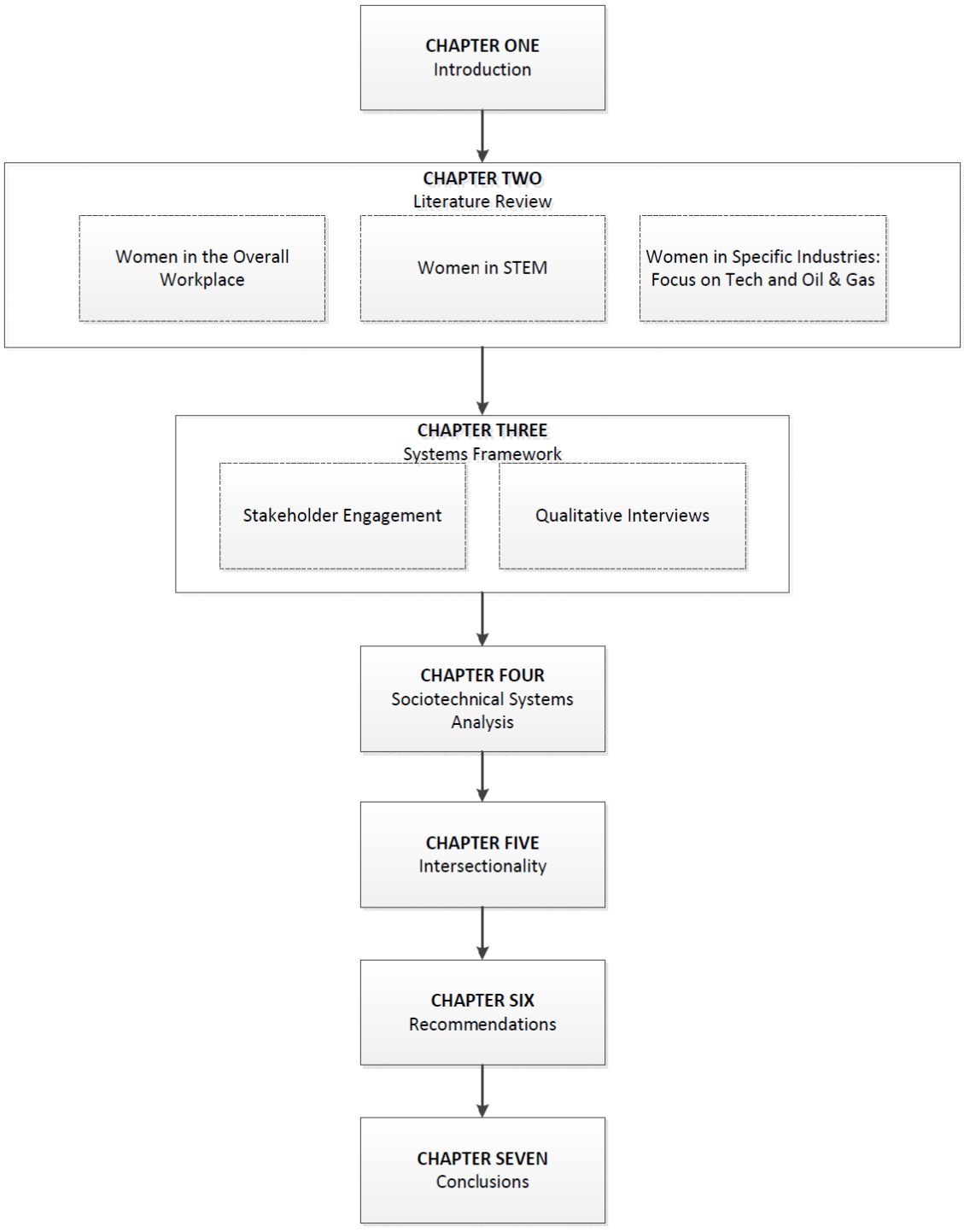

Figure 1: Thesis Organizational Structure

2 Literature Review

This literature review begins with a very wide lens examining gender inequity in professional workplaces of all disciplines. The focus then narrows to women in Science, Technology, Engineering, and Math (STEM) specifically with a discussion around job retention in specific career paths as well as factors that may contribute to this retention or lack thereof. Then the review focuses on two specific industries: Oil & Gas and Technology. Both industries employ a large number of females overall but have major attraction, promotion, and retention issues and concerns related to gender and other diversity characteristics. Data around these factors is reviewed and some possible ideas floated that are reexamined in the recommendations section of this thesis.

2.1 Terminology

Prior to beginning discussion of literature reviewed for this thesis, the definition of a few key terms is warranted to both build fluency and affirm alignment of understanding for anyone reading on this topic and looking to build additional fluency within their organizations. These terms often have conflicting definitions depending on the way in which they are employed, so a suggestion from this thesis is that in any discussions around inclusion and diversity within an organization, first ensure that the terminology being utilized in discussions is consistent, especially if the persons being informed or educated around a topic are not familiar with broader discussions in this realm.

- "**Talent Pipeline**": This term is defined broadly, but one set of characteristics referenced by www.recruitment.com defines the talent pipeline as "a cohort of passive candidates who you have previously engaged with and who are fit to fill future roles that might open up within your company" [5]. Other definitions leverage formal supply chain management tactics and terminology to discuss how companies can build up a steady supply of qualified workers for future acquisition through activities such as recruiting, training, metrics tracking, etc. [5][6]. The US Chamber of Commerce Foundation Center of Education and Workforce has an entire subsection dedicated to building talent pipelines in multiple industries along with concrete recommendations for various organizations addressing the development of talent pipelines for their own benefit [7].
- "**Broken Rung**": This term references the gap between men and women making the initial step to front-line manager in an organization [8]. The broken rung analogy implies that if a career trajectory is a ladder, the first rung is broken or missing for women, who are then unable to make the first step up the ladder in a similar timeline to their male peers, if at all.

- "**Glass Ceiling**": As defined in great detail by Jackson and O'Callaghan in "What Do We Know About Glass Ceiling Effects? A Taxonomy and Critical Review to Inform Higher Education Research", "the concept of 'glass ceiling effects' has emerged in social science research in general and higher education in particular over the past 20 years. These studies have described the impediments that women and people of color encounter in their quest for senior-level positions (e.g., CEOs) in society as glass ceiling effects. Literature, both empirical and non-empirical, has provided broad and varied interpretations of glass ceiling effects. In turn, the literature is less-than-settled on the application of glass ceiling effect" [9]. For the sake of this thesis, thinking of the glass ceiling as an overarching term for the limitation on advancement of an individual at a specific point in their career progression due to some characteristic they possess, in this case gender, suffices for the purposes of discussion to follow [10].
- "**Leaky Bucket**": This talent-retention terminology is less widely used but refers to the alleged outflow of women from the workforce at specific times in their careers. Most notably, there is a perception that women are more likely to make a career exit in their mid-30s for family reasons [11]. This is discussed in detail with statistical refutation in the sections to follow. If the flow of talent inwards is referred to as the pipeline, then once a person is employed, they are part of the "bucket" of workers, and if things are forcing them out, there is a thought that the "bucket is leaking" as can be seen discussed in the McKinsey publication entitled "Attracting and retaining the right talent" [6].
- "**Othering**": As defined in "Othering, an Analysis", "Othering is the simultaneous construction of the self or in-group and the other or out-group in mutual and unequal opposition through identification of some desirable characteristic that the self/in-group has and the other/out-group lacks and/or some undesirable characteristic that the other/out-group has and the self/in-group lacks. Othering thus sets up a superior self/in-group in contrast to an inferior other/out-group, but this superiority/inferiority is nearly always left implicit" [12]. Othering has come to have more broad definitions as well, but it is essentially the act of making someone feel as though they are "Other" to the primary group in a specific situation. With respect to women in engineering, a woman being in the minority group of the team of engineers would be "other" through her gender, and a woman who also displays a racial diversity characteristic in a group of otherwise homogenous races of men would now be considered "other" in two ways [8].
- "**Intersectionality**": Also referred to as Intersectionalism or intersectional theory. As defined by Kimberle Crenshaw in 1989, intersectionality is "The view that women experience oppression in

varying configurations and in varying degrees of intensity. Cultural patterns of oppression are not only interrelated but are bound together and influenced by the intersectional systems of society. Examples of this include race, gender, class, ability, and ethnicity" [13]–[15]. Intersectionality is discussed in detail in Chapter 5 of this thesis.

2.2 Women in the Workplace

To begin to understand the issues affecting women in all corporate workplaces, this thesis reviews the McKinsey & Company report "Women in the Workplace" for 2021 [8]. In partnership with LeanIn.Org, McKinsey explores in this report data associated with being a working woman in the corporate professional world through engaging with 423 organizations and surveying over 65,000 employees [8].The overall employee pool of the 423 companies engaged is approximately 12 million people, meaning of this group of companies, approximately 0.5% of their workforce was surveyed. This report encompasses data from 2021, which naturally reflects some of the impacts, both positive and negative, of the COVID-19 pandemic and its effects on women in the workplace [8].

At the onset of this report, a very important disclaimer is given that is repeated here for emphasis: "No single story can capture the range and diversity of women's experience. The data-driven narratives in this report shed light on some of the distinct experiences of Asian women, Latinas, Black women, lesbian and bisexual women, and women with disabilities in corporate America, but they are by no means comprehensive. Women have multiple and intersecting identities, which profoundly shape their experiences at work. It's critical that companies and coworkers are aware of these dynamics, so they can more effectively advance equity and inclusion for all women" [8]. This statement could not be more accurate, however, due to the intended scope and focus of this thesis, the topic of Intersectionality is discussed in Chapter 5 to give it appropriate attention. The focus of the overall thesis will remain on the subject of gender, understanding full well that to address a single diversity characteristic in isolation is an impossible task and would yield less than positive results if an organization or institution were to ignore all other diversity factors at play in the lives of the humans involved in their organization's mission, whether academic, capitalistic, or otherwise.

While the McKinsey report gives a multitude of important statistical data, this thesis highlights specific salient statistics that are deemed relevant for the further systems analysis in later sections and also is used to highlight aspects of the qualitative interviews. To aid in ease of accessing the overall themes of data by a reader, the statistics to be discussed are broken down into subheadings moving forward.

Representation

When discussing gender inequity, the first overarching topic that often arises is that of representation and most notably, visible representation. A theme that is discussed in more detail later is that of people of multiple characteristic groups having a hard time seeing where they fit in the organization with respect to upward mobility when they do not see people like themselves in those levels of the organization. To highlight some of the data from the McKinsey report, percentages of women in corporate America do seem to be increasing, however, women are still underrepresented and there are still "persistent gaps in the pipeline" [8]. Viewing Figure 2 below, it is clear that both the gender gap and the racial gap are more and more significant the higher one gets up the "corporate ladder" for the corporations studied.

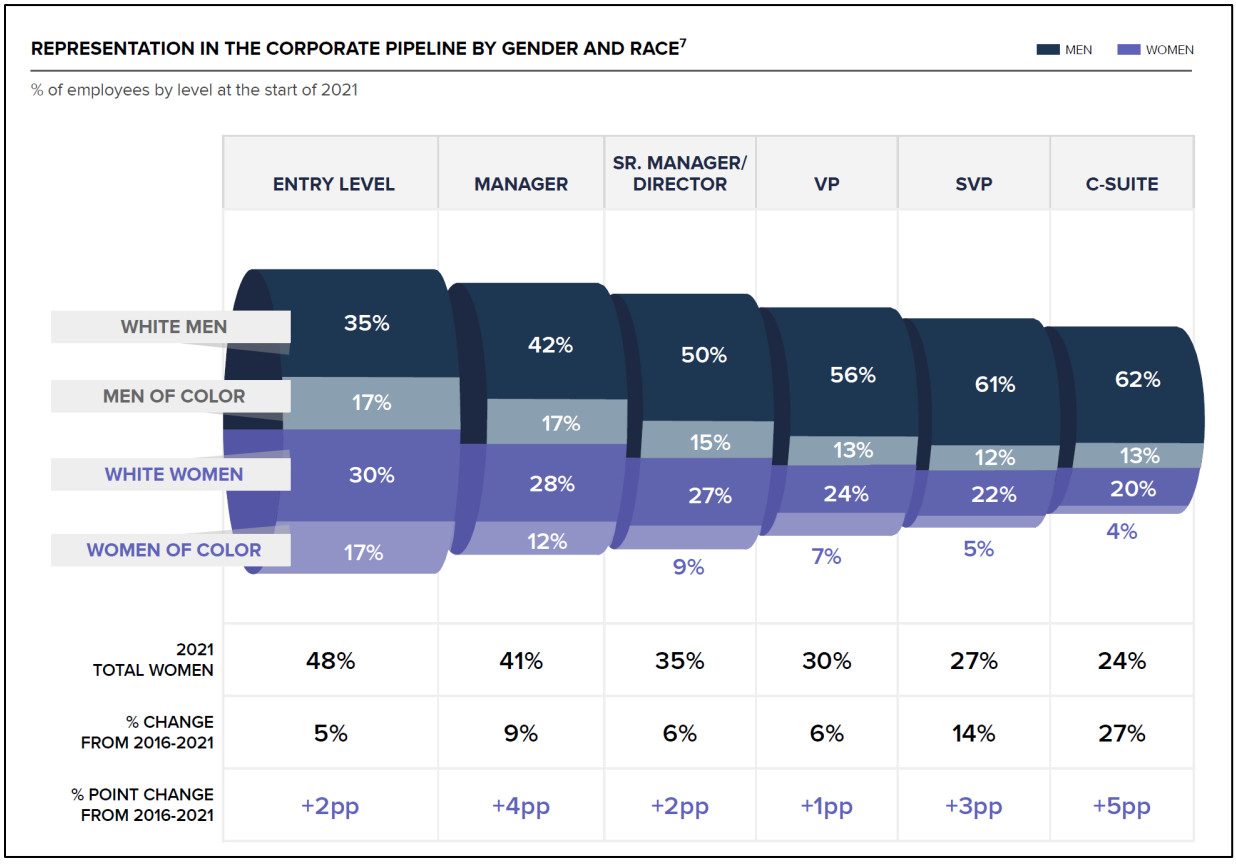

Figure 2. Representation in the corporate pipeline by gender and race [Visual from 2021 "Women in the Workplace" [8]]

There are a significant number of intersectional components in the study by McKinsey as well that are referenced in the section of this thesis on Intersectionality in Chapter 5.

Family Status

Much past research has focused on the difficulties related to childrearing while being fully employed, but much remains to be understood around the perceptions of managers of those on their teams who are working mothers. This is then reflected back to working mothers in feelings of guilt, judgment, and burnout [8]. As seen in Figure 3, if a woman is the only female in her group, as well as the mother of a young child, her experience is amplified even compared to that of other mothers of young children who are not "gender onlys" in their workgroups [8].

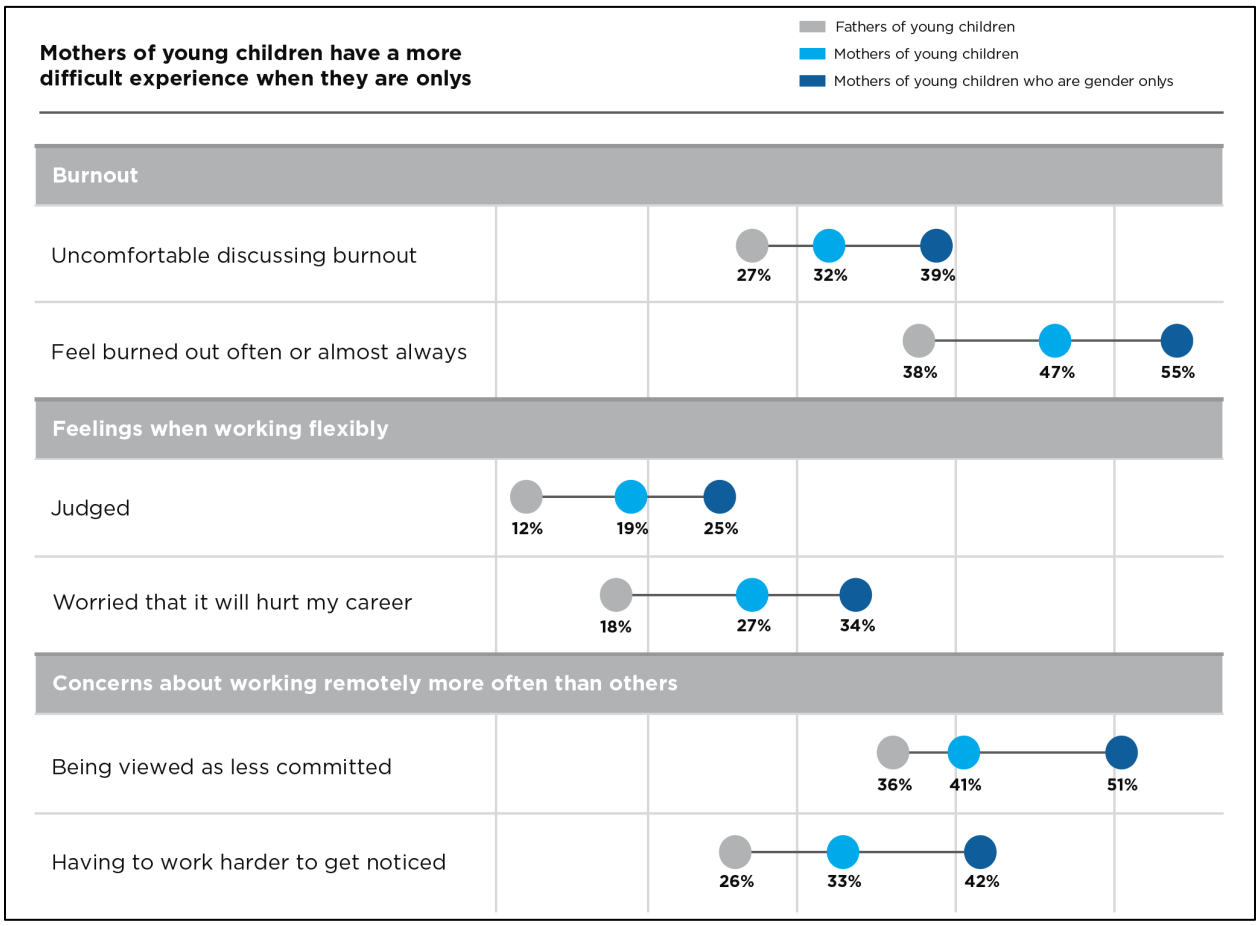

Figure 3. Experience of mothers of young children. Reproduced from [8]

Unpaid Labor

The Organisation for Economic Co-operation and Development (OECD) estimated in a 2014 study that "Around the world, women spend two to ten times more time on unpaid care work than men" [16]. This burden of unpaid labor not only impacts a woman's time utilization outside of the workplace, but also affects the types of unpaid job expectations that women carry the bulk of the

burden of in the corporate world. Anecdotally, the author of this thesis is very familiar with the inherent expectation that she be the one to organize happy hours, birthday cards, volunteer events, and going-away presents, among many other unspoken gender normalized activities on teams on which she has been a member. These activities may often be enjoyable, but they nonetheless are unpaid and not included in any job description for an engineering role for instance. The activities mentioned take time, and the female employees engaged in them must then make up the time elsewhere in the workday or be even more efficient than their male counterparts. An interesting set of statistics raised by the McKinsey study is related to the amount of additional at-work care activities undertaken by women as a result of COVID. "Compared to men at the same level, women are doing more to support their teams and advance diversity, equity, and inclusion efforts. They are also more likely than men to practice allyship. Yet this critical work is going unrecognized and unrewarded by most companies, and that has concerning implications. Companies risk losing the very leaders they need right now, and it's hard to imagine organizations navigating the pandemic and building inclusive workplaces if this work isn't truly prioritized" [8]. From a data standpoint, female managers are significantly more supportive emotionally to their employees than male managers and are also putting much more effort into ensuring workload of their employees is manageable and their subordinates are not getting burned out [8]. Figure 4 shows the breakdown of these support tasks in detail.

How managers are supporting employees		
% of employees who say their manager has consistently taken this action		
	Manager is a man	**Manager is a woman**
Well-being		
Providing emotional support	19%	31% **(+11pp)**
Checking in on overall well-being	54%	61% **(+7pp)**
Workload		
Helping to navigate work/life challenges	24%	29% **(+5pp)**
Working to ensure workload is manageable (e.g., shifting priorities or deadlines)	36%	42% **(+6pp)**
Helping take actions to prevent or manage burnout	16%	21% **(+5pp)**

Figure 4. Manager support of employees. Reproduced from [8]

To focus on a microcosm of the rest of North America, a study on Houston, Texas specifically assessed the burden of unpaid labor on women with respect to observed wage gaps [17]. The report entitled "Houston/Harris County Gender and Sexuality Data: Annual Report" shares that in 2019 the gender pay gap actually grew in this region, despite narrowing in much of the rest of the world. This phenomenon is attributed in large part to the oil and gas industry presence in Houston that includes a higher percentage of non-Hispanic white men in high-paid roles than other major US cities [17]. It is interesting to note that a large majority of the oil and gas industry jobs that are high paid require some sort of STEM background, often in engineering. Relevant to this thesis, a future question that may be useful for companies in this industry to ask themselves is whether their gender and racial gaps are contributing to even greater inequities in their broader communities. Additional aspects of the oil and gas industry specifically will be discussed in a later section.

In an excellent summary of the issues at play in Houston specific to unpaid labor, the report states "At base, gender is a work-assignment system, with a wage scale. It's intersected by race/ethnicity, which is also utilized to assign tasks and wages and further narrows options for many. Care tasks have long been viewed as 'women's work' – a 'naturalized' function viewed as deserving of no or low pay—and, as a result, women of all social positions, kept busy with care work and with no civic status or money of their own to spend, have had small roles in public life or policy making until recently. Because care tasks continue to be un- or low-paid, many women and their children become dependent on men for financial support, while society overall still depends on women to do the work of bearing, raising, and maintaining the nation's workforce. Though women have now advanced into leadership roles in some fields of employment, the lack of childcare support for working families has limited that advance to a 'trickle up.' There's a connection between the fact that even in non-pandemic times children are in public school during working hours only 37% of the time between age 0 and age 18" [17].

Promotion Gaps

Based on 2021 data, there is still a large broken rung for women, as defined previously. "For every 100 men promoted to manager, only 86 women are promoted" [8]. Figure 5 shows this statistical variation visibly and may make a useful tool for management to demonstrate the broken rung phenomena when discussing this issue with others in their organization.

Figure 5. Visual depicting the broken rung phenomena, from "Women in the Workplace" [8]

Following the understanding that women are already losing out on the first level of promotions, it makes logical sense that subsequent promotion pools inherently have a smaller quantity of women to pull from and a bit of a snowball effect perpetuates the problems through subsequent layers of management as can be seen visibly in the graphic of Figure 2 when following percentages of women at each progression through a career path.

The next discussion related to this in the McKinsey study is around companies putting focus on removing or reducing bias in performance reviews, compared to only in hiring practices, which is where most organizations currently focus the bulk of their bias-reduction initiatives [8]. Figure 6 demonstrates that while practices related to fairness have in general improved between 2019 and 2021 studies, the focus on fairness in performance reviews is still not there across the board [8].

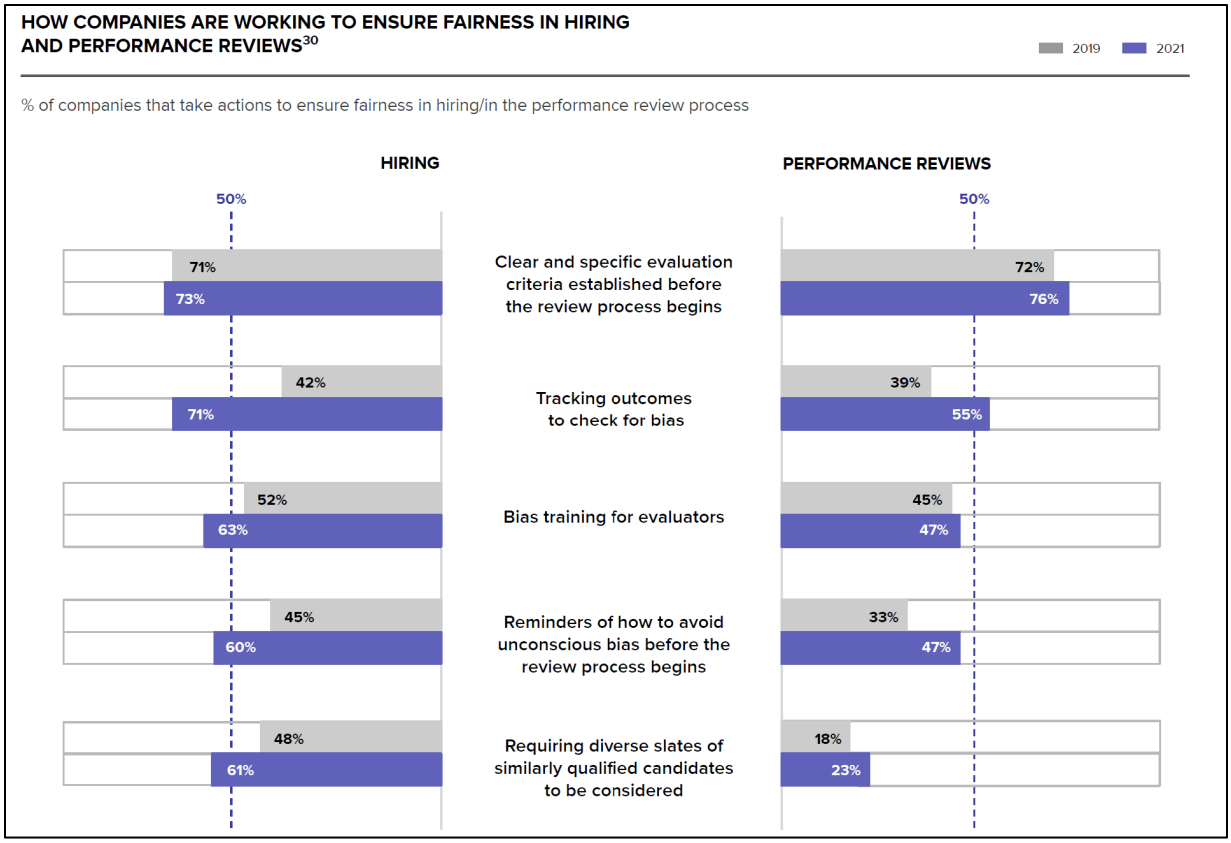

Figure 6. Fairness practices in hiring and performance reviews [Visual from "Women in the Workplace" [8]]

The effects of these fairness practices in performance reviews are discussed in greater detail in a study titled "'Potential' and the Gender Promotion Gap" by Benson, Li, and Shue. The study asserts that "widely-used subjective assessments of employee 'potential' contribute to gender gaps in promotion and pay" [18]. The study goes on to detail their main findings as follows. "First, women receive lower potential ratings despite earning higher performance ratings. This gap in potential ratings accounts for up to half of the overall gender gap in promotions. Second, potential ratings appear to be biased against women. Among workers with the same current performance and potential ratings, women receive higher performance ratings in the future. This is true for our full sample of workers, as well as for the subset who are promoted into new roles. Our analysis of promoted workers shows that women receive higher ratings of their future performance as managers both on average, and at the margin of promotion. Finally, we identify a key trade-off between information and equity. We show that potential ratings, although biased, are nevertheless informative about future performance. Rather than ignoring them, firms may want to invest in solutions that reduce bias in potential ratings, in order to retain their information content" [18]. This information may prove useful to firms who are looking to understand

why women are not moving up the ranks in a manner that tracks with their overall performance and skillsets.

Unconscious Bias

Unconscious bias is a popular term at play in recent diversity and inclusion literature and relates to the inherent biases against people that are not conscious to the perpetrator of them [19]. Unfortunately, the level of microaggressions personally observed by women can begin to affect the recipient of the microaggressions or microinequities in what this thesis will refer to as a "Death by a thousand cuts" phenomena. In other words, perhaps one individual isolated incident is not so terrible as to warrant a wound, psychological or otherwise, that would force a woman to leave a career or feel unwilling to proceed at a certain company. But the collective experience of multiple microaggressions day in and day out can exhaust the recipient to the point that they feel so exasperated that they make a change in their situation to escape the aggregate experience any further. Examples of microaggressions from the McKinsey report include "being interrupted, hearing comments on their emotional state, or having their judgment questioned" [8]. These experiences were collected in survey data among women in leadership versus their male colleagues as shown in the visual of Figure 7.

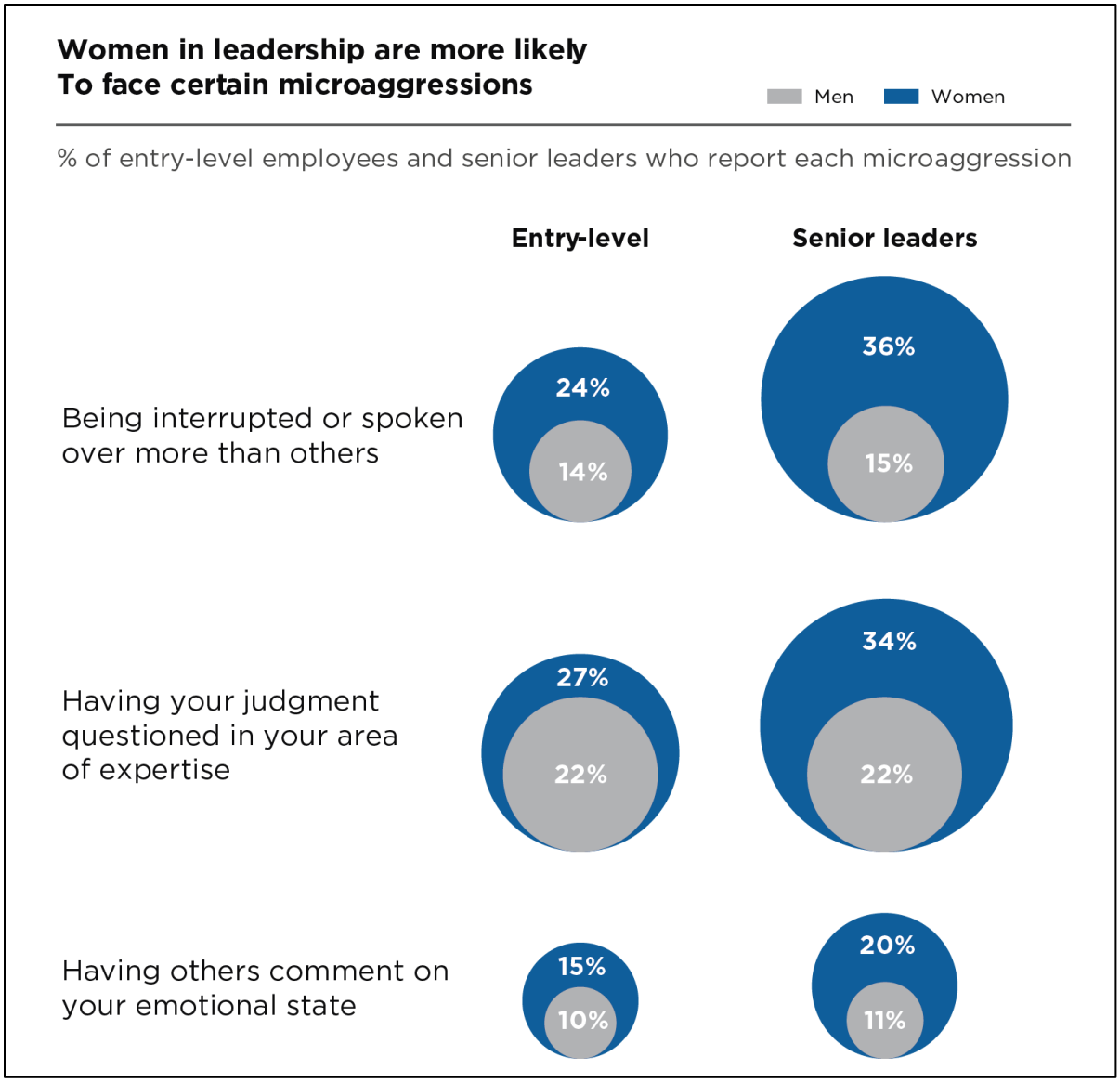

Figure 7. Microaggressions faced by women in leadership. Viisual reproduced from [8]

These microaggressions are even more insidious for women with an additional visible diversity characteristic, especially race [8]. The experience of being the only woman, along with the experience of being an only woman and the only person of a woman and of a different race is shown in Figure 8.

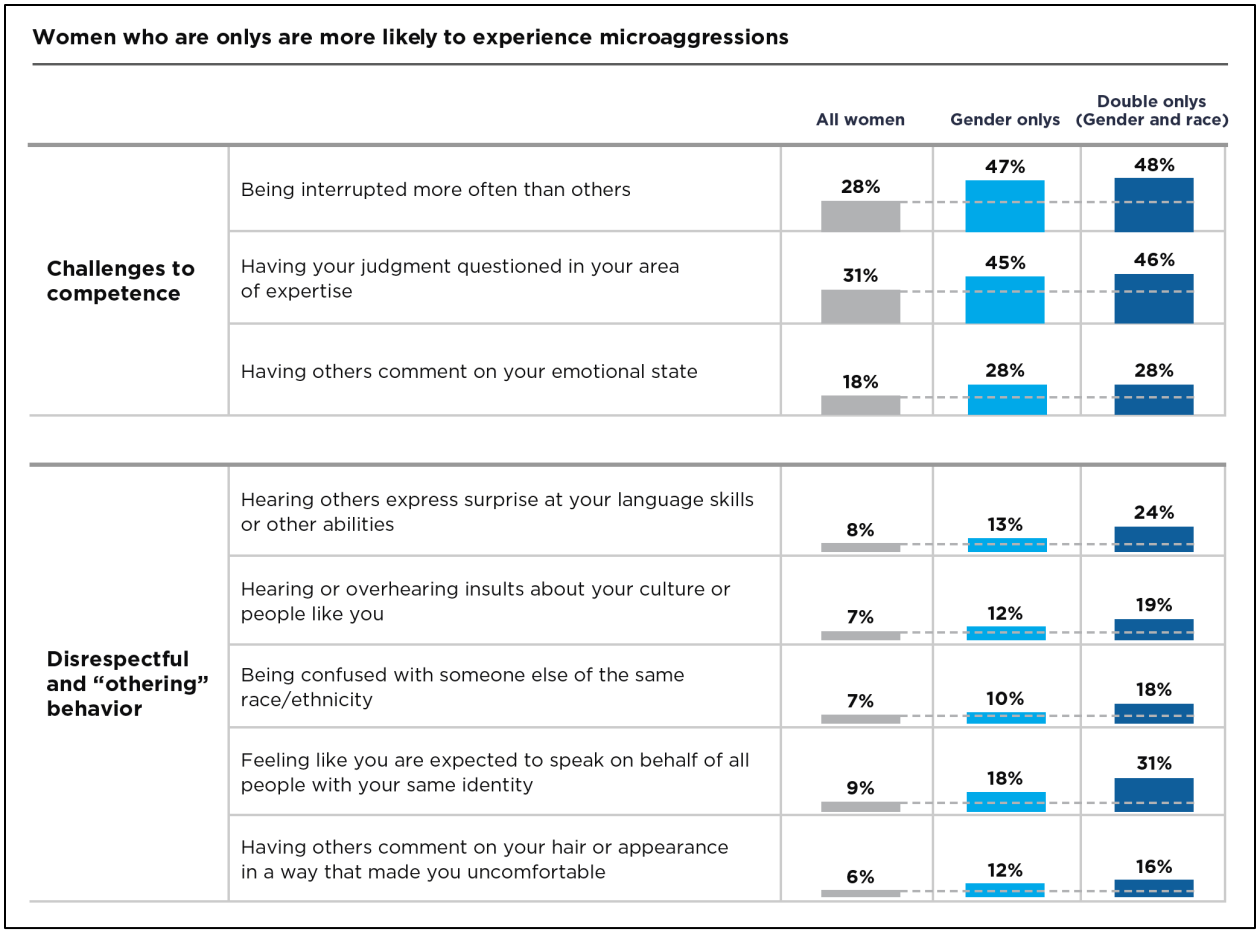

Figure 8. Experience of microaggressions for "Gender Onlys" and "Double Onlys", reproduced from [8]

Flexible Work Arrangements

Flexibility in working hours and working conditions are huge considerations for both male and female employees alike, but these issues affect women differently if they are expected to also manage the bulk share of childcare duties and unpaid labor duties in their home life. One interesting outcome of the COVID pandemic was that many corporations had to drastically shift their attitudes and policies towards remote and flexible working conditions. In the McKinsey study, "more than three quarters of senior HR leaders say allowing employees to work flexible hours is one of the most effective things they've done to improve employee well-being, and there are clear signs it's working. Employees with more flexibility to take time off and step away from work are much less likely to be burned out, and very few employees are concerned that requesting flexible work arrangements has impacted their opportunity to advance" [8]. One crucial piece of data that the McKinsey report highlighted is what appears to be a drastic disconnect between the level of flexibility that employees desire in future work

environments vs. what employers think is going to be the case for them in a year from the time of the study; Figure 9 shows the ideal scenario for employees vs. their employer's expectations.

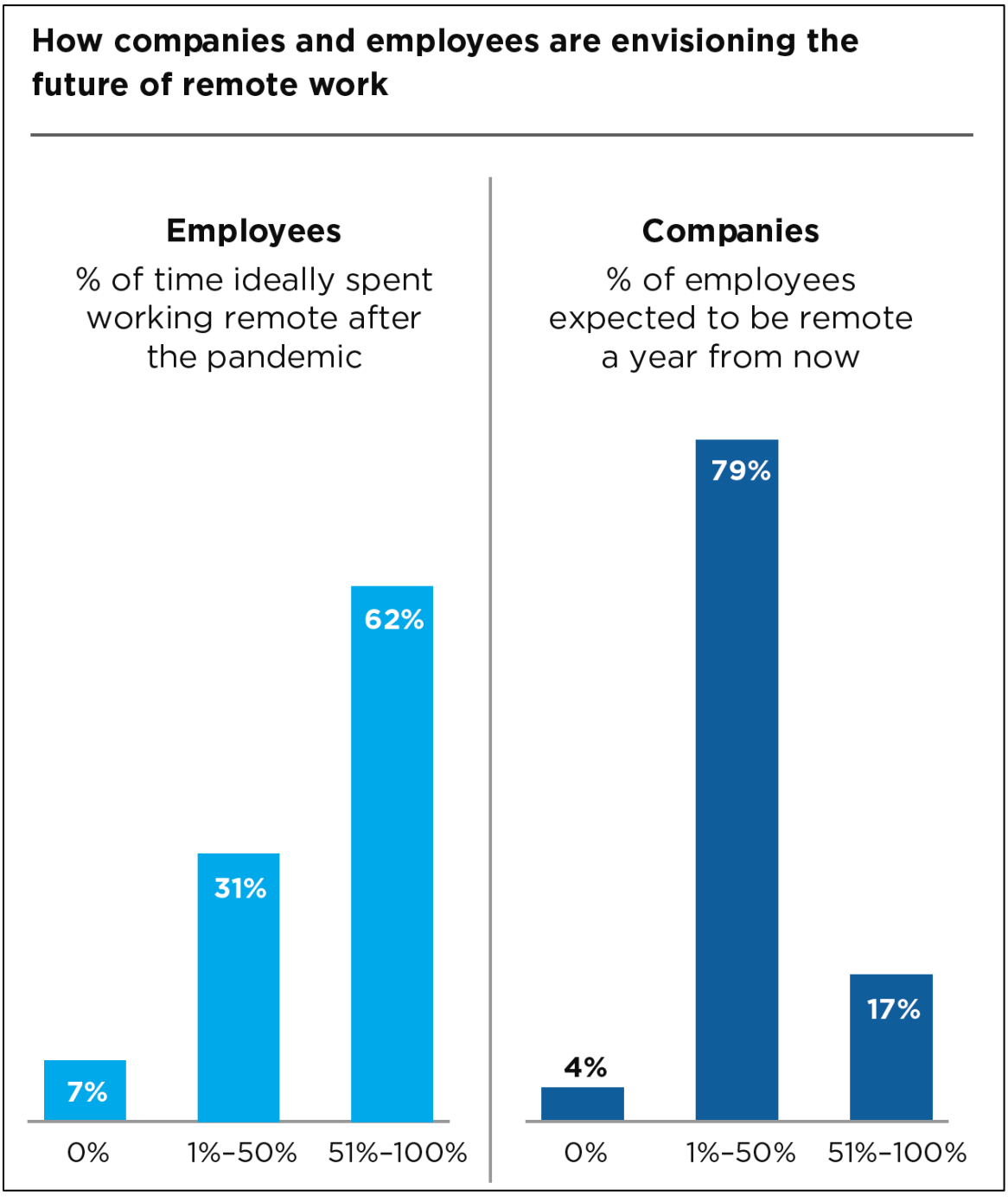

Figure 9. Employees and Employers differing opinions on the future of working remotely. Reproduced from [8]

2.2 Retention of Women in STEM

One aspect of data review that is often missing when examining gender bias in the workplace is time-based statistical analysis over the course of a woman's career progression. This thesis intentionally looks at sources that show time-measured changes in diversity attributes to demonstrate whether changes are indeed occurring, and if so at what rate and due to what factors. A 2013 research paper by Glass et al. entitled "What's So Special about STEM? A Comparison of Women's Retention in STEM and Professional Occupations" discusses the career trajectory of study participants from the National Longitudinal Survey of Youth in 1979 throughout their career journey and looks at the reasoning behind the mass exodus from STEM fields of women throughout that time despite their not actually leaving the workforce in the manner which is often perceived to have occurred [11]. The summary abstract for the paper gives some initial insights, stating "Results show that women in STEM occupations are significantly more likely to leave their occupational field than professional women, especially early in their career, while few women in either group leave jobs to exit the labor force. Family factors cannot account for the differential loss of STEM workers compared to other professional workers. Few differences in job characteristics emerge either, so these cannot account for the disproportionate loss of STEM workers. What does emerge is that investments and job rewards that generally stimulate field commitment, such as advanced training and high job satisfaction, fail to build commitment among women in STEM" [11]. The study asserts at the onset that data for women leaving engineering is too often compared to data against male counterparts, and not compared against women in other industries and/or disciplines [11]. When comparing women in STEM against men in STEM, the results look very different than when comparing women in STEM against women in other professions who entered the workforce at similar times and face similar age-related pressures throughout their period of comparison [11].

Similar to other sections of this literature review, this thesis breaks down this study into specific themes to allow for comparison of attributes during the interview and recommendations sections. The trends discussed in the study are counterintuitive in a few facets, specifically related to the preconceptions present in many corporations about women's exit rates in STEM, as well as how parenthood affects a STEM woman compared to a professional woman.

Representation

The Glass study examines, very systematically, the sample set of women who have completed at a minimum a four-year degree, which results in 1,258 individuals out of the original sample of 12,686 in the National Longitudinal Survey of Youth in 1979. While the study recognizes that the age of the women in this study will not reflect attitudes and changes in new college graduates, the data available from this age group allows for the inspection of marriage, parenthood, and other factors that more recent longitudinal samples would not be able to accurately represent on the existing time horizon [11]. The women surveyed would have been aged 14-22 in 1979 and this initial data was collected by the Bureau of Labor Statistics, with respondents being interviewed annually from 1979 to 1994 and biennially from 1996 to 2013 when the Glass report was compiled [11]. Of the initial set of 1,258 female respondents, 842 are in professional/managerial occupations, while only 258 are in STEM roles (Note: It is understood that the combined total of respondents discussed for the remainder of the data does not add up to the initial 1,258 and is only 1,100 combined respondents) [11]. STEM careers for the sake of this study intentionally exclude health professionals [11]. Additionally, for further understanding of who this study assesses, "female college graduates working in STEM are predominantly information technology (IT) or engineering workers, while professionals are predominantly managers and administrators, financial operators, and nurses" [11].

Unconscious Bias

The Glass study discusses indirect measures of tokenism, although eventually their results proved largely insignificant because of an inability to directly measure this attribute [11]. "While we expected that women's token status in STEM fields could be isolating and lead to dissatisfaction with STEM work environments, neither of our measures of tokenism (occupation proportion female or motherhood status) significantly affect retention in our multivariate models. In addition, results show that most of the workplace characteristics, including hours of work, earnings, and parental leave policies, affect retention in similar ways for women in STEM and professional employment. However, women in STEM fields do not react as positively to increasing job satisfaction, job tenure, and advancing age, suggesting that climate issues or lack of "fit" between worker and job persist for longer periods of time in STEM careers. This helps explain the widening retention deficit that STEM women experience over time relative to professional women" [11]. This implication that the cultural fit for women in STEM careers is so poor that they cannot overcome similar issues to women in other professional roles that

seem to improve with tenure and age suggests that a much more implicit than explicit set of issues is warranting of further exploration.

Family Status

Interestingly, marriage and childbearing percentages are very similar for this studied group between the STEM and professional job groups. Marriage has a vastly different effect on women in STEM for this age group, however. “We also found, as predicted, that adolescent expectations to marry later in life and have no children increase retention in STEM (odds of leaving STEM decrease by 57 and 45 percent, respectively), while professional women are *more* likely to leave their field if they expected to have no children (odds increase of 75 percent) and are unaffected by plans to marry later in life or not at all. Finally, actually getting married is more likely to propel women out of STEM careers than professional careers, with STEM women increasing their odds of leaving by 84 percent upon marriage, while the odds increase is not significant for professional women (although the difference between groups is not statistically significant). We tested the interactions between age and getting married as well as (liberal) gender ideology and getting married, to see whether being older or less gender traditional at marriage diminishes this negative effect on retention in the field among STEM women, but neither interaction was significant” [11].

There are additional fascinating implications for the duration of a marriage for a woman in STEM, as well as whether her partner is also employed in a STEM field as well. “Actual family formation also disproportionately influences the decisions of women in STEM to leave the labor force compared to professional women who show remarkably smaller effects of marriage and childbearing. While the act of getting married decreases the odds of a STEM labor force exit by about 85 percent in the subsequent year (though increasing exits from the field, as explained above), staying married is associated with dramatically *increased* odds of exiting the STEM labor force. This “pull” or demand for home production is exacerbated as spouses work more overtime among both groups, but STEM women look slightly more reactive to their partner’s overtime work hours. Here, as in the competing risk of leaving the field, having a spouse employed in the same STEM field dramatically reduces labor force exits (a near 100 percent reduction in the risk of exiting the labor force, although caution must be exercised because of the limited sample of exits among STEM workers here) and nullifies the negative effects of being married and having a spouse who works overtime. In contrast, having a spouse in a professional field does not affect the odds of leaving the labor force for professional women” [11]. A knock-on effect of having a partner in a STEM field is even visible for those women with advanced degrees who are more

likely to depart from STEM which is discussed in a following section. Odds of exit for those women with advanced degrees are "70 percent lower if their spouse is also employed in STEM" [11]. To highlight that salient point, having a partner who is also in a STEM role, drastically decreases a STEM-employed woman's likelihood of field exit or career exit.

Marriage is of course not the only factor affecting women in the workplace, and childbearing also has vastly different effects on women in STEM compared to professional women. "Having children, particularly a second or higher parity child, increases labor force exits among both groups of workers, but much more noticeably for STEM workers. A second child results in a 395-percent increase in the odds of leaving the labor force for STEM women but only a 147-percent increase for professional women. This pattern suggests a life course process in which the arrival of children may alter the earnings, hours, and job satisfaction of STEM women more than non-STEM women in ways that increase the attractiveness of exiting the labor force" [11].

To summarize the significant statistics discussed above, the percentages of women with spouses and children is not significantly different between women in STEM roles and women in professional roles, however, the effects of marriage and childbearing on field-exits for women in STEM roles is profoundly more pronounced than on women in professional roles.

Unpaid Labor

In keeping with themes from other literature, the Glass study discusses the "continued stigmatization of care work" [11]. The study also points to multiple prior works that share evidence that even when flexible work accommodations are offered, women are often hesitant to take advantage of them for fear of seeming "less committed" [11]. "Women may feel penalized for taking advantage of these accommodations, and may therefore feel that their attempts to balance work and family needs are not worth the effort" [11].

Flexible Work Arrangements

For the age group studied in the Glass report, there were not many flexible work arrangements that showed any impact, but to be fair to the data available, this study was pre-COVID and most of the study participants would not have worked the majority of their careers in flexible, more-digitally-driven settings as today's workplaces demand. However, one consistent trend that carries throughout modern research is that parental leave affects a woman's likelihood of leaving her field of work. This trend holds

for both STEM and professional women. “Parental leave is the only work-life amenity that significantly reduces field leaving but does so equally across both groups (39- and 44-percent decreases, respectively, in the odds of leaving for STEM and professional women)” [11].

Level of Investment

A very surprising conclusion of the Glass study relates to the retention of women in STEM with advanced degrees. The initial hypothesis of the study was that women with advanced degrees would have higher retention rates in their field and make less exits from their field as a result of more time/effort put into attaining the degrees and/or training. This was proved to be frighteningly untrue with female STEM jobholders leaving their field as a 166% higher odds if they have an advanced degree in STEM, and “195% higher if they have an advanced degree in a non-STEM field” [11]. Some thoughts around the reasoning for this phenomenon include aspects related to tokenism. “While holding an advanced degree does not affect the odds of leaving professional employment for either destination status (different type of job or labor force exit), increasing educational investment in STEM actually decreases retention and increases the odds of leaving STEM employment, suggesting that the STEM jobs held by advanced-degree holders are either more noxious or more isolating than those held by bachelor’s degree recipients. While unexpected, this is consistent with both the competition/demands and token status explanations proffered for the weaker retention of women in STEM employment. Whatever the origin of these effects, the fact that advanced training, increasing job tenure, job satisfaction, and aging do not deepen commitment to STEM fields as they do for most other workers in most other fields is particularly troubling.”

Exit Timing

“Women in STEM jobs do show slightly more egalitarian gender attitudes, higher earnings, and better work-life amenities, but this should make them less likely to leave STEM employment relative to women in professional jobs, especially for non-market pursuits like homemaking. Yet our findings reveal that women in STEM fields are dramatically less likely to persist in them over time compared to women in other professional fields and that this occurs because women in STEM move to non-STEM jobs at very high rates, not because women in STEM fields disproportionately move out of the labor force. Moves out of the labor force are in fact quite rare for both groups” [11].

The majority of exits out of the STEM field occurred in the first five years of employment for the women surveyed. Some closing summary thoughts on the reasoning for this are summarized as follows. “The patterning of these results supports the perspective that there may be peculiar unmeasured features of STEM jobs that are difficult to combine with family life, and that these are exacerbated as one goes up the hierarchy of skill and authority in STEM employment. But we hesitate to exaggerate the importance of these indicators of occupational commitment (family statuses and spouse characteristics) because the biggest problems in STEM retention occur so early in STEM careers. The large residual unexplained difference in moves out of field between STEM and professional women eludes explanation by family factors and simple job characteristics like earnings or work hours. Even work-life amenities such as flexible scheduling and telecommuting matter little in accounting for the lower retention rates of STEM workers. We suspect that the retention deficit in STEM may be due to the team organization of scientific work combined with the attitudes and expectations of coworkers and supervisors who hold more traditional beliefs about the competencies of women in these rapidly changing fields” [11].

2.3 Women in Specific Industries

Figure 10 showcases the differences in talent pipelines between industries across gender lines. This does not break down employment by discipline or function, and only captures the aggregate gender breakdown by gender for the entire industry, but even with this aggregate data it is easy to see that many industries have a significant gender gap. The McKinsey report calls out these specifics: “ Some industries struggle to attract entry-level women (e.g., Technology: Hardware; IT and Telecom; Engineering and Industrial Manufacturing), while others fail to advance women into middle management (Energy, Utilities, and Basic Materials) or senior leadership (Oil and Gas)” [8]. There are even greater disparities in gender breakdown within specific technical disciplines within some industries, for example, the percentage of female engineers in the Oil & Gas industry compared to the aggregate numbers that include finance, accounting, and administrative functions, with the aggregate numbers often painting a rosier picture for gender representation than truly exists in corners of that sector.


ENTRY LEVEL
MANAGER
SR. MANAGER
VP
SVP
C-SUITE
ASSET MANAGEMENT AND INSTITUTIONAL INVESTORS
50%
42%
35%
28%
21%
19%
BANKING AND CONSUMER FINANCE
51%
45%
37%
33%
30%
30%
CONSUMER PACKAGED GOODS
54%
50%
43%
40%
36%
31%
ENERGY, UTILITIES, AND BASIC MATERIALS
40%
27%
27%
23%
21%
21%
ENGINEERING AND INDUSTRIAL MANUFACTURING
32%
24%
20%
22%
23%
22%
FOOD AND BEVERAGE DISTRIBUTION
46%
37%
32%
27%
20%
20%
FOOD AND BEVERAGE MANUFACTURING
52%
40%
36%
33%
33%
20%
HEALTHCARE SYSTEMS AND SERVICES
74%
69%
59%
44%
36%
28%
INSURANCE
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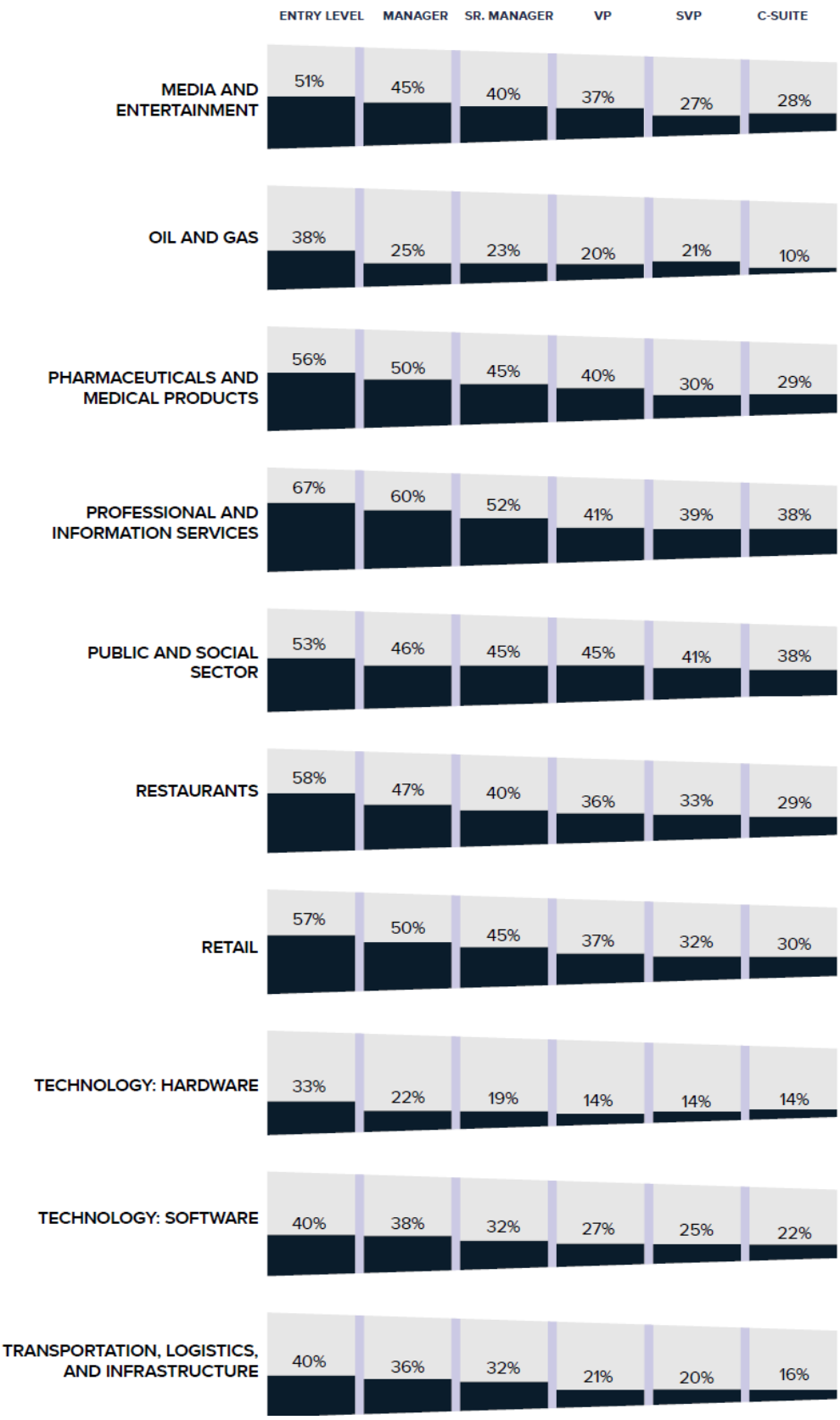

Figure 10. Talent Pipeline of women by industry [Visual from "Women in the Workplace" [8]]]

2.3.1 Women in the Oil & Gas Industry

In conjunction with the timing of the World Petroleum Council hosting the World Petroleum Congress every three years, the Boston Consulting Group produces a report entitled "Untapped Reserves" with the first report appearing in 2017 and the most recent and subsequent report being published in 2020 [20]. These two groups intend to jointly publish a similarly themed report every three years moving forward. The intents of this report are numerous, but one crucial objective is to provide traceability for statistical data around a multitude of diversity-centric data, with the bulk of the focus being on gender equity and what the report refers to as "gender balance" [20]. Similar to other portions of this literature review, the discussion around this report will be broken down into some overarching themes to allow for ease of review and access to data for later reference. The breakdown of companies that were included in the benchmarking data in this 2020 report include 50 companies with a combined revenue of $2 trillion and are comprised of international oil companies, national oil companies, and oilfield services and equipment companies among others [20].

Representation

The Untapped Reserves report dictates that the overall "percentage of women working in the oil and gas industry remains unchanged at 22%, the same level reported in 2017" [20]. Some hypotheses the report gives to this lack of change include effects from COVID-19 along with related oil pricing fluctuations [20]. The severity of the gender gap in oil and gas is visibly displayed in Figure 11, and within the oil and gas industry, the global percentage of women in the industry by region is shown in Figure 12.

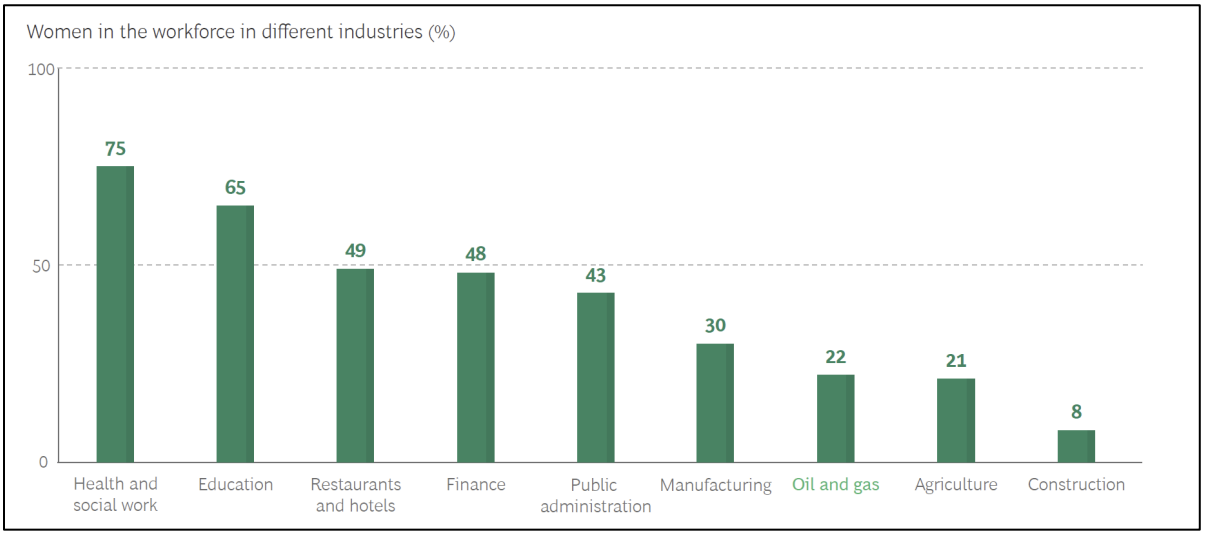

Figure 11. Percentage of women in the workforce in different industries from "Untapped Reserves" [20]

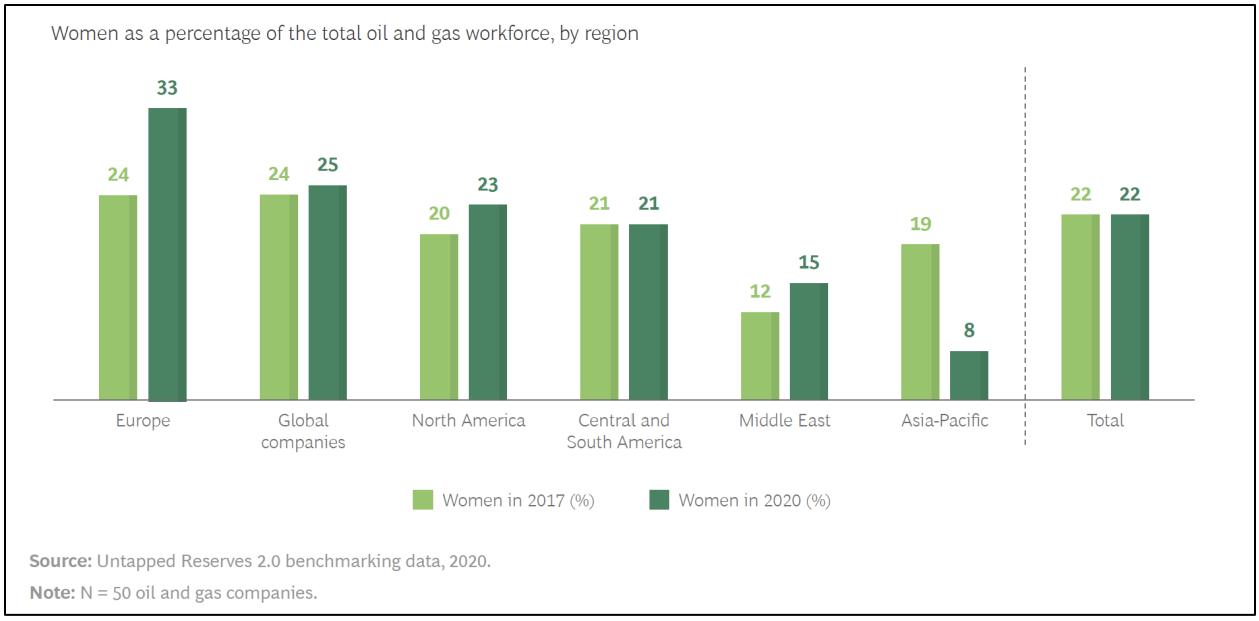

Figure 12. Women as a percentage of the total oil and gas workforce, by region from "Untapped Reserves" [20]

While Europe is currently considered a "world leader" in the industry for their reaching 33% females in industry, this is still barely a third of the industry's workforce and does not display the remaining disparities between technical and non-technical roles within industry.

Promotion Gaps

Referencing back to the talent pipeline visual shown in Figure 2, Oil & Gas demonstrates similar trends in a significant decrease in female representation in higher echelons of management within the industry. "Men hold over four-fifths of decision-making senior and executive-level positions, increasing the risk that a lack of understanding of the actual barriers faced may negatively impact women's prospects for advancement" [20]. Relatedly, "the proportion of women in senior-level decision-making positions is half that of women in midlevel positions" or phrased differently "The overall decline in representation as women progress from midcareer positions to more senior roles exceeds 50% - a figure consistent with what we observed in 2017" [20].

Metrics

An important element that this thesis discusses in Chapter 6 Recommendations is that of metrics for tracking progress, or lack thereof. According to the report by BCG, "less than half of companies link leadership compensation to D&I goals. And only one-third have procedures to ensure "blind" screening of candidates to remove unconscious recruiter biases" [20].

Awareness Gaps

Likely unsurprisingly to any woman who has spent time in a role in the oil and gas industry, men were more optimistic than women about the D&I progress their company had made since 2017. Overall, 75% of men and 66% of women said that there had been "some" or "significant" improvement. In addition, twice as many men as women said that their organization's current promotion criteria were fair, whereas twice as many women as men said that companies needed to put more effort into promoting women" [20].

Family Status

A somewhat unique aspect of job experience in the oil and gas industry, especially in technical roles, is the implied necessity of international expatriate assignments to bolster one's career trajectory. Additionally, flexibility with respect to job relocation is often viewed as a "must" to progress in certain companies. The promotion of women into roles requiring relocation has often been a point of contention when considering candidates, as there can be a perception that women with families are less flexible than their male counterparts who are viewed as being moveable especially if they are termed the "leading spouse". This perception is actually damaging to both genders, in that both male and female candidates alike are likely to pare back their willingness to relocate based on their dependent status. The BCG report "indicates that caring for a dependent person affects women's job choices more than men's, but such responsibilities have a noticeable impact regardless of gender: 30% of women with dependents and 48% of men with dependents would be willing to take on an international assignment, versus 61% and 66% respectively for individuals without dependents. The best approach for companies to take is to avoid making assumptions about personal circumstances, and instead to ask and offer opportunities equitably. Although both men and women with dependents may decide to decline assignments that entail relocation, a substantial number of those with dependents (30% of female respondents and 48% of male respondents in our survey) indicated that they would say yes. The bottom line is not to assume what the answer will be, but instead to ask each individual directly". The data supporting the insights above is shown in Figure 13.

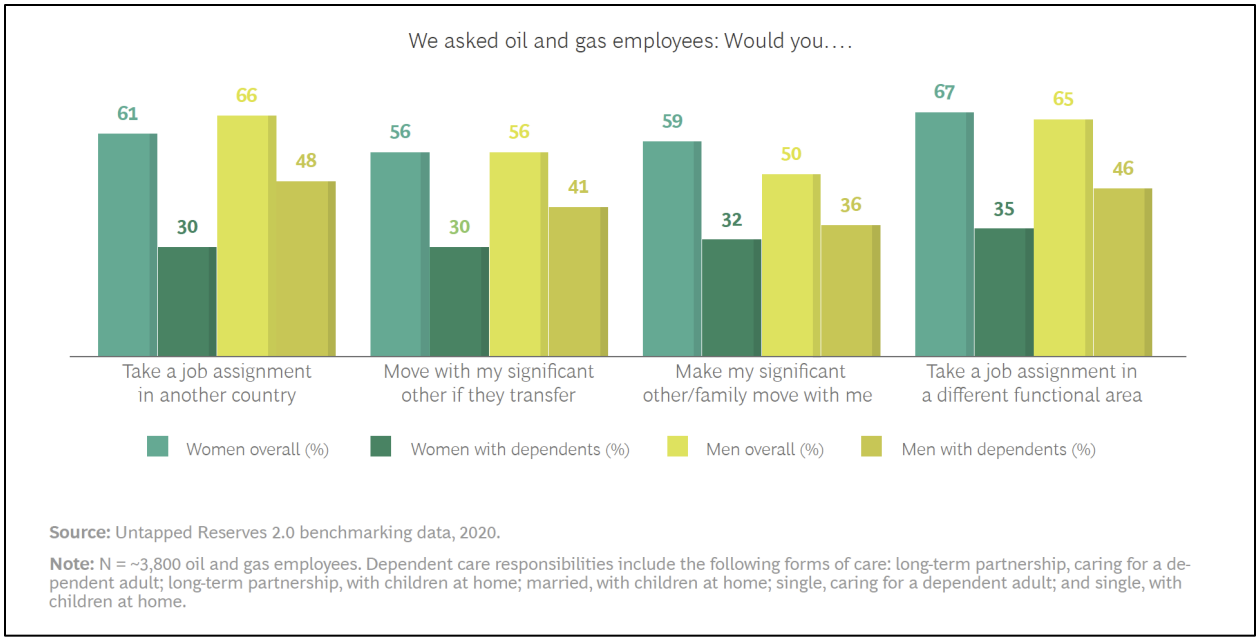

Figure 13. Percentages of workers likely to accept assignments requiring relocation from "Untapped Reserves" [20]

Unpaid Labor

Continuing the themes discussed with the McKinsey study and OECD Study, the BCG study affirms that "female employment was more impacted by the pandemic than male employment. According to a BCG survey across all industry sectors, women, on average spend 15 more hours on domestic labor each week than men do" [20].

Flexible Work Arrangements

In keeping with trends across multiple industries, employees in the oil and gas industry also appear to be responding positively to flexible work practices that have emerged as a result of the COVID-19 pandemic. The BCG study reports "about 65% of male and female respondents said that they expect to benefit from the new models that have been introduced or expanded as a result of the pandemic" [20]. The report also interestingly shows that company leaders in the oil and gas industry believe that these "changes in working practices are here to stay" with "84% of oil and gas companies providing some form of flexible working" [20]. This breaks away from the general sentiments of the data from the McKinsey study shown in Figure 9 that would imply managers expect remote work to dwindle significantly in coming years, which appears to be a mismatch with their employees' desires.

Unconscious Bias

Based on the 2020 data for the companies surveyed, an existing 79% of the companies have some form of unconscious bias training in place for their employees [20]. Forty-seven percent of those companies implemented this training between 2017 and 2020, so the impacts of the training may be difficult to observe as of yet [20]. Some other related trackable data points show room for improvement in areas that are related to unconscious bias, for instance:

- "About half of the male and female employees we surveyed say they don't use their company's D&I policies and programs. While some employees said that doing so was 'too much effort,' others said that they felt unsupported unless their supervisor was also from a diverse group" [20].
- "Men hold over four-fifths of decision-making senior and executive-level positions, increasing the risk that a lack of understanding of the actual barriers faced may negatively impact women's prospects for advancement" [20].
- "Twice as many men as women said that their organization's current promotion criteria were fair" [20].
- "Twice as many women as men said that companies needed to put more effort into promoting women" [20].
- "Only one-third" (of oil and gas companies) "have procedures in place to ensure so-called 'blind' screening of candidates to remove recruiters' unconscious bias" [20].
- As of report issuance, 58% of oil and gas companies surveyed had unconscious bias training for recruiters in place [20].
- As of report issuance, 78% of oil and gas companies surveyed had gender-specific accommodations and facilities [20]. This could be as impactful as a woman having a clean bathroom to use privately in an offshore facility, or something as seemingly small as a woman having size and shape appropriate coveralls in a field environment.
- As of report issuance, 69% of oil and gas companies surveyed explicitly call out diversity in their employee engagement survey [20]. Without engagement with the workforce on their level of fluency and concern around unconscious bias, positive changes are unlikely to occur.

2.3.2 Women in Tech

As the inspiration for this thesis, the book *Brotopia* by Emily Chang is a highly recommend reading for anyone looking to learn more about the environment for women in the tech sector. Brotopia has encouraged numerous other women to share their experiences around being a female in a male-dominate industry, and as a follow-on to the "Me Too" movement, the book has helped countless women share their often-horrific experiences in the boys' club of Silicon Valley [3]. The shock value of many of these narratives aside (although perhaps not shocking to most women in male dominated fields), the book is full of data-driven insights around being a woman in the specific tech discipline as well as suggestions for companies looking to do better. Breaking down this source into noteworthy themes, the following salient focus areas emerge.

Representation

Brotopia begins with a discussion through multiple chapters related to the history of women in the Technosphere. Interestingly, the representation of women in technology was not always so bleak from a percentage standpoint as it is today. "In 1984…women in tech reached a high point, receiving almost 37 percent of computer science degrees. Unfortunately, that's when women's progress in tech suddenly stalled" [3]. There are many factors discussed that contributed to this decline of women in the specific computer science field, but a notable factor includes the stereotyping of the antisocial, nerdy, white man as the "ideal" candidate for companies looking to build their internal programming prowess [3]. Once one company set the mold as this stereotype, others followed suit, to the inevitable detriment of anyone who didn't fit that mold for hiring, and arguably also to the detriment of the companies themselves who were now putting together teams of people who didn't inherently work well with others, look for creative solutions to problems they weren't familiar with, or step outside their comfort zone, all barriers to potential future innovation [3]. A 2013 study by Sapna Cheryan, a professor of psychology at the University of Washington in Seattle, showcased a "wide-spread belief that good programmers lacked interpersonal skills and were fanatically obsessed with computers to the exclusion of most other life pursuits" [3]. This stereotyping is damaging to any enterprise trying to attract women to the company and does not align with many pursuits women expressed a desire to possess in Cheryan's study such as "working with and helping others" [3].

As of time of *Brotopia*'s publishing, "women hold a mere quarter of computing jobs in the United States, down from 36 percent in 1991" [3]. Another statistic mentioned that is related to the

Glass study cited previously is that "women are leaving jobs in technology and engineering more than twice as fast as their male peers" [3], [11].

Tangential to the STEM-focused roles in Silicon Valley, *Brotopia* shares that in the tech start up entrepreneur world "women-led companies received only 2 percent of venture funding in 2017" [3]. "Women accounted for only 8 percent of VC partners at top funds in 2017. Of nearly seven thousand VC-backed companies surveyed in a study at Babson College, just 2.7 percent of them had a female CEO. All this despite research that shows that women-led companies outperform their peers" [3].

Family Status

Silicon Valley does not differ from other STEM-heavy industries in that often the female employees in STEM disciplines choose to defer parenthood for the sake of their careers, as discussed in the Glass and Hunt studies. Some interesting differences arise in how tech companies handle the conversation around this delay. Chang describes how "In 2014, Facebook and Apple simultaneously decided to offer their female employees what appeared to be the ultimate life hack, all expenses paid. The companies would now cover the cost—up to $20,000—for women to freeze their eggs, literally putting their fertility on ice" [3]. Chang goes on to detail how at face-value "this was a generous and genuine attempt to give women employees more choice, and an ingenious way to attract and retain female talent in an industry starved of women" [3]. However, as Chang points out, the mechanisms tech companies put in place to allow for deferred family planning have exactly that effect and often encourage employees to push themselves to further extremes with respect to work-life balance, or lack thereof. "Egg freezing is just one example of how the tech industry has addressed the thorny issue of work-life balance. In fact, some tech folks are actively pushing back on the idea of 'balance' as ideal, because it's nearly impossible to achieve, instead advancing terms like work-life 'blend' or 'integration.' In an era when companies seem to be demanding more of their employees' time than ever, Silicon Valley offers in return not only generous salaries and stock options but incentives and hacks to make work obsession both easier to indulge in and more enjoyable" [3].

Awareness Gaps

The entirety of "Brotopia" does a marvelous job of weaving together data and personal narratives and there is no shortage of anecdotes that support the vast displays of unconscious biases at specific companies in the Tech world. Some comical, yet sad, examples include a story about a tech

venture capital executive that took fellow “tech bros” to his vacation home hot tub to see if they could “hang” with the rest of the club and talk business. The author of Brotopia calls this out stating, “What he did not seem to grasp – perhaps because he suffers from the same blind spot as so many other men in the industry – was any awareness that the demographic of people who might be comfortable sharing a hot tub with a potential investor might be rather narrow” [3].

Unconscious Bias

Frighteningly, the tech industry has had no shortage of “Me Too” moments in the last decade, with some showcasing the overt comfort level that men in the industry have with sharing their biased views. One very overt example of this is a memo released from a young engineer at Google that the author of Brotopia refers to as “The Infamous Google Memo” [3]. This engineer “argued that there were ‘biological’ reasons that men were more likely to be hired and promoted at Google. He suggested that men have a higher drive for status than women” and went on to suggest that women were unable to handle stress and were prone to anxiety and “neuroticism” [3]. This ten-page rambling memo went into great detail about the alleged biological inferiority of women, which is infuriating in and of itself, but the most troubling part is that this engineer felt comfortable sharing this within Google and saw no potential for ramifications to himself.

Another somewhat humorous account of how women are treated differently in certain corners of the tech industry comes from a now infamous article written by Susan Fowler about her time at Uber. The article tells multiple horrifying details of her treatment, but one salient example stands out in her story about leather jackets. “Things came to a head with one particular email chain from the director of our engineering organization concerning leather jackets that had been ordered for all of the SREs. See, earlier in the year, the organization had promised leather jackets for everyone in organization, and had taken all of our sizes; we all tried them on and found our sizes, and placed our orders. One day, all of the women (there were, I believe, six of us left in the org) received an email saying that no leather jackets were being ordered for the women because there were not enough women in the organization to justify placing an order. I replied and said that I was sure Uber SRE could find room in their budget to buy leather jackets for the, what, *six women* if it could afford to buy them for *over a hundred and twenty men*. The director replied back, saying that if we women really wanted equality, then we should realize we were getting equality by not getting the leather jackets. He said that because there were so many men in the org, they had gotten a significant discount on the men's jackets but not on the women's jackets, and it wouldn't be equal or fair, he argued, to give the women leather jackets that cost a little

more than the men's jackets. We were told that if we wanted leather jackets, we women needed to find jackets that were the same price as the bulk-order price of the men's jackets" [21]. Like many other anecdotes from their experiences in Silicon Valley, the myths of meritocracy often seem to wash over the fact that equality and equity are not the same, and companies risk excluding and othering people when they twist defining characteristics of equality and thus make conditions even less equitable for their female employees [3].

One interview in Brotopia also raised the interesting commentary that "companies have been focused more on raising awareness about unconscious bias rather than educating employees about actions they can take to combat bias" [3]. Building fluency is a valid first step but determining meaningful steps forward to address the issues and encourage change must follow.

Flexible Work Arrangements

Many of the seemingly benevolent perks advertised by Tech companies have the end-result, whether intentional or not, of pushing employees to stay at their place of work for extremely long hours and avoid home life to seem more career-oriented [3]. As Brotopia describes in the following detailed discussion:

> "At most established tech firms, free food and alcohol are givens, and they are advertised as selling points. 'We take care of the details so you can focus on what's really important. You never have to think about what's for breakfast, lunch, and dinner,' Dropbox boasts on its website. 'We're always looking for ways to take the stress out of each day.' Facebook and Google have masseuses, doctors, dentists, even hairdressers on call at their headquarters. Ping-Pong and foosball tables are ubiquitous.
> Some companies offer fitness classes on-site, discounts on gym memberships, and a laundry service for your dirty gym clothes. Others encourage employees to bring their pets to work and give discounts on dog walking, pet insurance, and pet supplies.
>
> While some of these benefits would appeal to any employee, many skew for the young and single. So many perks, yet day care is not on the list. Few employers offer stipends for child care, and even fewer provide on-site child care. Sure, you can bring your dog to work, but you are (mostly) on your own with your baby.
>
> That's because Silicon Valley companies have largely been created in the image of their mostly young, mostly male, mostly childless founders. They don't call their

> offices 'campuses' for nothing. Facebook employees tell me that although Sandberg has had an immeasurable effect on the company culture (Facebook's website makes a point to emphasize it wants to help employees thrive 'at all stages of life'), to a certain extent the campus will always feel a little bit like a nineteen-year-old's dorm room. Google is slightly more mature, a hangout for single PhD candidates. With no kids waiting at home, many young, single employees just out of college are susceptible to making work life their entire life, a tendency the companies are happy to enable. Thanks to the seemingly generous perks they provide, you don't have to leave the Google or Facebook campus except to go home and sleep (at some start-ups, I've heard, employees skip home altogether by keeping cots under their desks). Along with working in a creative environment with brilliant people, you get to play in the Ping-Pong tournament or enjoy a massage at lunch, grab a free beer from the company fridge, and ride the Wi-Fi-enabled company bus home. The last one leaves the Google campus in Mountain View at 10:30 p.m., which lands you in bed in your San Francisco loft by midnight. For the right person, at the right life stage, it can be heaven. But women thirty-five and up are usually not that person, and the usual perks of the job do not address the reasons so many women in that age-group decide to leave" [3].

Sexual Harassment

Brotopia had the unique timing of being published shortly after the "Me Too" movement gained significant momentum and a large portion of media attention was being paid to certain political candidates' histories of sexual assault and harassment. The book does not shy away from this topic and instead helps share links back to larger collections of accounts from women in industry of their own personal experiences. To not take away from the impactful communication of this section of the book, the portion summarizing the "Elephant in the Valley" report is quoted directly below in entirety [3]:

> "Until recently, there hasn't been any way to quantify the harassment, sexism, and amorphous "bro culture" in the tech industry. People could dismiss misogynistic stories like Susan Fowler's as one-offs, exceptions and not the rule. But in 2016, a group of industry insiders, in conjunction with Stanford University, published a survey of women and their

experiences at Silicon Valley workplaces. The “Elephant in the Valley” study (yes, that’s its real name) found that of the more than two hundred women respondents (most of them having had at least ten years’ experience), the vast majority—90 percent—reported witnessing sexist behavior at industry off sites and conferences. Sixty percent said they had personally been sexually harassed or received unwanted sexual advances, most of the time from a superior. Bear in mind, according to the study’s authors, 25 percent of the women surveyed were C-suite level; 11 percent were founders.

These women also reported the “little things”: 84 percent of those surveyed said they’d been called too aggressive at work; 66 percent have felt excluded from social or networking activities because of their gender; 59 percent felt they had not gotten the same opportunities as their male counterparts. Most said questions that should have been directed to them were asked of their male peers instead, and almost half have been asked to do lower-level tasks such as taking notes or ordering food, jobs that male colleagues are not asked to do.

In addition to these statistics, the “Elephant in the Valley” surveyors collected hundreds of heretofore unpublished anonymous stories they agreed to share with me. With the help of an incredibly patient researcher, I spent hours organizing these stories into categories that included “sexual harassment,” “porn use in office,” “bro culture,” “rape jokes,” and “assault.”

The data dump came in the form of a massive spreadsheet including around 250 accounts of women in tech. Their stories were an exhausting read, for both their volume and their emotional content. The largest number of

complaints, by far, fell into my category of sexual harassment—inappropriate and unwanted come-ons by coworkers, bosses, or superiors. One woman working among a hundred male engineers reported being hit on repeatedly, with one engineer telling her, “If I was 20 years younger I would rock your world.” There are several reports of unwanted kisses and gropes, and even of men showing up at the homes of their female colleagues expecting some form of sex and refusing to leave when asked.

Off-color remarks and sexual jokes were also a common theme in these accounts. Apparently, at tech firms, comments and jokes about sexual behavior, Viagra, porn, and even rape seem to fit right in. One woman reported, “I was walking with some male colleagues around the office at lunch, and when we found ourselves in a remote area of the building with a sketchy old door, one of them said, jokingly, ‘Quick! Grab her legs, let’s rape her!’” Many women had also had the uncomfortable experience of seeing male co-workers watch porn while at work and hearing them rate women in the office based on sexual attractiveness.

According to the stories, things often get really dicey at company off sites or social events. One woman said her company’s designated happy-hour location was Hooters, where she listened to her boss complain about his wife. There are tales of strip clubs, of course, accounts of uncomfortable come-ons whispered into women’s ears at parties, and one report of being groped in a hot tub at a company retreat. Many women felt they had no choice but to participate in these events and one reported that “only those who would party and drink excessively with the CEO on Friday nights would get promoted.”

> After reading dozens of the anonymous "Elephant in the Valley" stories, I noted that the women spoke in a surprising tone: more exasperated than outraged. Like the dozen women I had gathered in my living room, they were tired of the toxic culture they worked in and tired of having to explain it to those who somehow managed to ignore it. It is because of their endurance and courage, I believe, that we have reached a cultural tipping point. From here on out, ignorance of the problem can only be willful. Reactions like "Gosh, I didn't know this was going on" and "Is it really that bad?" are simply no longer credible. Or acceptable." [3]

Metrics

A bold software engineer, Tracy Chou, realized while attending the 2013 Grace Hopper conference that the data around diversity metrics that would hold companies accountable was not available or readily publicized [3]. Chou published a Medium article shortly after the conference asking Tech companies to come forward with their diversity data and many did, although it took some companies quite a while [3], [22]. "With her employer's permission, Chou revealed the percentage of Pinterest's engineers who were women (12 percent at that time), putting the pressure on other tech companies to keep the ball rolling. Like Fowler's post, Chou's essay became the talk of the Valley. It took some time, but most of the major tech companies ponied up. In 2014, Apple, Google, and Facebook revealed their diversity data, and, unsurprisingly, the picture was dismal. Not only were women outnumbered, but in the most critical and most senior positions they were grossly outnumbered. The women who do work at these companies are generally more junior, a trend that preserves an 'old boys' club power dynamic that often works against the young women's advancement. The import of the numbers that Chou had forced the industry to reveal was something that every woman in the group was familiar with. Because engineering teams are often made up of only a handful of people, there's often just one woman, if that, on every team" [3]. The publication of these metrics has since enabled much healthier conversations driven by data around topics like promotion gaps, tokenization, unconscious bias, and many other themes discussed at length already in this thesis.

2.4 Women in Specific Subdisciplines

Before diving into analysis of women in engineering specifically with interview data, two additional literature sources were reviewed. One discusses participation of women within physics and STEM courses and is framed from an academic focus point, and one discusses the persistence of women in engineering specifically.

Physics and STEM in Academic Settings

The report "Gender inequity in individual participation within physics and science, technology, engineering, and math courses" was created to demonstrate whether specific pedagogical approaches in academia that may be more fruitful towards encouraging participation of women. These enhanced understandings of relevant pedagogy may also aid in organizations assessing how they interact with and retain female employees as well. The report examines gender inequity through the lens of "individual verbal participation" in large introductory courses in STEM disciplines as well as physics specifically [23]. The study examined active participation in coursework through multiple mechanisms and then also assessed whether certain modes of instructor engagement and/or feedback were conducive to improving participation equity across genders of students in the class [23]. An interesting data-supported result from this study is that greater participation showed significant correlations with sense of belonging and inclusivity [23].

As the data from this report shows, there is indeed a large inequity in the verbal participation across the genders in both physics and broader STEM undergraduate courses. The incorporation of non-verbal participation tools, such as clickers, appears to improve on some aspects of the inequity, but they are not a panacea for class engagement [23]. Some suggestions from the report are interesting as they also follow as reasonable considerations for a company or other organization to take when encouraging engagement of a broad group of employees or members in settings where women may be the minority and are additionally wary of speaking and have higher levels of "belonging uncertainty" which "might undermine women's motivation to participation" [23]. These suggestions include:

- Set clear expectations: "Instructors can begin by reflecting on the ways they encourage participation in the classroom, making sure their expectations for participation in the course are outlined or defined in the syllabus. Instructors should also verbally communicate their expectations to the students" [23].

- Create a sense of community: “To foster a safe environment that encourages all students to verbally participate, instructors can normalize mistakes and emphasize the collaborative, community aspects of learning” [23].
- Model attitudes that allow for growth mindsets: “Instructors can model the behaviors the expect from students. If they make an error in class, they can treat it as an opportunity to affirm that everyone makes mistakes. This approach will create an environment where students may be more likely to participate because they will feel less pressured to provide the correct answer and instead contribute to the learning process” [23].
- Do not continually get feedback from a select few: “Prevent the same students from always answering questions posed to the class by, for example, resisting the urge to always choose the first hand that goes up” … “Ask for volunteers, or for new voices. These actions can help encourage new students to verbally participate, and instill a sense of shared responsibility for answering questions” [23].

The study also showed throughout the report and in the final conclusions that increasing the number of women in the classroom was also not a solution to every problem. Even when women made up the majority of the classroom, men still often dominated the verbal participation in those classrooms [23].

Engineering Retention Gaps

The article “Why Do Women Leave Science and Engineering” by Hunt leverages data from the 2003 and 2010 National Survey of College Graduates to assess why women leave science and engineering at higher rates than their male colleagues. Hunt’s analysis shows that from the data available, women in engineering have the highest rate of excess exits from their field and significantly surpass the percent of exits even of women in other science disciplines [24]. However, consistent with the findings of the Glass study, Hunt concludes “that excess female exits from science and engineering are present only in exits to another full-time job” [11], [24]. With further assessment of the data and regressions assessed, Hunt goes on to summarize her conclusions as follows:

“Neither worker characteristics nor worker preferences about job attributes, including salary and opportunities for advancement, contribute to explaining the excess female exits from engineering, and I find no differential impact of having children for women trained as engineers. Furthermore,

I have shown that the problems are not the family-related ones emphasized in most of the previous literature. Rather, I find that the most important driver of excess female exits from engineering is dissatisfaction over pay and promotion opportunities, a factor explaining half of the differential gender gap in exit rates. Family-related constraints are not a factor; although many more women than men cited family issues as the reason for leaving engineering, the gender gap is just as large in non-science and non-engineering fields. I find that working conditions, the unavailability of a job in the field, changes in professional interests, and job location play statistically significant but secondary roles.

The results appear to point to problems for women that are specific to the engineering profession. Nevertheless, I show that the excess exits of women trained as engineers, as well as their excess exits because of pay and promotion opportunities, are no larger than would be expected given the share of men in the field; compared to men, women have relatively higher total exit rates and pay- and promotion-motivated exit rates from male dominated fields of study. This result is robust to controls for the field's working hours, wages, and share of workers in management, all of which are positively correlated with the male share. This is consistent with my finding that excess female exits from engineering are much smaller (and statistically insignificant) compared to the male-dominated economics and financial management fields than compared to non-science and non-engineering fields generally. The implication is that a lack of mentoring and networks, or discrimination by managers and coworkers, are the more promising of the existing explanations for excess female exits, and that explanations hinging on the precise nature of engineering work, such as use of equipment, labs, and field work, and consideration of natural phenomena, should be discarded" [24].

3 Systems Framework

This chapter describes the initial framework development process of this thesis, stemming from literature review and moving into strategic conversations with key stakeholders in the systems at play. The system framework then develops further through an in-depth review of qualitative interviews and a collation of the themes coded from the qualitative interviews. Along with the themes discussed, some poignant, anonymized anecdotes are shared from the interviews to further support information shared in detail in the literature review. Some new themes emerge as a result of the interview discussion, which further shape the systems analysis in Chapter 4.

3.1 Engaging Stakeholders in Framing discussions

Prior to beginning literature review, multiple senior female leaders in various fields were engaged in an informal capacity to discuss the focus areas they thought should be at the forefront of this thesis. The women selected for these initial framing discussions included:

- Director of Women's Gender & Sexuality Studies at a public university
- A member of the Houston Women's Commission
- Chief Diversity and Inclusion Officer of a large multinational corporation
- A Leader of a large Data and Artificial Intelligence networking group
- General Manager of Asset Development for a global energy company
- President of a private science and engineering university

These women each provided a minimum of an hour of their time to discuss the issues at hand that they felt most passionately about in the world of engineering and gender equity. All but one of the aforementioned stakeholders have STEM backgrounds, and all have at least an undergraduate degree, with most holding advanced degrees in fields such as statistics, business, and patent law. These stakeholders have all managed to persevere in fields that have not been historically welcoming to women, and as mentioned in the acknowledgments section of this thesis, they have paved the way for many of the women who now occupy engineering roles. Multiple themes emerged through these stakeholder framing discussions that warrant further discussion. These included, but were not limited to, the following list. This list is purely based on the framing conversations held and the leaders engaged will remain anonymous to protect the candor they displayed in sharing their thoughts.

- Pedagogy in academic settings that is inherently less competitive is more conducive to cooperation between classmates and ends up being more inviting to students who feel as

though they are “other” from the primary group in fields such as engineering, computer science, and physics.

- Visible representation in academic institutions of female faculty and administrative staff in STEM departments allows students to see a representation of themselves in leadership and decision-making roles which enhances their feeling of “fit” in the culture of the institution.
- There is low female representation across the board for engineering disciplines.
- There is a general feeling among these women that progress has not been fast enough nor sweeping enough in scope.
- Academic programs that allow for more flexibility in degree selection appear to be more enticing to women who do not want to be “pigeon-holed” into selecting a degree they are not sure they will be successful in pursuing.
- Gender often functions as a work assignment principle.
- Perceptions from managers sometime result in feelings that women are unreliable workers. Some of this stems from the fact that when women have children, the child is only in school for 37% of the time between the ages of 0-18.
- Broad research continues to support that companies benefit from more diverse boards, more diverse workforce, more diverse engagements with the communities they are involved in, etc.
- There was a general feeling among many of these female leaders that they were “very lucky” to have gotten as far as they have. The author of this thesis would like to note that these women sacrificed greatly and worked extremely hard to get where they are in their careers.
- One female leader mentioned that with respect to harassment, there was never one large thing, it was a collection of a million little things that became unbearable over time. Historically, there was also a lack of ability to report issues as they arose, so one comment she gave was that things have drastically improved in the regard of zero tolerance for harassment and assault. However, she did note that to address any continued issues, the problems must be reported, which still is problematic and stigmatized in many settings.
- As many of the women increased in tenure, they mentioned that things they would have put up with when they were younger, they were no longer willing to tolerate. This resulted in them being more comfortable pushing back and calling people out for bad behavior.

- Multiple business leaders mentioned the need for opening up recruiting criteria for specific jobs to be less restrictive to the already limited pool of women for potential future assignments. This is especially relevant for opportunities that have previously required offshore work, expatriate assignments, or field assignments, which have historically been extremely male-dominated and often not offered to women. If companies continue to constrain hiring for future upward roles based on jobs that women couldn't have ever been expected to hold, the companies cannot expect women to ever move up into positions of leadership.
- Empathy is quickly becoming a very well-recognized requirement for a person to be considered a good manager. One leader in a very male dominated industry was optimistic that this recognition of Emotional Quotient (EQ) would allow women to accelerate careers more quickly, as she believes that empathy is an inherent trait for many women.
- A diversity and inclusion leader at a large corporation recognizes a prime challenge to removing gender biases and unconscious promotion bias in front-line supervisor scopes. She believes that this first supervisory hurdle is a hang up for many young women to get to the next logical step in their career. This is line with much of the "broken rung" discussion from the literature review of this thesis.
- Establishing a sense of community in one's workplace is critical to retention of employees from many diversity groups.
- The "myth of the model minority" was referenced by a female leader, with respect to the feeling that people in the minority of a workplace must be the perfect representation of their specific group at all times. This puts undue pressure on the employee for a number of reasons and can introduce intense feelings of "othering".
- There is a need for targeted sponsorship of individuals from specific groups to enable them to actually achieve upward mobility. This often means that the sponsor will not be of the same background and needs to work in an ally role with an understanding of the issues that they may be unfamiliar with while providing sponsorship to someone outside their own group.

3.2 Qualitative Interviews

Following the initial framing conversations with female leaders in multiple domains, the focus of this thesis turns to engagements and conversations with female engineers who are earlier on in their career and thus have less published data sets available around their career progressions in aggregate.

For example, the Glass study discussed in the literature review of this thesis is able to intensely analyze themes around career progression and effects of marriage and childbearing because the respondents are already through the potential inflection points of career exits. The interview section of this thesis intends to focus on the female engineers that are still within those inflection point timelines and are potentially changing the ways in which companies need to think about gender issues in engineering moving forward.

3.2.1 Interview Participants

To solicit input from female engineers from multiple disciplines and backgrounds, a call was put out via multiple social media avenues including LinkedIn, Facebook, and Slack through the MIT System Design and Management communication network. The posting shared across these networks included a link to a Google Forms document where interested individuals could self-populate a record of their desire to participate. A snapshot of the form instructions is included in Figure 14, along with the collection fields shown in Figure 15.

Interview Request

You are receiving this survey because you have been identified by Katherine Papageorge (me), or a colleague of Katherine, as a potential interested party in participating in interviews for my thesis for the MIT System Design and Management Master's program.

My thesis title is "A Systems Approach to Understanding Gender Inequity in Engineering" and I intend to take a systematic analysis approach to examining gender disparities, inequalities, and inequities in the field of engineering.

How will these interviews be used: As an interview participant, your commentary will be used as support in the conclusions I draw relative to the strength of certain biases and relationships in the systems at work in the engineering world. Your name and company will be removed/scrubbed from any published information. All information is intended to be presented in aggregate so no identifying characteristics will remain in your inputs.

Interview Process: Each interested interviewee will be able to select an hour time slot via a Calendly link sent to you upon receipt of this survey response. This hour long interview will be via Zoom or Teams and will be recorded to allow for transcripts to be collected (you do NOT need to have your video on if you are not comfortable, but I will leave my video on if you'd like to talk more casually). These interviews will be largely guided in a conversational format and I will work to pursue detail on any topics you would like to dive deeper into. The transcripts of these interviews will be coded in a transcription app (Otter.ai and Nvivo), where your name will be removed, to allow me to do potential interview coding for data analysis. Following the conclusion of this thesis in August 2022, your video/audio recording will be deleted permanently.

Demographic Information: As part of the interview process, I ask that you provide some very basic demographic information. You may decline to comment on any of these items you are uncomfortable discussing. These demographic responses will enable me to discuss aspects of intersectionalism in inequity, and will also help me confirm that as a researcher I have reached out to a broad and diverse subset of female engineers and not only a group that matches my own attributes. Once you agree to proceed with the interview process, I will send you a survey to collect this demographic information along with the Calendly scheduling link discussed above.

If you have any questions at any time, or ever become uncomfortable in this process, please inform me immediately and we can cease the discussion and I will purge your records immediately. A huge THANK YOU in advance for making this thesis interview process possible.

Figure 14. Initial Interview Request form created by thesis author to solicit interviewees

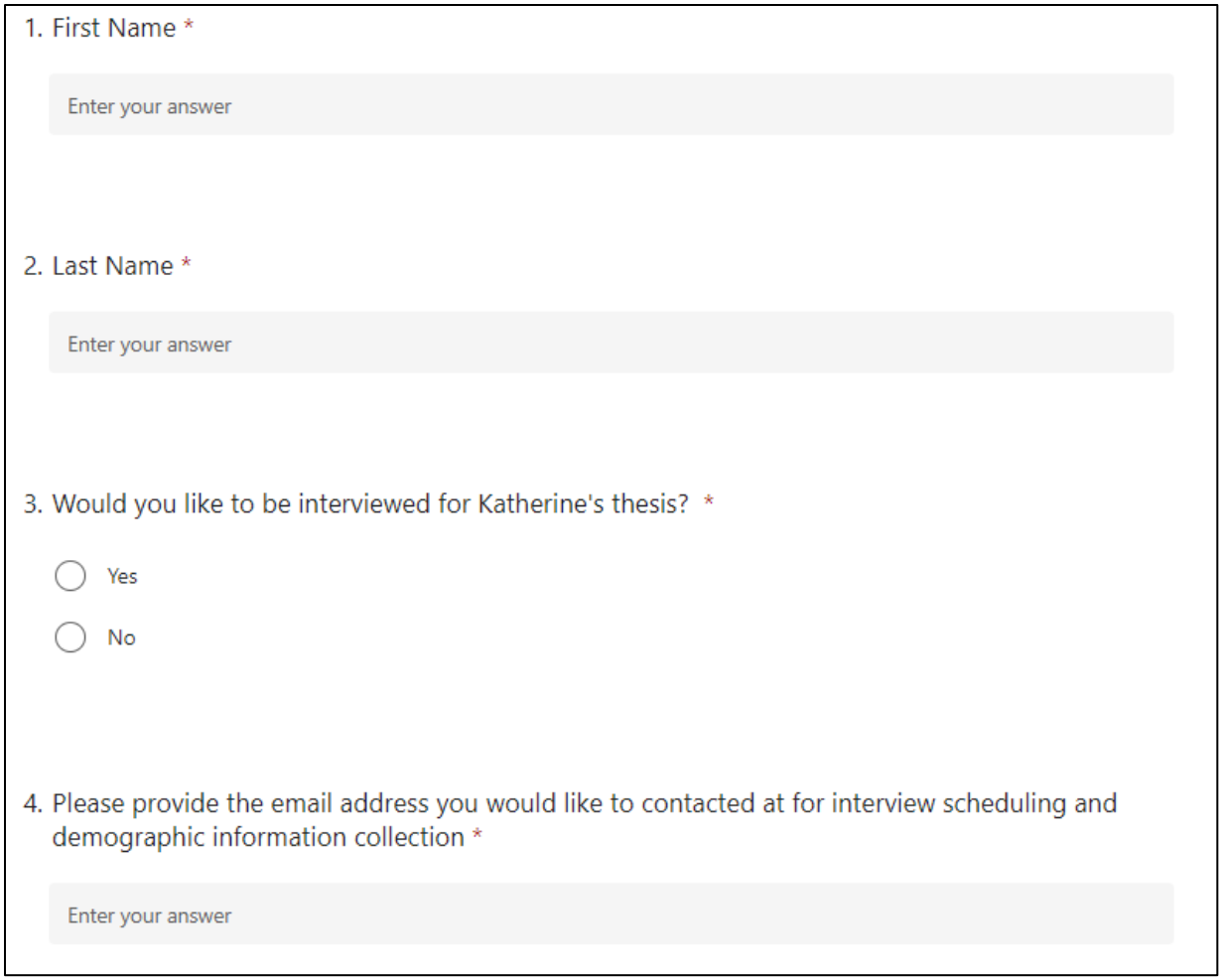

Figure 15. Collection fields for initial interview interest form

The initial feedback from the interest survey returned 84 respondents who voiced an interest in participating. Once these 84 women were identified, a second call for input went out to begin to determine which of these interested parties would be able to contribute to the final verbal interviews. The intent in the second call to the original pool of 84 women was to collect demographic information that may prove influential to the eventual content of an interview. The intent of assessing the demographic information ahead of time was to ensure that the thesis author queried as diverse a pool of candidates as possible, considering factors including race, age, marital status, income level, number of dependents, subdiscipline of engineering, employment tenure, and country primary work has been based in. The instructions given and questions asked of the demographics inquiry form are shown in Figure 53 of APPENDIX A.

After sending the follow-up demographics collection request to the initial 84 women, 47 women completed the demographics survey. Of those 47, the self-reported racial breakdown was as follows in Figure 16. The results of this input are, sadly, in line with the general racial makeup of the North American engineering landscape. Zippia career services estimates demographics associated with engineers in the United States and then verifies the estimates against the Bureau of Labor Statistics, the Census, and current job openings [25]. Zippia finds that 13.7% of engineers in the US are women, and the overall ethnic breakdown of engineers is 71.7% White, 14.0% Asian, and 8.4% Hispanic or Latino [25]. The National Science Foundation report entitled "Women, Minorities, and Persons with Disabilities in Science and Engineering" recently shared their 2021 findings which include data from 2018 with respect to demographics in engineering, and while they note these numbers are pre-pandemic, the total percentages of women earning degrees in engineering is still woefully low. A table showing the percentages of women with multiple degree levels earned in three sample periods, 1998, 2008, and 2018, is shown in Figure 17 with the most recent year's data highlighted in gray for easy viewing [26].

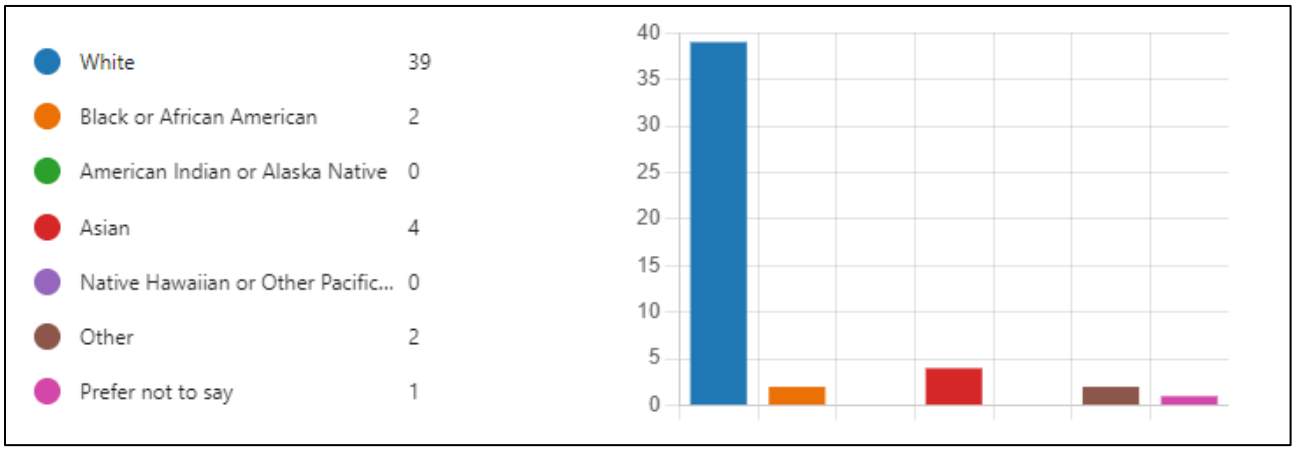

Figure 16. Racial breakdown of 47 potential interviewees

Degree and year	Percent women	Number of women (thousands)
Doctorate, 1998	12.26	0.73
Doctorate, 2008	21.55	1.75
Doctorate, 2018	24.53	2.69
Master's, 1998	19.8	5.16
Master's, 2008	23.02	7.64
Master's, 2018	25.78	14.43
Bachelor's, 1998	18.61	11.34
Bachelor's, 2008	18.48	12.92
Bachelor's, 2018	22.2	27.6

Figure 17. Degrees awarded to women in 2018 by degree, percentage, and total number [Data from [26]]

Additional interesting graphics from the preliminary demographics collection are shown in:

- Figure 18. Marital Status of 47 potential interviewees
- Figure 19. Self-reported Income level of 47 potential interviewees. Responses to question: "What is your income level? (Of you alone, not including a partner or spouse)"
- Figure 20. Highest degree level achieved by self-reported data of 47 potential interviewees
- Figure 21. Self-reported data from 47 potential interviewees on number of children they have
- Figure 22. Tenure of work experience from 47 potential interviewees

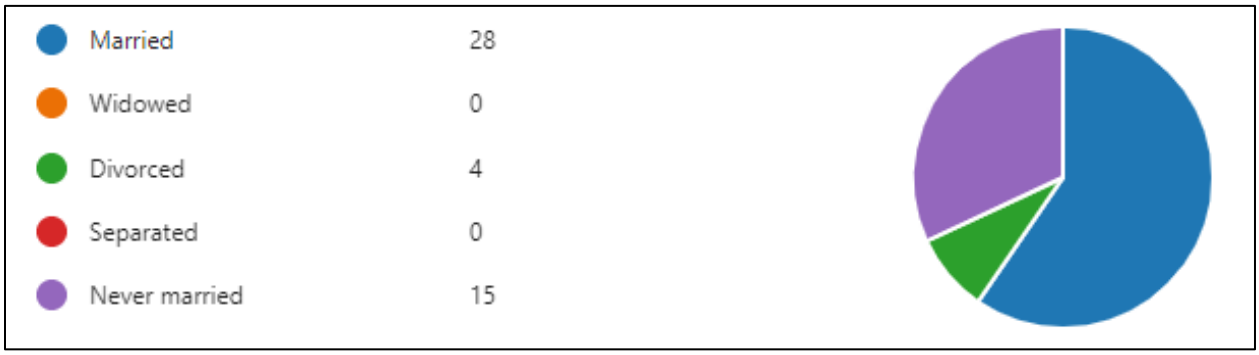

Figure 18. Marital Status of 47 potential interviewees

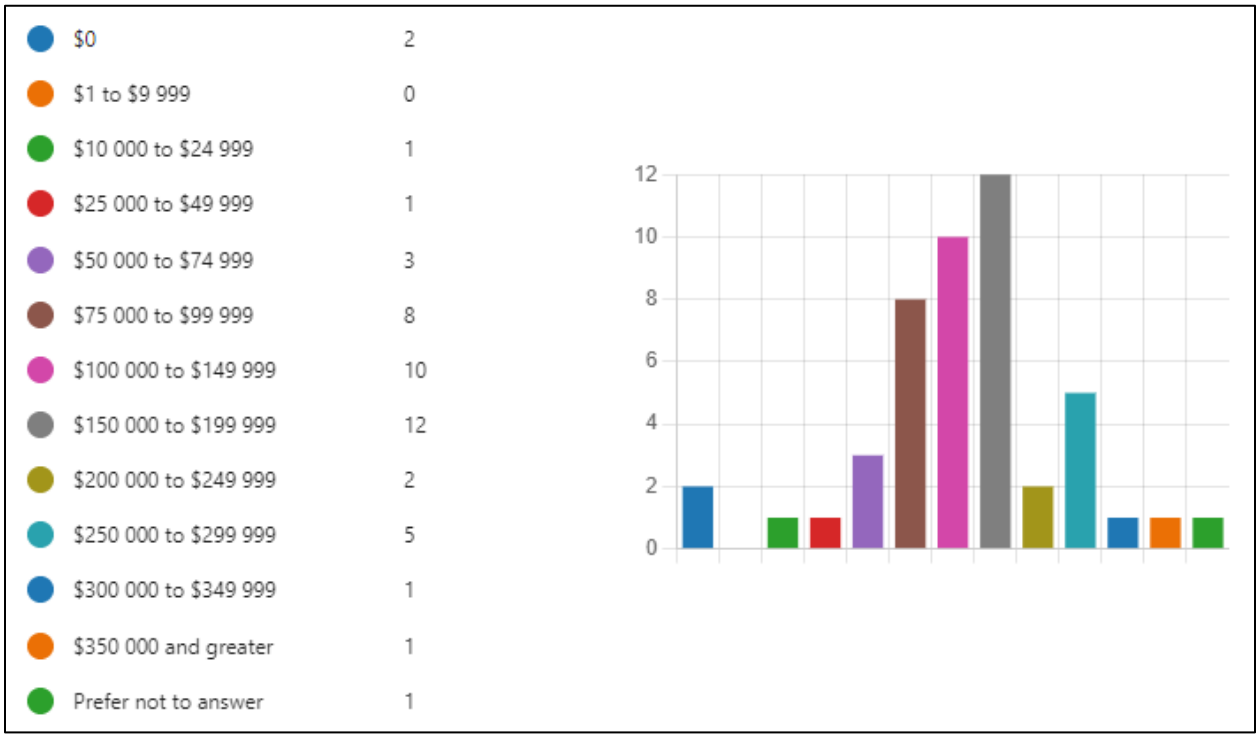

Figure 19. Self-reported Income level of 47 potential interviewees. Responses to question: "What is your income level? (Of you alone, not including a partner or spouse)"

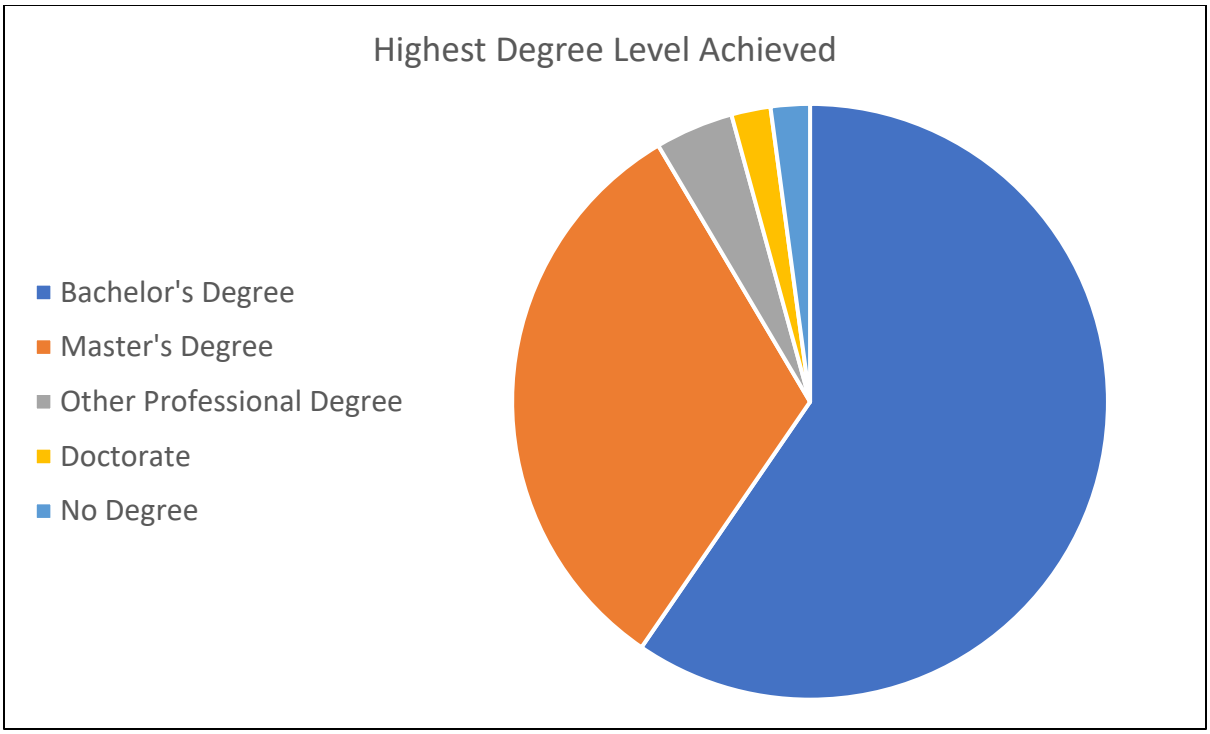

Figure 20. Highest degree level achieved by self-reported data of 47 potential interviewees

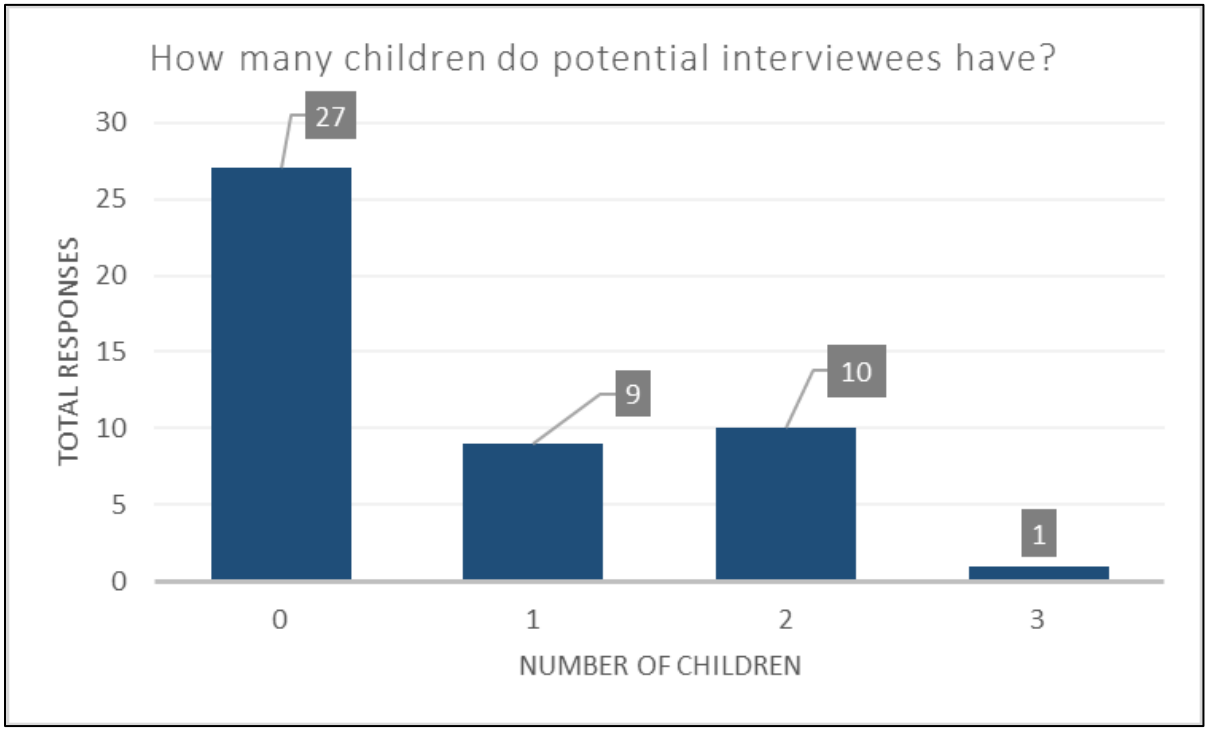

Figure 21. Self-reported data from 47 potential interviewees on number of children they have

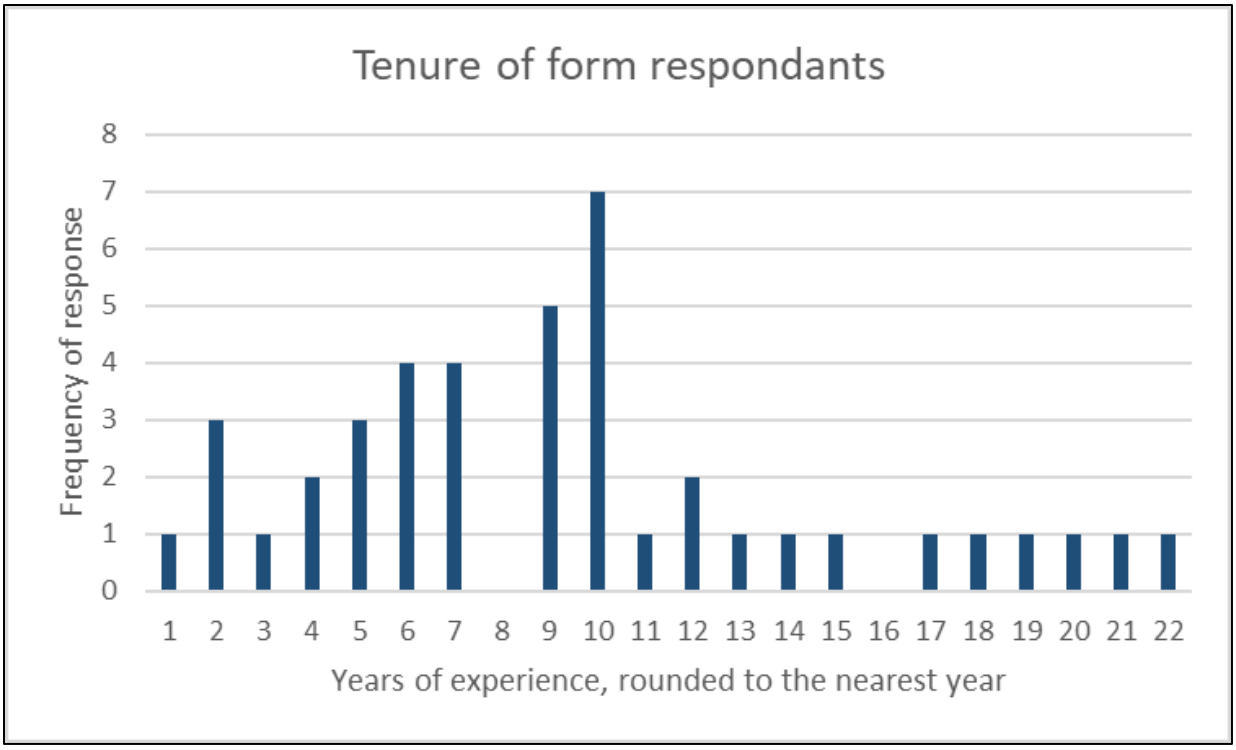

Figure 22. Tenure of work experience from 47 potential interviewees

One additional input from the survey of the potential interview candidates was the primary country in which the individual had worked for the majority of their career. As discussed in the scoping portion of this thesis, the focus on female engineers has intentionally been limited to experiences in the United States and Canada to avoid undue cultural influences from other nations that would be difficult to control for in interview questions and theme development.

Upon review of the 47 received demographic survey responses, a preliminary pool of 25 candidates with diverse backgrounds, experience levels, dependent statuses, marital statuses, races, and ages was contacted to register for an interview slot if their time allowed. Of the 25 contacted, 17 individuals registered for a 30-minute interview slot and were the final pool of interviewees that were engaged in a detailed qualitative interview session. A note, while the sessions were scheduled for 30 minutes to be respectful of participants' time, most interviews extended longer at the discretion of the interviewee. The majority of interviewees ran for 45 minutes to one hour in duration. The demographic makeup of the final pool of 17 interviewees is as follows:

- 12 White, 3 Asian, 2 Other (Mixed races).
- 11 Married, 2 Divorced, 4 Never Married.
- 10 with No Children, 3 with 1 Child, 4 with 2 Children.

- Tenure of interviewees includes women with as little as one year in the workforce and up to 18 years working as an engineer and over 20 years in the workforce in general. The average and median tenures in engineering roles are both 8 years.
- 11 interviewees have bachelor's degrees in engineering, and 6 Interviewees have additional master's degrees.
- Interviewees ranged in age from 23 to 54 with the median age being 33 years old and average age being 34 years old.
- Industries interviewees actively work in or have worked in include Chemicals, Refining, Construction, Sound Engineering, Oil & Gas, Architecture, Civil Design, Structural Engineering, Academia, Energy Policy, Military Service, Manufacturing, Aerospace, and Data Science.

Visual aids for salient attributes of the interview pool are shown as well for reference in Figure 23, Figure 24, Figure 25, Figure 26, Figure 27, and Figure 28:

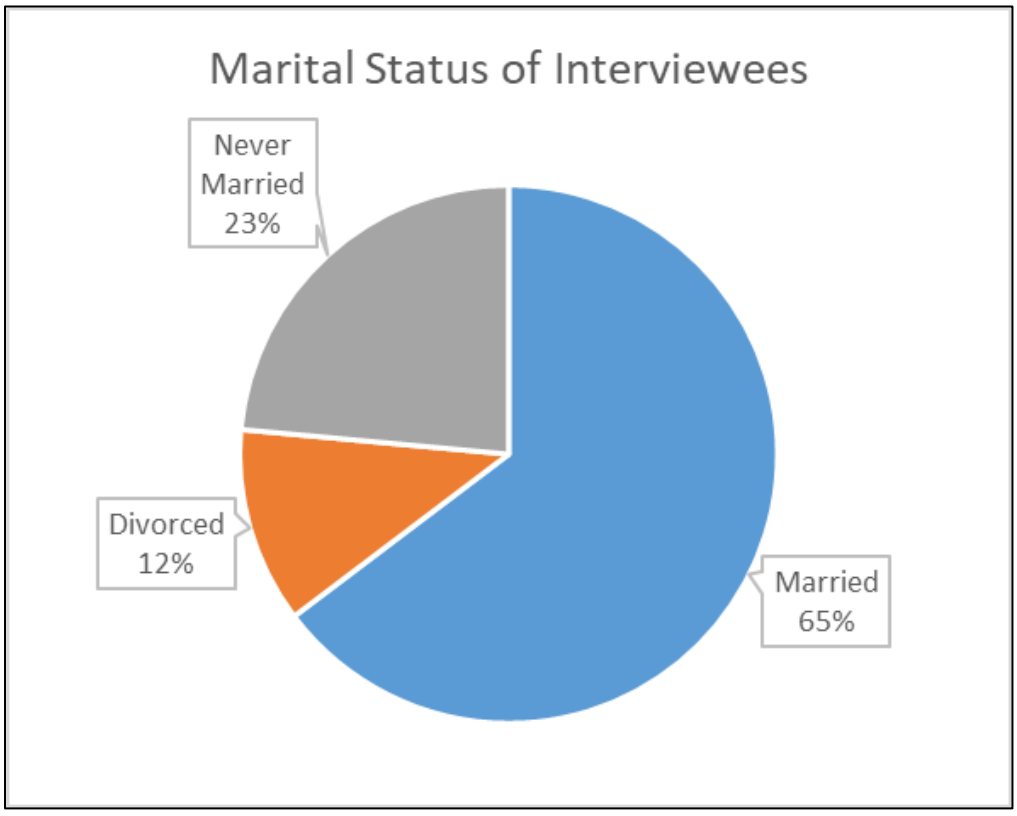

Figure 23. Marital Status of Interviewees

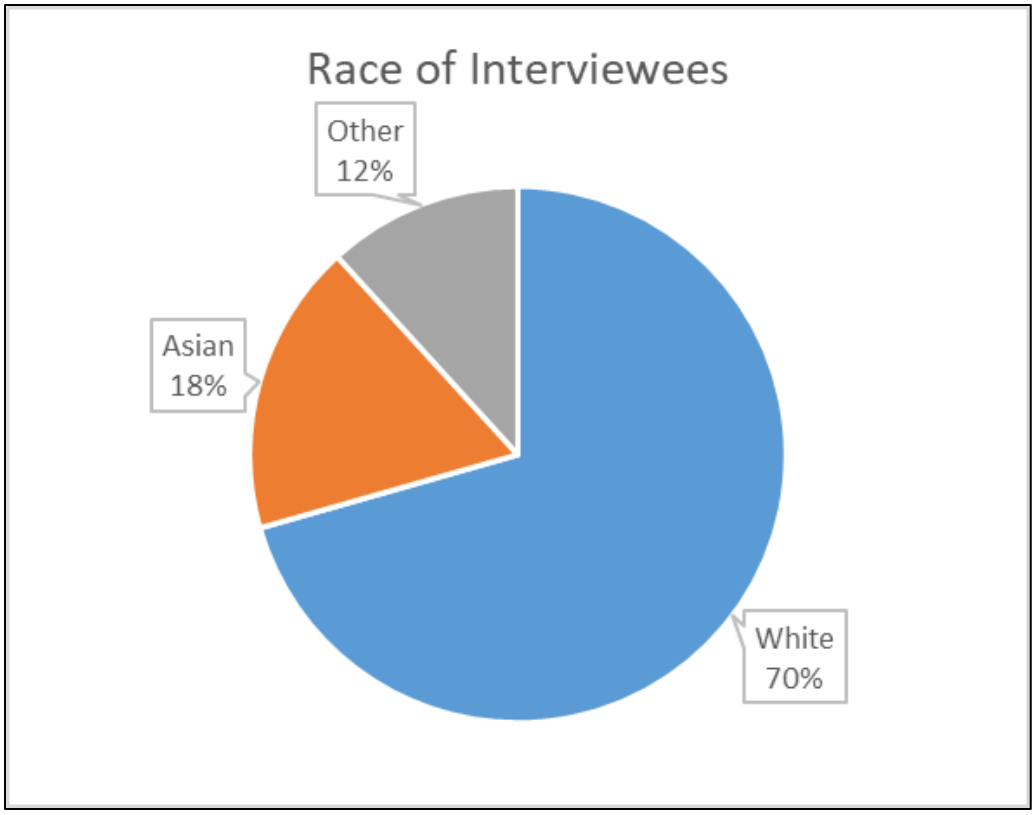

Figure 24. Race of Interviewees

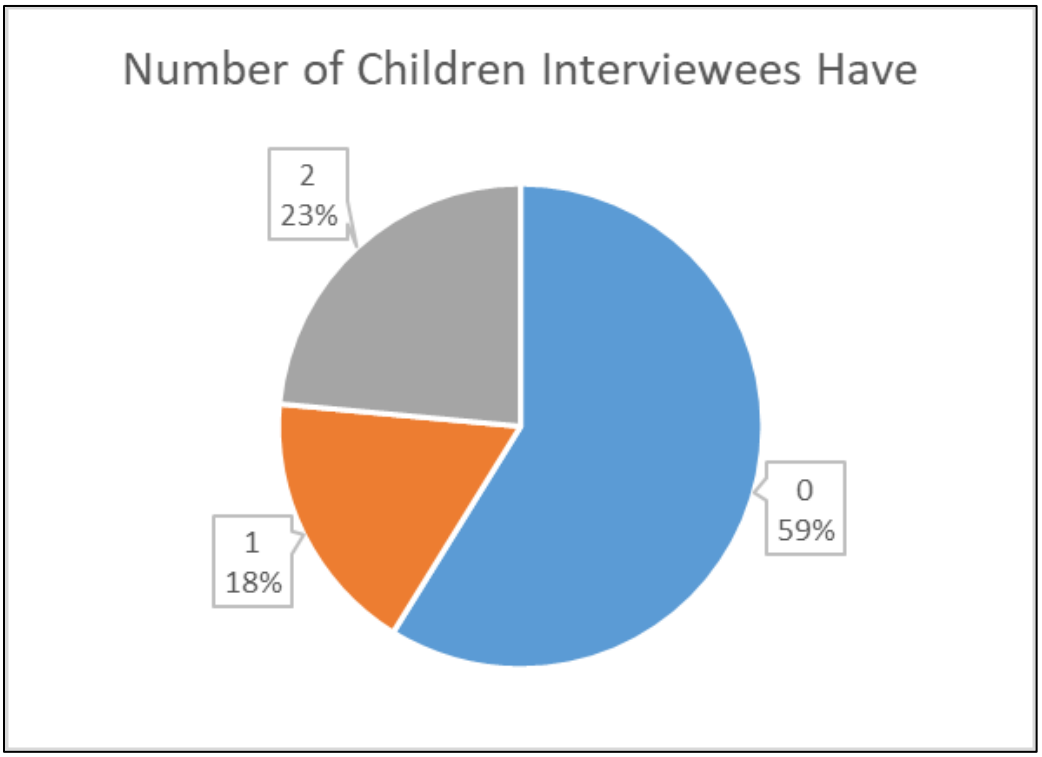

Figure 25. Childbearing status of Interviewees

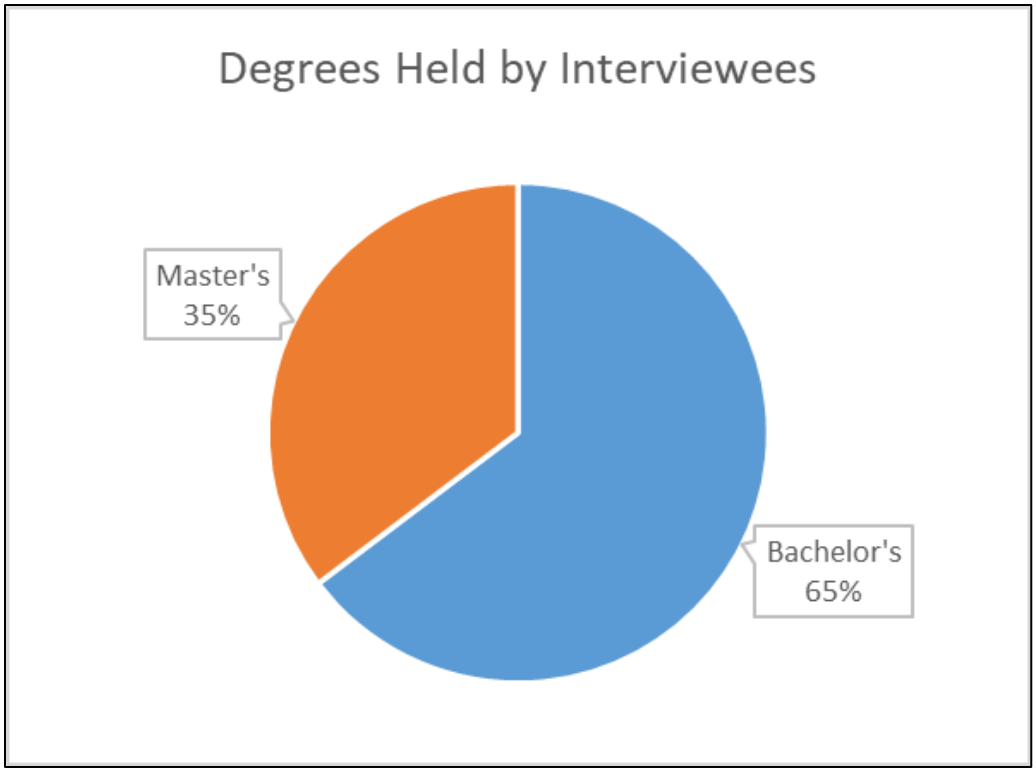

Figure 26. Degrees Held by Interviewees

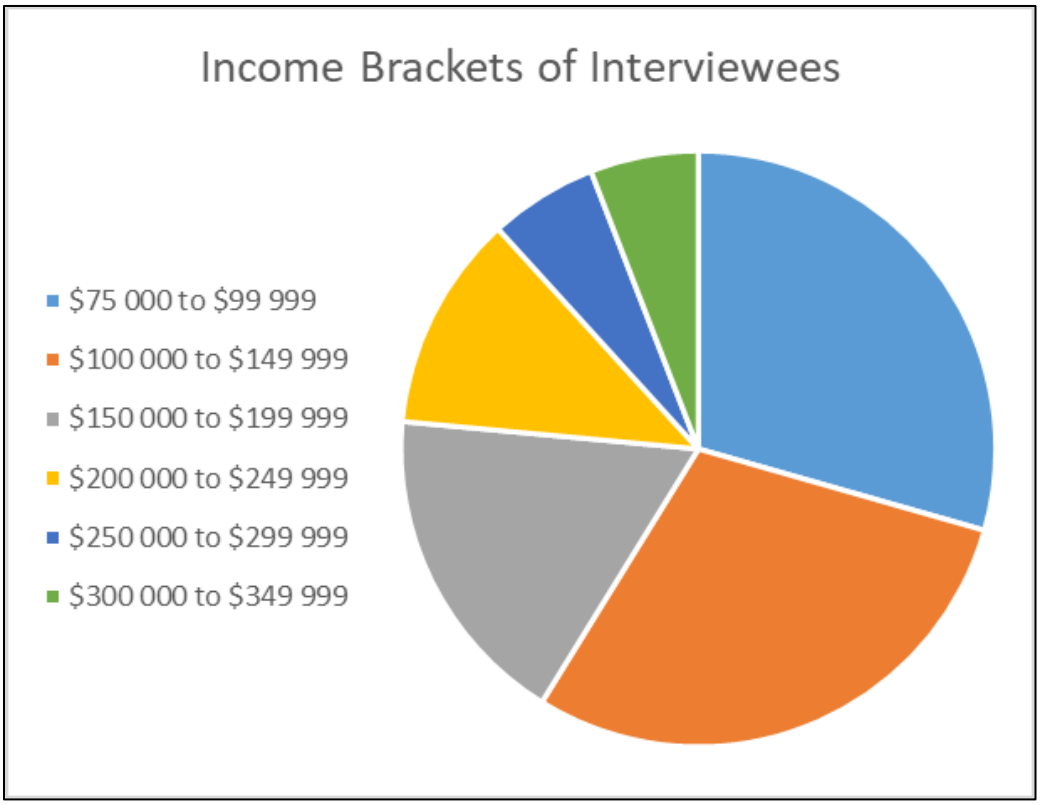

Figure 27. Income ranges of Interviewees

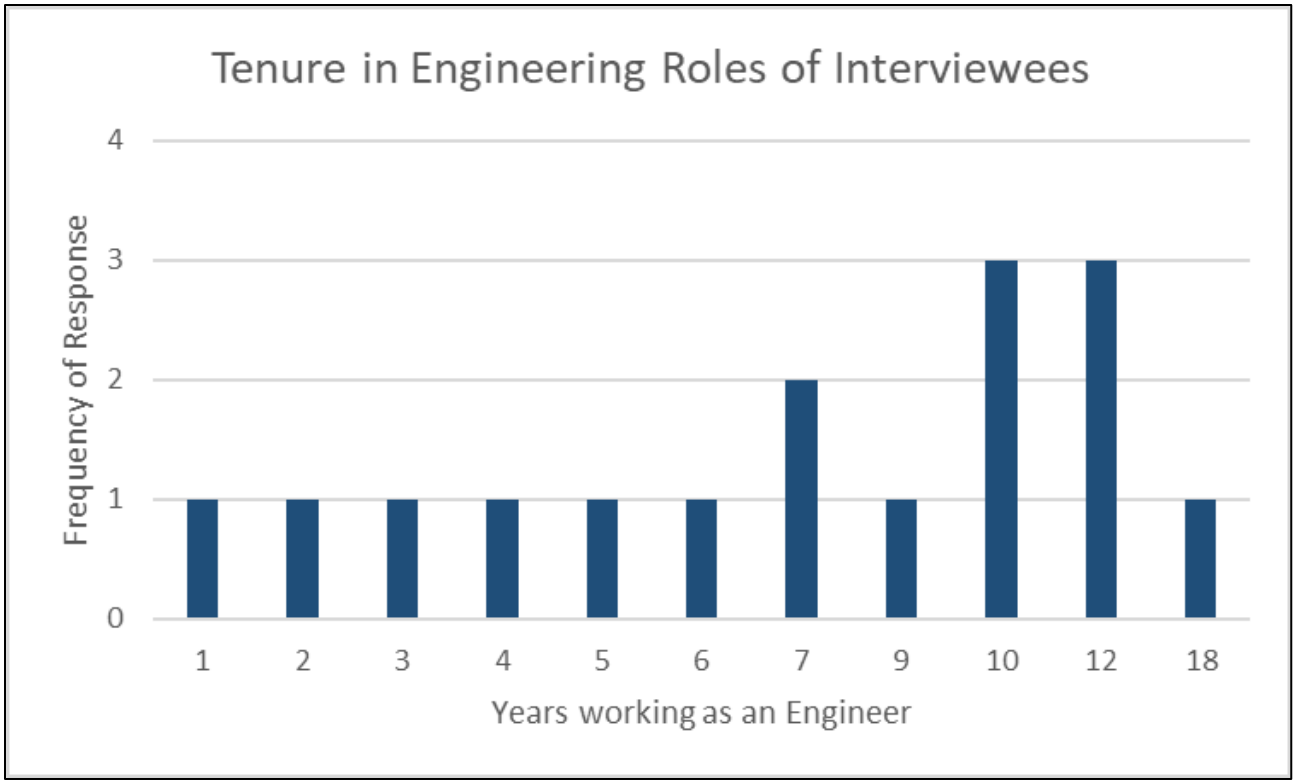

Figure 28. Tenure of Interviewees in Engineering Roles

3.2.2 Ethical Considerations

Prior to discussing the format and outcomes of the interviews, it is important to briefly review the ethical considerations that were observed throughout the preparation and execution of the qualitative interviews for this thesis. The researcher executing the interviews is also the thesis author and said researcher undertook the MIT recommended Collaborative Institutional Training Initiative online human subjects research course for social and behavioral research investigators prior to any outreach activities occurring, including the preliminary call for volunteers. This training allowed the researcher to make a preliminary determination that the qualitative interviews inherent to this thesis would not require a full Institutional Review Board review and approval with respect to human subject research. To ensure appropriate record was made, and full process was adhered to, the researcher submitted the line of inquiry to the MIT Institutional Review Board to request exemption and exemption was granted. This determination was able to be made due to the anonymized sharing of interview results and data, and the ability to prevent harm to research participants, in this case the interviewees, throughout the process. Despite being exempt from formal review, the researcher made every provision to provide a similar document to an informed consent form to potential interviewees to advise them

that all data collected on them would be discarded in a specific time horizon and that all interview results would be aggregated and anonymized to prevent any potential negative effects of their input to this thesis. For an example of the continuous ethics-themed notices to potential participants, see the Google Form inputs in Figure 15 and Figure 53.

3.2.3 Interview Outcomes

A small subset of questions was asked of each of the final 17 interviewees, with the remainder of the conversation being very organic and going in whatever direction of conversation the interviewee led it. As mentioned previously, despite the original interviews being set at 30-minute sessions, the large majority of interviews stretched to nearly an hour of conversation as the interviewees were all extremely passionate about sharing their ideas and experiences. In order to evaluate all feedback methodically for this thesis, transcripts were recorded of the conversations via both Zoom transcriptions and Otter.ai transcription services. To allow for ease of transcript coding, the Delve software was leveraged. This software is an online interface that allowed all transcripts to be uploaded in Word document format and then categorized and coded within the same online interface.

Before discussing the themes resultant from the interviews along with interesting data, the list of set questions/prompts that was asked of every interviewee throughout their sessions is as follows. The items are not numbered, as they were provided by the researcher in differing orders throughout the discussions.

- "Were/are either of your parents engineers?"
- "Please give a brief overview of your educational background and career history"
- "Have you ever considered making an exit from engineering or from the workforce entirely?" – This was followed by a why/why-not dependent on their responses.
- "If you were writing a similar thesis, or giving a presentation on this broad topic to your management, what would your top 2 or 3 highlighted areas of focus be?"
- "Did anyone other than your parents ever actively encourage you to pursue engineering?" – Sometimes this question had already been answered through a discussion of how they were inspired to pursue engineering.
- "Have you been treated differently in the workplace in a manner you believe was due to gender?" – This question was left intentionally vague so as to avoid any skew towards a negative or positive.

- For married participants: “Describe the breakdown of housework you and your spouse each undertake.”
- For participants who are married and have children: “Describe the breakdown of childcare activities and support between you and your spouse.”

To mirror much of the discussion in the 2 Literature Review section of this thesis, the outcomes of the interview will be grouped into broader relevant themes. Commentary from interviews were coded to themes using the Delve software, and there are some additional new themes that emerge from the interviews that have not been previously discussed. All interview commentary referenced is synopsized and anonymized to further protect the identity of all interviewees.

Representation

Of the women interviewed, there is a very broad array of company sizes and industries. Many of the smaller companies seemed to have a more even gender split based on interview feedback. One common theme that emerged was that while there may be near gender parity in representation in some companies, this distribution shifted drastically at the higher levels of management, in keeping with the themes shown in the McKinsey study [8]. One woman interviewed has a female CEO at her current company, and she noted an extreme cultural difference from her last company in the same industry that had a male CEO and also noted that she attributes a large majority of the cultural aspects that she appreciates being a result of the current CEO being female.

One engineer in the chemical industry noted that there were many women in management ranks, however not in the top management positions. Women appeared to have made it to team lead roles and some tech managers, but not above that. Most women noted that the representation of women in their companies appeared to be lower than their representation in college classrooms. Interviewees varied between 15% to 40% female in their undergraduate educational experiences in engineering school, and their work breakdowns were much closer to 20-25% female across the interview subsets. Based on the queries around representation, some interviewees were asked about the concept of “critical mass”, which is of interest in recent research, although no consensus appears to be readily available as to what would effect real change from a percentage standpoint. When asked “what would critical mass look like to you?” with respect to their work organization, respondents gave various answers summarized as:

- "I felt more comfortable in classroom settings even when there was just one other woman present. So, making sure that a woman is not the only one in a setting is important"
- "A company should represent the demographics of the area where it is located. So, if the population of the city of Houston is 51% women, the company should be 51% women. Same for racial and ethnic representation"
- "There have to be women in industry to keep women in industry, so it's a catch 22 of how you get there"
- "I wish that I worked in a company where leadership was more representative of the demographic"

Motivations for Entering Engineering

Of the 17 interviewees, the majority (11) have at least one parent who is an engineer, as shown in Figure 29.

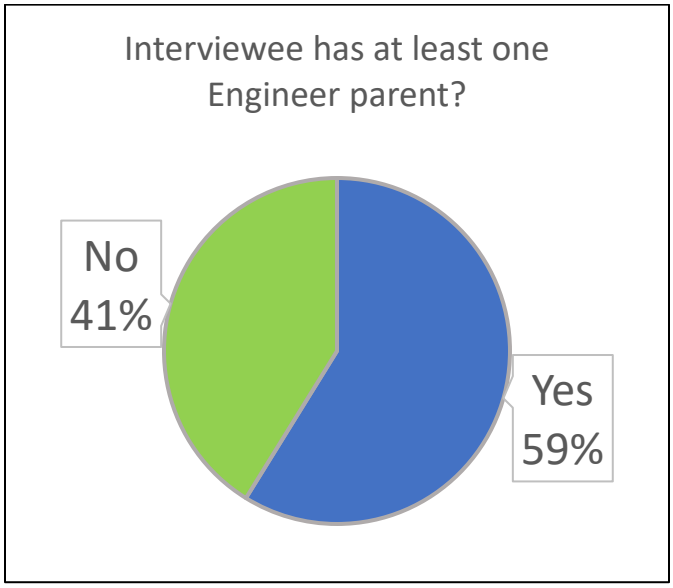

Figure 29. Percentage of Interviewees with at least one engineering parent

This initial line of inquiry around whether a female engineer has an engineering parent was sparked by personal experience from the thesis author having participated in corporate university recruiting for a number of years and noting that many female candidates mentioned being open to pursuing engineering because their parent was an engineer. This attribute seemed relevant enough through observation that a hypothesis was created that a large portion of women in engineering have at least one parent who is an engineer. While the sample size of 17 is not large, it does provide some

foundation for future research to probe similar lines of inquiry perhaps with a larger sample set. Another interesting, related question is whether a similar trend would hold for other fields or would hold for male engineers as well. Debiasing the question by both discipline and by gender may provide some insights into the strength of the influence an engineering parent has on a female looking to pursue that career path.

Interestingly, of the interviewees who did not have a parent who was an engineer, most had a parent who was in a technical function that was engineering adjacent such as welding or machining, so they had some early exposure to some hands-on job scopes. Nearly all respondents said their parents were supportive of them pursuing engineering, with only a few saying their parents wished they had pursued a "less dangerous" and "more friendly" career path.

Other motivations for pursuing engineering that arose as very common themes in the interviewees were the desire for flexibility in job assignments as well as potential financial remuneration. When asked why they pursued a specific discipline, a large portion of the interviewees discussed feeling that engineering offered a wide variety of eventual career options. Many of the women who noted financial reasons as their primary or secondary driver for pursuing engineering were also first-generation college students and they felt that engineering could effectively elevate them from their current financial status.

Related to the mindset of these women, when prompted with the question "what else motivated you to pursue engineering?", an intriguing 10 out of 17 women reported that they thought it the logical conclusion as they were "good at math and science". One went so far as to refer to say, "I just was always a math and science person". This response was given without any other context other than motivations for becoming an engineer and seems to be an interesting insight into what subjects these women were bolstered in throughout their younger years. Also interestingly, when asked if they had experienced any active detractors throughout their K-12 educational years, of the only women that did have people opposing their pursuit of engineering, those opposition forces were teachers, almost always male, in those same math and science classes that these women were excelling in. One interviewee had a slightly different spin in that her economics teacher told her "You are wasting all your talents" when he found out she intended to pursue engineering. Of the interviewees that discussed experiences with teachers, two noted very positive and encouraging experiences, and two noted very negative and discouraging experiences. Thankfully, in the case of the discouraging scenarios, both women noted that they are "stubborn" and do not like being told what they can and cannot do so they viewed that discouragement as a challenge more so than a barrier. One question that arose from this

line of discussion is whether a certain personality type is actually bolstered by the discouragement in the way that a stubborn person would want to do something they are told they cannot do. On the reciprocal of that, would someone who is easily dissuaded based on others' input be deeply put off from engineering by such a negative interaction with an instructor? This thought leads into the effect that early engagements in K-12 can have on a woman's confidence in STEM curriculum for years to come, and calls into question effective pedagogy if the female STEM admissions rates in colleges are to be improved.

One final motivation that appeared as a theme in a few interviews is that of the desire to help others through their work in engineering. The women who discussed this theme mentioned that they like the creative problem-solving aspects of an engineering education and saw it as an avenue to have a meaningful, tangible impact on the world around them. Some women also noted the desire to see a visible end product from their work pursuits, such as buildings and large equipment scopes. This idea of seeing a final product with their own eyes was mentioned as very rewarding.

Work Environment

Of the women who stated they were looking to leave their current role, or had left roles in the past, the majority of them noted some very extreme issues with cultural fits in those roles.

For the interviewee who has a female CEO at her current company, when asked for details on cultural elements that were appealing, she cited the welcoming environment of the company as well as the collaboration focus rather than competition focus between colleagues. The company has a very flexible working arrangement where people can work remotely as needed, and she noted that the practice of leaving to tend to personal or family matters is well respected and not at all stigmatized. Her company also allows employees to choose whether they would like to retain a physical workspace, which they are able to do if they go into the office at least three days a week, or they can opt to work remotely the majority of the time and have a designated shared workspace to use on "office days". This, she notes, also allows them to leverage their existing office spaces while hiring more people.

Multiple interviewees alluded to their companies' diversity, equity, and inclusion initiatives as seeming performative, "for show" as one interviewee called out. While their higher-level managers may verbally espouse desires for change and progress, the interviewees noted that the actual changes are limited and never seem to match the proposed progress.

Unconscious Bias

As is the case with much unconscious bias, the interviewees discussed the gray areas of certain comments and behaviors that they had observed throughout their careers. Most of the anecdotes they shared played into a "death by a thousand cuts" mentality that they discussed were not horrible as isolated incidents, but when added up in aggregate become really unwelcoming and othering.

Some examples of activities and behaviors observed include:

- Being told in performance reviews to smile more to seem less cold
- Observing a professor in high school tell a female classmate that "women don't go to Harvard"
- Older men announcing "watch what you say there's a lady in the room"
- Being asked by an interviewer what your plans/timing for family planning are
- Despite performing the same job roles as male peers, being the only team member told in performance reviews that "you need to socialize more"
- Noting that "if a man is single, we view him as being empowered to have a career, whereas for women, if they are still single at a certain point in life, we wonder what is wrong"
- At a team potluck, one single woman was chastised for not bringing in home-cooked foods, and when she asked the all-male team who made their dishes, they all realized that their wives did
- Observing a man state to a woman working offshore "I don't even think we should have women working offshore"
- Being told "You only got this interview because you're a pretty girl"
- Having men start a meeting with "hello gentlemen" and then awkwardly adding in "and lady!" or worse, "and girl!"

Egalitarian Relationships

Of the 11 married interviewees, 4 of them have partners who are also engineers which they noted adds some levels of support in that their partners are understanding of their job roles. In two cases, the interviewee and their spouse work for the same company, so their employers are more easily able to move them together which can be a good thing or a bad thing, depending on who is tagged as the "lead" career. Before discussing this topic in further flawed vernacular, it is worth discussing the terminology of "leading spouse" versus "trailing spouse". From a historical standpoint, the term "trailing spouse" was defined as a marital partner who was uprooted as a result of their spouse being reassigned, most frequently to a job that required relocation [27]. When the term was first coined in the 1980s, it

nearly always implied the trailing spouse was the female of a heterosexual marriage. The wife in these cases either didn't have a job or had to alter her job trajectory to follow behind the husband who was making a move as the "leading spouse" [27], [28]. In some industries, these terms are still being used today, albeit jokingly at times. But even in joking, they have the propensity to cause harm with respect to unconscious biases around egalitarian partnerships being possible in dual career couple scenarios. The married interviewees were asked about their expectations versus their partner's expectations for their careers and they all gave a variety of answers, with the most central theme being that their partners were extremely supportive of their careers and wanted them to excel. When asked, in an intentionally biased question, to identify who the leading spouse and trailing spouse was, 4 interviewees identified themselves as leading, 2 identified themselves as trailing, and 4 identified themselves as neither and stated they were equal. It is noted that all of the respondents asked this question balked at the terminology and noted they dislike any time it is raised in corporate settings, even in a joking manner. One interviewee is being forcibly put on sabbatical by her current employer due to their unwillingness to allow her to work remotely while her partner completes a short-term assignment out of state, and when asked "how do you feel about the terminology of leading spouse and trailing spouse" she replied, "I hate it" and went on to say that she feels it devalues her career. Many of the women who considered themselves equal to their partners in career trajectory mentioned that they have "taken turns" throughout their relationship with who gets to move for jobs and take advancement positions, but the conversations between themselves and their partners always returns to an egalitarian middle ground where both spouses have careers they find meaningful.

All women interviewed pointed to their partners as a source of inspiration and continued support in their careers and lives. An observation of the researcher is that all of the interviewees acknowledged that partner support was critical to their continued career success. This is very much in line with the findings of the Glass study around career exits which found that spousal support and egalitarian relationships were critical to preventing exits from the field of women in STEM [11].

Family Status

Seven of the 17 interviewees have at least one child, with the breakdown of those 7 being 3 with one child and 4 with two children. Of the interviewees with children, nearly all of them described their balance of childcare with their partners as extremely equal, which follows relative to the feedback on their marital balances of power and support as well. Multiple interviewees talked about the myth of true work-life balance and noted that for them the important aspects are what is top priority and when

is it top priority; and those priorities are always shifting. One mother noted working on her laptop while preparing dinner and feeling like she was doing half of both jobs: worker and mom, and it being a frustrating dichotomy. One mother also noted that there is "a lot of guilt associated with stuff because if one is doing more than the other, then someone feels guilty".

All interviewees touted the necessity of parental leave policies in place for both parents. Multiple women mentioned being able to leverage flexible working arrangements resulting from the COVID-19 pandemic into continued flexible work arrangement that have enabled more effective parenting. One woman mentioned a policy that would have benefited her significantly which is access to pre-partum leave. She delivered far ahead of her original due date, and access to care prior to the scheduled delivery date is a benefit that demonstrates real care for the health of the mother.

From a standpoint of generational differences, interviewees noted that colleagues of their own age or younger were much more understanding of childcare obligations and attempt to balance work life and home life. Multiple interviewees discussed how higher-ranking males who always had a "house spouse" at home to tend to the children are much less empathetic to circumstances requiring flexibility related to family needs. Some women interviewed did mention that their schedule as well as their partner's is often dictated by timing of schools and daycares being open and this is largely more constraining to the woman in most circumstances. One woman shared that as her supervisor is not in charge of childcare obligations in his family, he seems to look down on her when she arrives after him in the mornings because she has to complete school drop-off. The concept of non-negotiable schedules for family time seems foreign to some employers. One mother shared that when she dictates no 6 pm meetings, she is given pushback from her team, but the rest of them do not have children and that time is exactly when her toddler has his dinner. Toddlers are much harder to negotiate with on timelines.

Unpaid Labor

A topic that arose related to the additional burden of care arising from home tasks is that often in hectic job scenarios, some women opt to hire out for help for things like childcare and housekeeping. One woman who raised this issue mentioned that if she was not spending so much time working, she wouldn't actually need to use her money to pay someone to complete house tasks for her. She sees this as a lose-lose scenario where money can be spent to do chores there is not time for, or she could spend less time at work and seem less dedicated to your career but be able to tend to home chores herself.

Another interesting concept that arose during discussion was the aspect of mental labor versus physical labor. Some emerging research is beginning to discuss the additional mental burden that

women take on more frequently than men and was highlighted in both a BBC and New York Times article in recent years [29], [30]. These articles dig into the "cognitive labor" that women take on the brunt of, and how it affects their well-being and ability to perform tasks elsewhere. One interviewee called this out explicitly when asked about the division of labor between her and her partner. She noted that while their share of executable tasks was the same, the burden of "conception and planning" falls almost entirely to her. This presents itself in remembering birthdays, booking boarding for their dog, making sure her partner packs for his conference, picking out flooring, etc. as she described tasks that on paper look equal, but in planning take a lot more of her time. This theme carries over into the workplace and multiple interviewees discussed that when an office birthday or retirement party needs organizing, they are nearly always called upon to lead the effort, whether they want to or not. There appears to be a perception that women are just "good at that stuff" and therefore they are stuck with the burden of that labor that is firstly, not in their job description as an engineer, and secondly, not compensated in any way. In fact, some women mentioned that completing these tasks makes them feel as though they are taken less seriously in the workplace and are less respected than their male peers. Additionally, these women noted that these tasks are time consuming, and they have to then find other time in their day to make up for their actual jobs.

Sexual Harassment

There were some interesting themes arising from uncomfortable interactions the interviewees had experienced with men in the workplace. One of them was mentioned by three independent interviews and was an aspect of humanizing versus sexualizing women in the workplace. One interviewee said that, to paraphrase, older men in the office liked to either treat her like she was their daughter, try to date her, or sometimes both. Outside of being unsettling to any woman being on the receiving end of this behavior, it can have other troubling aftereffects such as discrediting women for their accomplishments when others in teams seem to believe that men in management positions or leadership roles are playing favorites out of some perverse attachment to the female engineer. Multiple women mentioned instances where a male superior had made an unwelcome advance on them, and the women were then in a position that they had to extricate themselves from the situation as delicately as possible to not encourage further advances, not offend the perpetrator, and not lose face with colleagues who may see the woman now as an object of that male superior's desire. These situations are often lose-lose for the female engineers, as they are then objectified in the eyes of not only the perpetrator but also now their team, making it more difficult for them to do their jobs effectively.

Additionally, if anything positive does come of that woman's career trajectory, and others know that a male superior had inappropriate feelings towards that woman, that advancement now is tainted with potential speculation that the woman was unfairly favored or somehow "slept her way to the top". On the other hand, women who act formally and are always proper around their male colleagues are often unfairly branded as cold and unfriendly, even though they are often just fighting to maintain boundaries for their own protection. These situations become even more charged and potentially dangerous when careers involved expatriate assignments, offshore rotations, field visits, and other such non-office scopes.

A tangential, but no less off-putting scenario, to that of sexual harassment described in these interviews is the experience described by two interviewees who have had male superiors that refuse to be alone in a meeting room with a woman. This is of course no fault of the female engineer, but their career and opportunities are nonetheless jeopardized by a behavioral issue of a male who is unable to properly supervise them. If private conversations cannot be held one on one between a supervisor and subordinate without some sort of gendered safety concern or bias coming into play to prevent the meeting entirely, how is a female engineer supposed to advance her career or get honest feedback around performance. Not to mention, if a woman is told by a male superior that he cannot be alone with her, she is likely to feel unsafe and unwelcome in every task she does in that role regardless of their interactions or lack thereof.

Career Exit Considerations

A large majority of the interviewees admitted to considering leaving engineering and making a field exit into something outside their current engineering field, or at a minimum leaving their current company of employment. In line with the conclusions of the Glass and Hunt studies discussed in the Literature Review of this thesis, the primary considerations interviewees cited as their drivers for leaving were lack of visible promotion opportunities, lack of satisfactory pay, and significant burn out [11], [24]. Burn out is mentioned in the 2021 McKinsey "Women in the Workplace" report as being significantly more impactful to women, a theme that presented itself in multiple interviews [8].

Male Allyship

Interviewees mentioned the importance of having sponsors who are interested in supporting their career development. Multiple interviewees mentioned that these sponsors were often far more

effective if they were male leaders. This unfortunately plays into another area of bias where female leaders hold less sway in enterprise settings. The interviewees who brought up male allyship also mentioned the importance of having male peers who cared about, or at a minimum respected, conversations around gender equity in their workplaces. Most women noted that having men as allies was relatively common among peers of their own age group, but often became more difficult to find in older, higher-ranking men who ultimately are in the decision-making roles.

Intersectional Components

One interviewee identifies as LGBTQ+ and made this known during the interview discussion. The interviewee described some of the unique attributes from this perspective, most notably the difference in cultural expectations between work locations she has been in. Her current work location is in the northern United States and attitudes towards her being out are generally neutral to favorable, but her experience was extremely different when she worked a prior role in the southern United States. While she was never directly harassed at work because of her sexual orientation, she heard many othering comments throughout the office and coworkers would not engage in conversations about her family like they did with other colleagues which made for an additionally unwelcoming workplace. The conversation around allyship was additionally raised as a necessity for acceptance of LGBTQ+ persons in the workplace, and once again this conversation centered around allyship of those in positions of power, which in engineering in the United States continue to be straight, white men.

4 Sociotechnical Systems Analysis

In this chapter, the engineering workplace is analyzed as a sociotechnical system using systems architecture techniques. Leveraging the many aspects discussed in the literature reviews, as well as insights gleaned from the qualitative interviews conducted, a sociotechnical system analysis is used to demonstrate the interconnectivity of multiple attributes that affect the everyday experience of being a female engineer. One of the primary intents of applying systems design tools and skills is to break something complex into its requisite components and then begin to dissect these aspects into meaningful chunks that can be configured or reconfigured in ways that make sense for a given desired outcome. System engineering and system architecture processes and principles are leveraged to where "system thinking helps us making complex things less complicated" [31]. In order to fully understand a system, an ideal procedure is to deconstruct the system and begin to understand it in digestible formats.

4.1 System Decomposition

Systems Architecture can be defined as the "structure of a system – embodied in its elements, their relationships to each other (and to the system's environment), and the principles guiding its design and evolution – that gives rise to its functions and behaviors" [4]. The study of systems architecture itself assumes that a systems architect can treat anything as though it is a designed system. In this way of thinking, a sociotechnical system can be treated with many of the same tools and processes as any designed and/or built system that is being addressed by a system architect. As Eppinger states "All types of systems have architectures" [4]. Driving at the true nature of a sociotechnical system may be more nebulous and challenging but using the same tools and processes may sus out insights to a sociotechnical system that are not overly apparent when looking at individual elements and not the system as a whole. Eppinger goes on to elaborate that "architecture drives behavior. The structure of a system's elements and interactions causes the emergence of system attribute, functions, and behaviors (some anticipated and some not). Architecture also governs a system's performance and value (both short and long term)" [4]. If the "system" of gender inequity in the engineering world is considered to be something that was at some point architected, whether knowingly and intentionally or not, it is something that can be processed, understood, and potentially improved. Eppinger follows the description of systems architecture with "it is often possible to make drastic improvements to a system without significantly changing its elements or their interactions. Large benefits can be achieved merely by changing the way the elements are structured" [4]. This may or may not prove to be true for gender

inequity when treated as a system, but the potential for benefit merits the cost of analyzing the system to determine if any improvements can be recognized.

One of the many driving principles of systems architecting is Miller's "7 plus or minus 2 Principle" dictating that at any given time, the human brain can really only focus on somewhere between 5 and 9 things at a time [31]. To understand the entirety of gender inequity in one fell swoop is understandably impossible when trying to look at each individual component at the same time. So, following the underlying principle of decomplexifying the sociotechnical system of being a female engineer, a level 2 system decomposition has been created to act as a visual representation of the many attributes observed in a typical engineering workplace. The terminology of level 2 merely means that the system starts with an overarching system boundary being level 0, or in this case the system name of "Existence as a Female Engineer", and then is broken down into subsystems or subcomponents in the Level 1 arena that are in this case broad sweeping themes or attributes, and then these subcomponents and subsystems are subsequently broken down into the next layer of items to be considered, which are thus labeled at Level 2. This system could assuredly be broken down into many different layers of decompositions, and it should be noted that a system decomposition is very subjective to the system architect designing it. As a result, this decomposition is not meant to be all encompassing, nor is it meant to be accurate for every single female in engineering. It is, however, intended to be a useful tool to show how intricate the attributes are that affect daily life as a female engineer. It is also meant to encourage additional conversation in an organization around how the specific aspects in this somewhat linear looking representation may be interrelated. The relationships between these many individual attributes are unmistakably linked in numerous ways, and this thesis aims to demonstrate a data-driven interpretation of how the attributes are linked in the following sections.

Systems Architecture literature discusses how systems can be thought of in a top-down or bottom-up approach, dictating the "direction in which you approach a system" and defining a top-down approach as where a system architect will "start from the goals of a system and proceed to concept and the high-level architecture. Then you develop the architecture in increasing detail until you reach the smallest entities of interest to you" [31]. The inverse approach of bottom-up is defined as where an architect will "think about the artifacts, capabilities, or services that are available in the lowest-level entities and build upward from them, predicting emergence" [31]. The main text on Systems Architecture goes on to elaborate "Because there is really no top or bottom to truly complex systems, in reality we always apply a *middle-out* approach; we start at some arbitrary point in the system hierarchy and try to reason one or two levels up or down" [31]. This is precisely how this thesis proceeds, with an

understanding of the system architecture developing in a middle-out mechanism from the insights yielded through literature review and qualitative interview analysis. To begin discussion, the initial Level 1 decomposition of the sociotechnical system is shown in Figure 30.

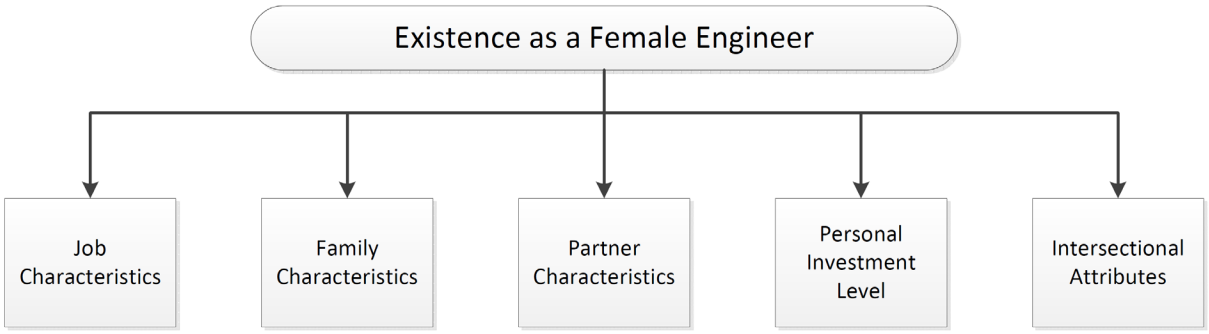

Figure 30. Level 1 System Decomposition

These overarching elements or themes in the Level 1 decomposition are not perfect by any means, and naturally there will be components and factors that do not neatly roll up into one category or another. As previously discussed, this breakdown is not intended to be an exact description of the system elements as they relate to gender inequity, it is intended to demonstrate an approach to understanding the elements in relation to one another and ideally encourage deeper conversation and understanding. These initial Level 1 entities were drafter largely based on the individual inputs with significant statistical focus in the Glass study as well as McKinsey and BCG reports [8], [11], [20]. It is thought that in replicating similar entities to the themes discussed in those publications as well as the themes reflected throughout interview responses, the data associated to these themes is more meaningful in the next phase of system analysis related to assessing the strength of relationships between individual attributes and factors.

To assess the Level 2 decomposition breakdown, this thesis examined the overarching themes and contributing factors from the Literature Review as well as Qualitative Interviews and first designed a List-based hierarchy of factors that have been mentioned. This list is shown in Figure 31. As is clear from the list breakdown, more than two levels of system are shown. For the sake of visualization for the decomposition diagram, only the Level 2 decomposition is full composed for this thesis. Based on the initial hierarchical list composed from assessing the resources analyzed in this thesis, the Level 2 decomposition is displayed in Figure 32.

- **Job Characteristics**
  - Challenging Scope(s)
  - Promotion Gaps
    - Sponsorship
    - Experience requirement skews
  - Visible Representation
    - Among Peers
    - Among Leadership
  - Worker Fatigue/Burn-Out
    - Hours worked outside of 40 hours/week
  - Total Compensation
    - Base Pay
    - Benefits
    - Maternity Leave
    - Paternity Leave
    - Prepartum Care/Leave
    - Bonuses & Recognition
  - Unpaid Labor Burden
  - Flexible Work Arrangements
  - Male Allyship
  - Accommodations
    - Suitable Uniforms & Personal-Protective-Equipment
    - Sanitary Facilities & Lodgings
    - Workplace accommodations for breastfeeding
- **Family Characteristics**
  - Has 1 Child
    - Egalitarian Division of Childcare Duties
    - Gendered expectations from superiors or colleagues
  - Mas more than 1 Child
    - Egalitarian Division of Childcare Duties
    - Gendered expectations from superiors or colleagues
    - Significant additional burden of care and financial obligation
  - Doesn't Have Children
- **Partner Characteristics**
  - Marital Status
    - Married
      - Egalitarian Division of Labor
      - Spouse in same field
      - Spouse working significant overtime
    - Single
      - Stigma from colleagues
    - Divorced
      - Stigma from colleagues
- **Personal Investment Level**
  - Level of Education
    - Bachelor's Degree
    - Advanced Degree
  - Extent of On-the-Job Training
  - Initial Motivations for Entering Engineering
    - Parent(s) Engineer(s)
    - Financial Motivators
    - Wanting to Make a Difference
  - Tenure in Current Field
    - Less than 5 years
    - 5 years or greater
- **Intersectional Attributes**
  - Personality
    - Adherence to gender norms
    - Socialization preferences
  - Race
  - Age
  - Sexual Orientation
  - Disability

Figure 31. Hierarchical List Style Breakdown of System Attributes

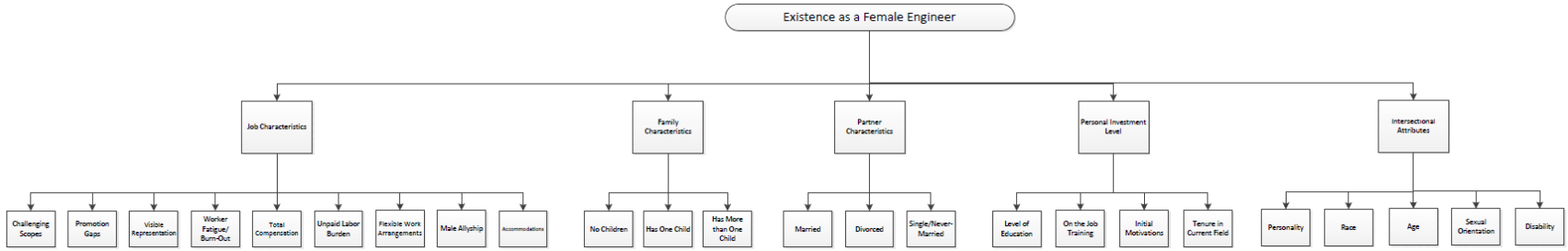

Figure 32. Level 2 System Decomposition

As the full Level 2 decomposition is very difficult to read on this page layout unless the reader zooms in substantially, the individual breakdowns of each subsystem are shown in subsequent figures: Figure 33, Figure 34, Figure 35, Figure 36, and Figure 37

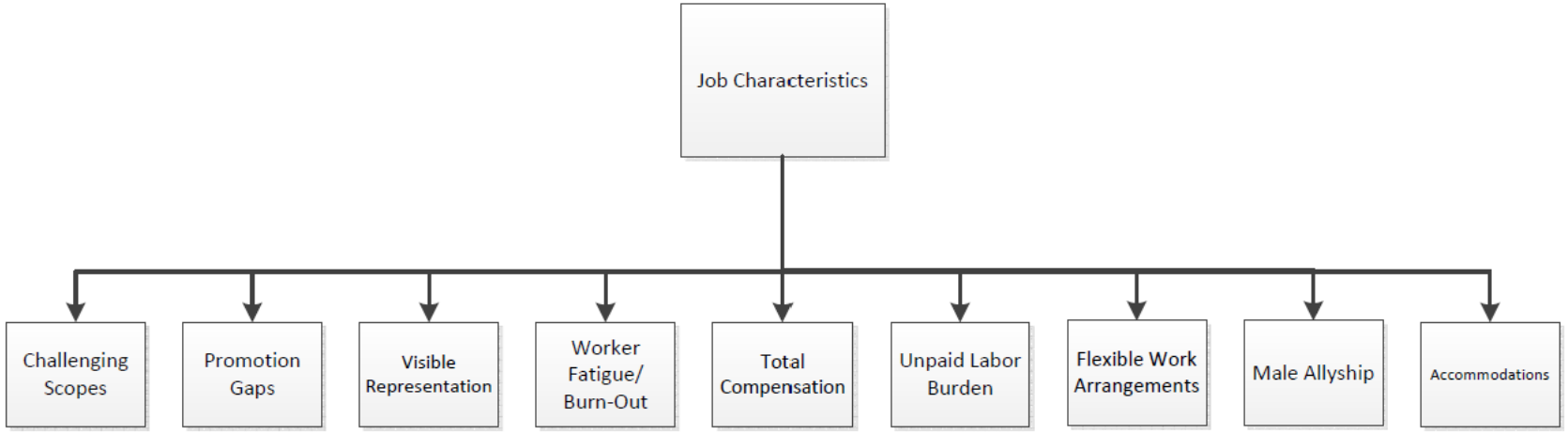

Figure 33. Job Characteristics Subsystem Breakdown

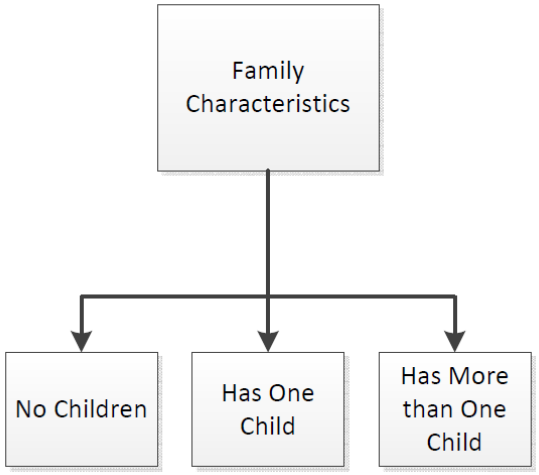

Figure 34. Family Characteristics Subsystem Breakdown

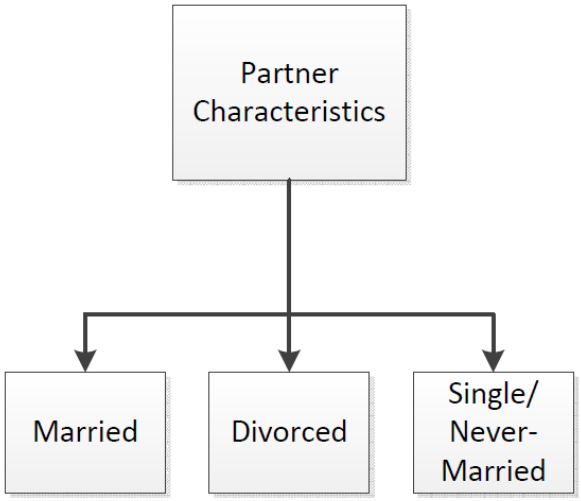

Figure 35. Partner Characteristics Subsystem Breakdown

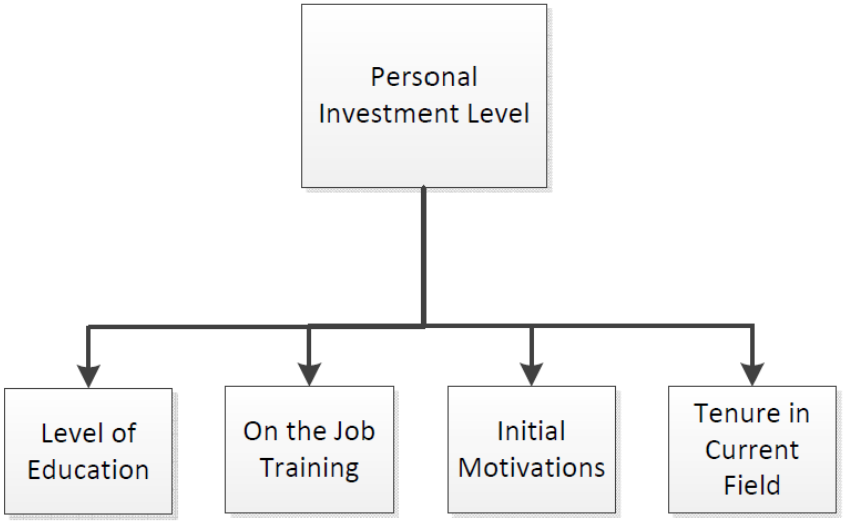

Figure 36. Personal Investment Level Subsystem Breakdown

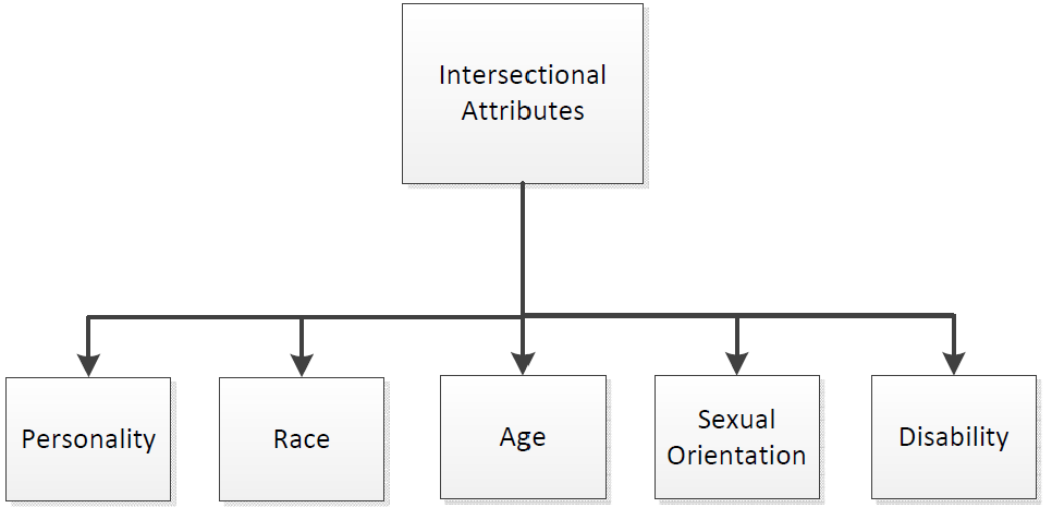

Figure 37. Intersectional Attributes Subsystem Breakdown

4.2 System Design Structure Matrix

To begin this section, this thesis will first define a Design Structure Matrix, commonly referred to as a DSM. The DSM was originally created as a "network modeling tool used to represent the elements comprising a system and their interactions" [4]. In the foundational text "Design Structure Matrix Methods and Applications" by Eppinger and Browning, multiple "typical" varieties of DSMs are defined and described with examples given. A DSM in summary is a "square N x N matrix, mapping the interactions among the set of N system elements" [4]. The DSM is rightfully referred to as a "a highly flexible tool" [4]. The four main types of DSMs defined in the textbook are product architecture, organization architecture, process architecture, and multidomain architecture which would represent some combination of the first three varieties [4]. The type of DSM most in line with what this thesis intended to use as a tool for furthering the understanding of gender inequity in a systemic view is the Organizational DSM. The underlying principles of mapping relationships between elements of a system are the main draw to using this tool as a basis for furthering comprehension.

The DSM can be used to uncomplicate a very complex system. As Eppinger states "the primary benefit of DSM is the graphical nature of the matrix display format" [4]. The DSM methods used in this thesis will follow the somewhat standard convention of "inputs in rows and outputs in columns" [4]. The relational elements displayed in the system DSM for this thesis will be defined in detail, so the reader does not have to work overly hard to understand the detailed mechanisms of interpreting different varieties of DSMs. The recommended five-step approach overview for architecture modeling and analysis is presented as:

1. Decompose – Break the system down into its constituent elements perhaps through several hierarchical levels.

This step is discussed in the previous section along with the decomposition of the system architecture.

2. Identify – Document the relationship between the system's elements.

This step will be documented in the DSM later in this section, and the relationships between the elements has been determined through a mixture of data-driven interpretation from the literature review, influential information from the qualitative interviews, and subjective decisions made by the thesis author as a result of lived experience existing in the sociotechnical system in question.

3. Analyze – Rearrange the elements and relationships to understand structural pattern and their implications for system behavior.

4. Display – Create a useful representation of the DSM model, highlighting features of particular importance or of special interest.

5. Improve – Most DSM applications result in not only better understanding of the system but also improvement of the system through actions taken as a result of the DSM analysis and interpretation of its display [4].

The reference textbook clarifies that this is intended to be an ongoing process and would ideally involve feedback from the last step to the first to allow for continuous improvement [4].

Much recent research into sociotechnical systems has been put towards aspects of information flow and teamwork [32], [33]. These systems analyses are somewhat complex because they assess the flow of information or the power of influence of one aspect of a system over another. Additionally, to further complicate things, the information flow of many teams and groups is often not only one-directional. Bidirectional communication is common, although the frequency, volume, and merit of information flowing in both directions is rarely equivalent. This makes modeling even more complex. These challenges are all similarly observed in trying to model the sociotechnical system of the engineering world from a standpoint of the elements related to gender inequity. Fitting the entirety of someone's human experience in a 20-to-50-line-item DSM is not a simple task.

To begin, the individual components in the level 2 "subsystems" are shown in the DSM matrix as an N squared matrix with the row labels mirroring the columns. For further visual clarity, the level 1 system headings are shown as groupings in the initial layout. The Level 2 decomposed elements have been given some additional detail from their level 3 and level 4 attributes that were shown in the list-style hierarchical breakdown earlier in this chapter. These attributes are intended to yield some additional insights into some of the subcomponents within those individual entities. For instance, providing a field for only "level of education" achieved, but not differentiating between degree types would not allow for the statistical effects of different degree types on a female engineer's experience to be adequately visualized in the DSM.

To create the DSM for this thesis, the interaction between individual factors is assessed with respect to one another relative to their effect on a female engineer's experiences, and the interaction/relationship is given a weak, moderate, or strong relationship/interaction designation. The circle size ascribed to the relationship varies along with this designation, with weak being the smallest, moderate strength being the middle sizing, and strong interactions being the largest size circle shown. Then, to add an additional element of understanding, the relationship gradings have been ascribed a color coding of red, orange, or green. Red implies that the interaction of the column input on the row input is a negative interaction, which can then be judged on the strength of relationship via the sizing of circle. Orange designates an interaction as neutral, with potentially both good and bad elements, and/or an interaction lacking in a clear understanding of the cause/effect relationship of those specific components based on current data but acknowledging that there is a known interaction. Green designates the interaction between the two elements as being a positive one. A quick reference guide is shown below in Figure 38 as a legend for reading the DSM.

DSM Legend	Weak Interaction	Moderate Interaction	Strong Interaction
Negative Impact			
Neutral Impact - Both good and bad aspects			
Positive Impact			

Figure 38. DSM Legend: How to read interaction designations

As mentioned previously in this chapter, this thesis uses the somewhat standard inputs as rows and outputs as columns approach for its DSM. What that means is that someone reading the DSM for the

first time would read the first-row entity and look across the columns within the row until coming upon an interaction. They would then assess that interaction as the row acting upon the columnar element. Taking the first blank subsection of the DSM as a reference guide in Figure 39, the reader would take the row "Challenging Scopes" and reading from left to right see if "Challenging Scopes" has a positive, neutral, or negative effect, and to what degree, on the "Promotion Gaps - Sponsorship" category and so forth. If there is no circle shown in a box, it implies that there is not a notable interaction between the row and column factors/attributes. Additionally, since the DSM is an N x N matrix, the row to column interactions between an entity in a row and its reciprocal in the column is null, so this is shown by the grayed out "x" boxes in the DSM along the matrix diagonal.

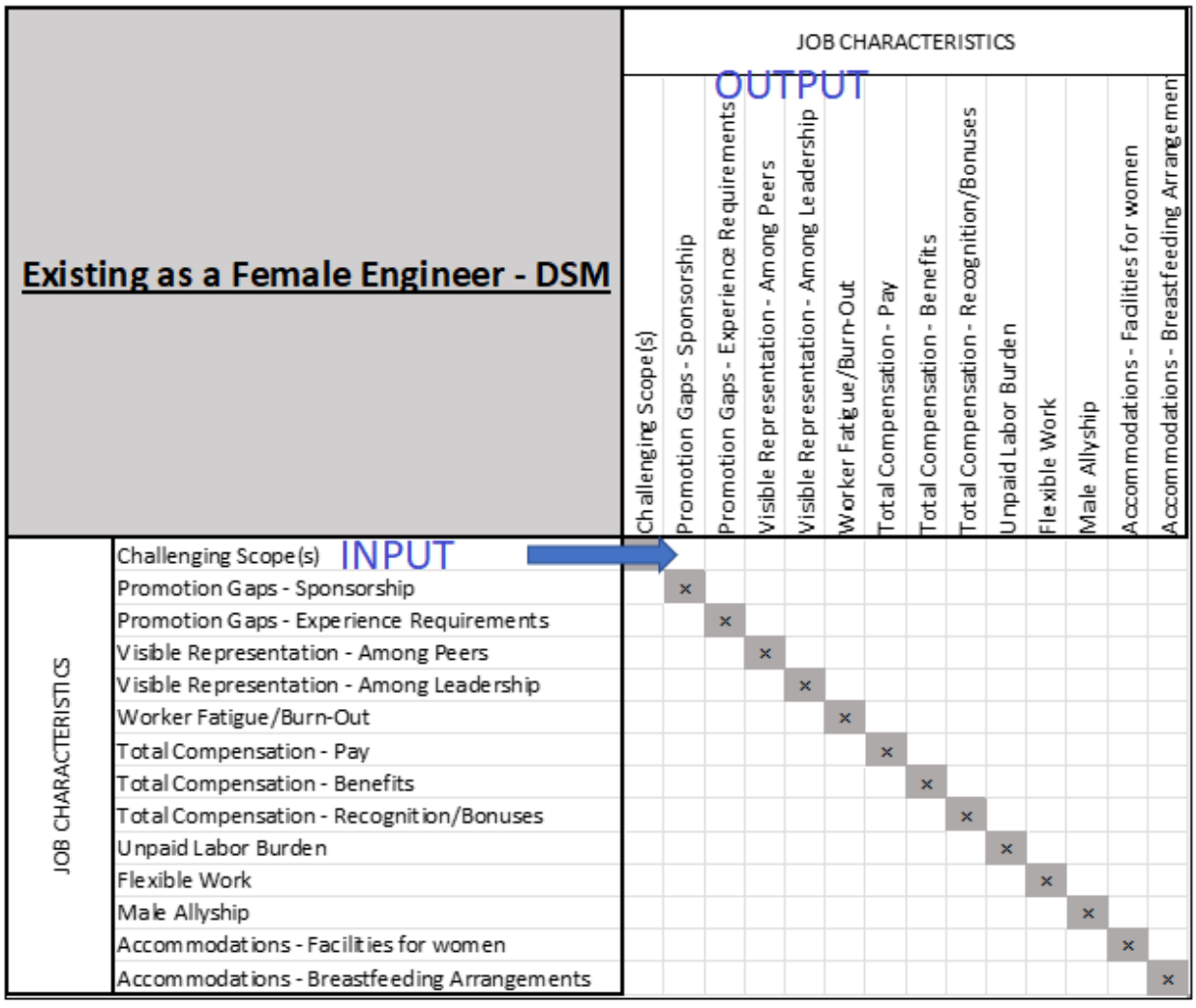

Figure 39. Reference for reading DSM in input - output form

As a hypothetical example: If there was a large sized green circle in the aforementioned box, it would tell the reader that “Challenging Scope(s)” interacts with “Promotion Gaps- Sponsorship” in a way that exerts a strong, positive impact on a female engineer’s experience.

The strength of impacts presented here are somewhat subjective in determination, through the aforementioned compilation of information from literature review, statistical data review, and interview inputs. Much like the system decomposition, the DSM in this thesis is not intended to point out a perfectly deconstructed view of the female engineering experience, but rather to spark conversation and spur on deepened understanding of the relationships and interactions between all the factors that affect women in the engineering world on a nearly daily basis.

The full DSM created for this thesis is shown in Figure 40, but as the rows and columns are very difficult to read in small font, the individual sections of the Matrix are also shown in APPENDIX B: DSM Subsections.

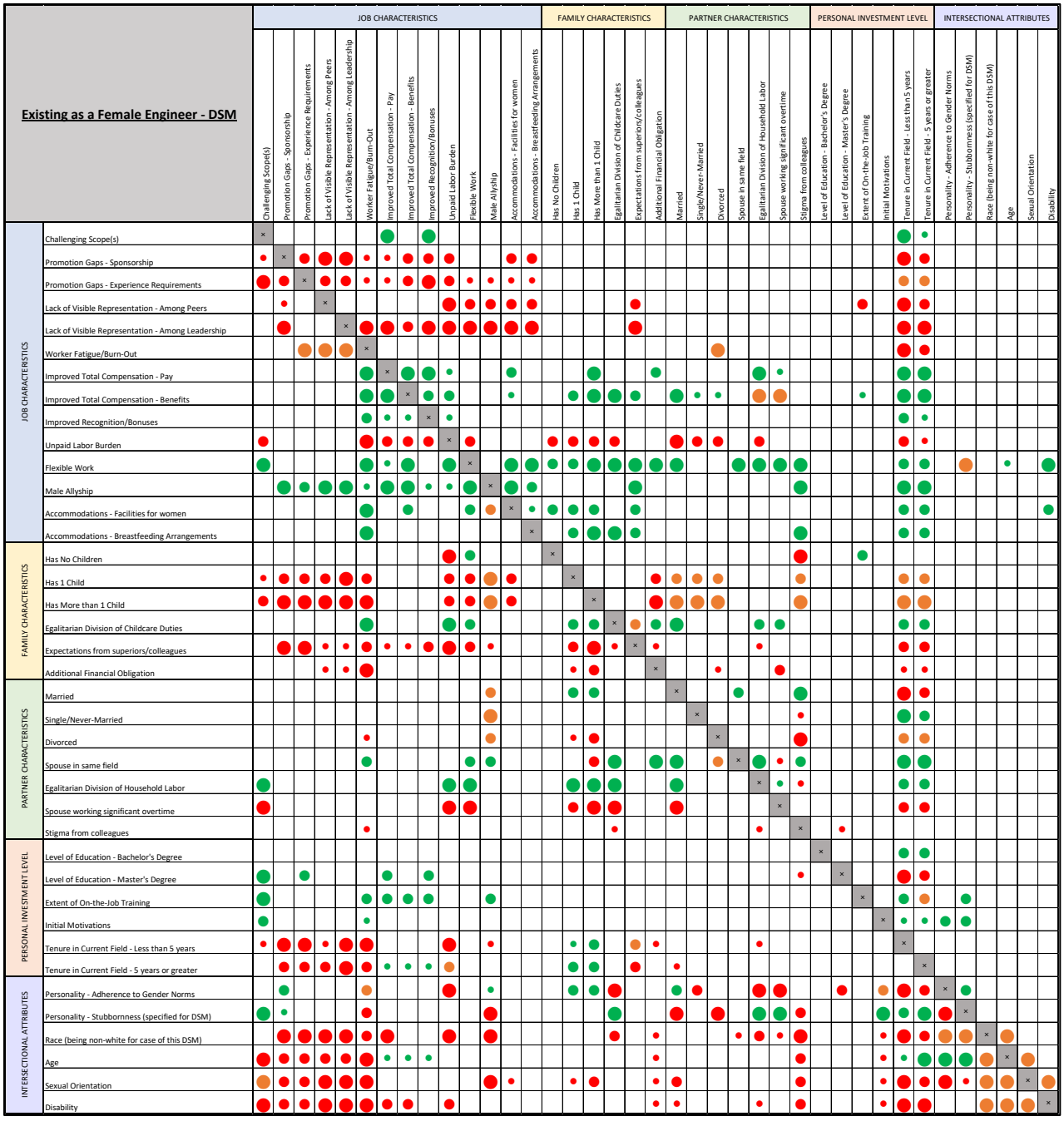

Figure 40. Design Structure Matrix for sociotechnical system of being a female engineer

While the reader can draw conclusions visually from the subsections in greater detail, some salient relationship effects emerge from the DSM that this thesis highlights as the following:

- Tenure of a female engineer is influenced by a large majority of the factors discussed in the DSM. The effect of the factors is gauged as positive or negative primarily based on the research by Glass and there are notable differences in a woman's first five years on the job, when most exits out of engineering are observed [11].
- Many of the impacts of promotion gaps and lack of representation are on things that may not seem overtly intuitive, but this thesis suggests that a reader consider the cause-and-effect relationships of not having women in management ranks or decision-making positions. For example, if there is a lack of visible representation among leadership of females, there is much less likelihood of having facilities design for women, breastfeeding accommodations, a decreased burden of unpaid labor, and many more attributes that negatively affect a female engineer's day to day experiences.
- Some of the positive impacts may seem counterintuitive as well, such as the positive effect of improved pay on improved benefits. This is not intended to demonstrate a true improvement on the outcome category, but rather to demonstrate that because of the improved pay, even if the improved benefits category remains stagnant, a female engineer's experience/perception has improved because her total remuneration is more positive. Improved benefits have a large knock-on effect to many other attributes because this category is so impactful to a woman's quality of life, especially during childbearing years.
- As discussed in Chapter 2 literature review of the Glass study, having more than one child is a very different experience than having one child as a female engineer.
- The effects on worker fatigue/burn-out should be viewed in aggregate as they contribute to the "death by a thousand cuts" scenario discussed at length in the rest of this thesis. Taken individually, each of the factors affecting that category may seem minimal. However, when compounded together over time, and repeatedly day in and day out, the exhaustion that develops is likely to contribute to field exits. For example, based on the inputs on this DSM, if a woman goes to work every day and sees herself passed over for promotions that she is deserving of through performance, does not have a place to adequately breastfeed to take care of her child, has a spouse who does not do their share of childcare or household duties, and is not granted options around flexible work, her situation very rapidly becomes untenable.

- Many of the intersectional attributes have interactions with one another that are either a mixture of positives and negatives or are lacking in enough data to draw meaningful conclusions about the real effects of intersectionality of those aspects. This is discussed in detail in Chapter 5 of this thesis, but the prospects at further understanding the true interfaces of these attributes and how they affect women at work is an area of research in dire need of further attention and efforts.
- Of the intersectional attributes that do have known affects, the McKinsey report and BCG report do an excellent job of describing the effects that are shown in this DSM [8], [20]. Notably that being an "other" in more than one category has measurable negative effects on the individual in nearly all realms related to pay, promotion, and feelings of exclusion. What this DSM does not capture much at face value is the microaggressions dealt with by double-others or double-onlys in group settings. The microaggressions most certainly impact the "death by a thousand cuts" feelings, and other than capturing data around field exits and fatigue, it is hard to capture via statistics how truly difficult this situation is for those individuals. Microaggressions are discussed at length in Chapter 5 of this thesis to aid in understanding.

5 Intersectionality

In this chapter, specific issues related to intersectionality are discussed and addressed. For the purpose of the overall theme of this thesis, the topic of gender is discussed in a solitary manner due to the frank reality that the statistical data associated with employees of more than one "only" category are drastically different when examining topics such as representation, microaggressions, promotion rates, and equitable treatment as a whole. These topics are discussed briefly by category, but this thesis intends to only share the overarching theme that all diversity should be considered as a complete system with complex interrelationships between characteristics. While this thesis focuses on gender primarily, it does not do so to belittle or deny attention to the vast number of other extremely important diversity and inclusion topics that warrant addressment by nearly all workplaces in corporate America.

5.1 History of "Intersectionality"

The terminology of intersectionality stems from the black feminist movement of the 1980s and 1990s and the original term was coined by Kimberle Crenshaw who discussed that "Cultural patterns of oppression are not only interrelated but are bound together and influenced by the intersectional systems of society. Examples of this include race, gender, class, ability, and ethnicity" [13], [14].

In Crenshaw's paper on "Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics", she describes the many pitfalls inherent to analyzing issues on a single-axis frame of reference, for example only on race, or only on gender [13]. As she aptly describes, "Because the intersectional experience is greater than the sum of racism and sexism, any analysis that does not take intersectionality into account cannot sufficiently address the particular manner in which Black women are subordinated" [13]. This concept carries through to all other intersectional attributes including age, sexual orientation, disability status, and many others. This concept mirrors some theory of system architecture in that through combining multiple systemic elements, an "emergence" may occur that exhibits behaviors not inherent to any individual component or element of the system itself [31]. The colloquial phrase "the sum is greater than the parts" comes to mind. As a person with both a systemic gender disadvantage and a systemic racial disadvantage, a system architect attempting to "deconstruct" and understand the systems affecting that person could not just additively sum all of the effects from both race and gender and say

the system was understood. The nuances of intersectionality are vast and complex, and the interface points between different attributes of a person cannot easily be encompassed in neat, distinct buckets.

The frameworks around discussing and analyzing intersectionality are still in many ways in their infancy, and organizations are often only just beginning to truly understand why the concepts of Intersectionality matter to the ways they treat their employees [15]. Like most social science, these concepts will continue to grow and evolve. It is prudent for companies to work to understand the foundational elements of the attributes that affect their employees' lived experiences so they can effectively work to benefit all aspects of that person and in the end ensure that their employees are happy, healthy, and delivering the best results possible.

5.2 Data around Intersectionality

Current data trends continue to provide support for the intersectional interactions of multiple aspects of a person's identity having an effect on their work life. The McKinsey & Company report "Women in the Workplace" gives data from 2021 that reinforces the intersectional effects that race, sexual orientation, and ability status have on women specifically [8]. Specific examples from the McKinsey report will be shared in following sections related to briefly discussing each attribute.

The Boston Consulting Group report "Untapped Reserves" from 2020 shows that in oil and gas companies studied, the topics related to diversity of gender are still considered at the forefront of what companies believe are important to their definition of Diversity and Inclusion as shown visually in Figure 41. However, interest and discussion of other intersectional attributes is increasing and some attributes that are more important to employees than to their employer need to be considered as the graph demonstrates.

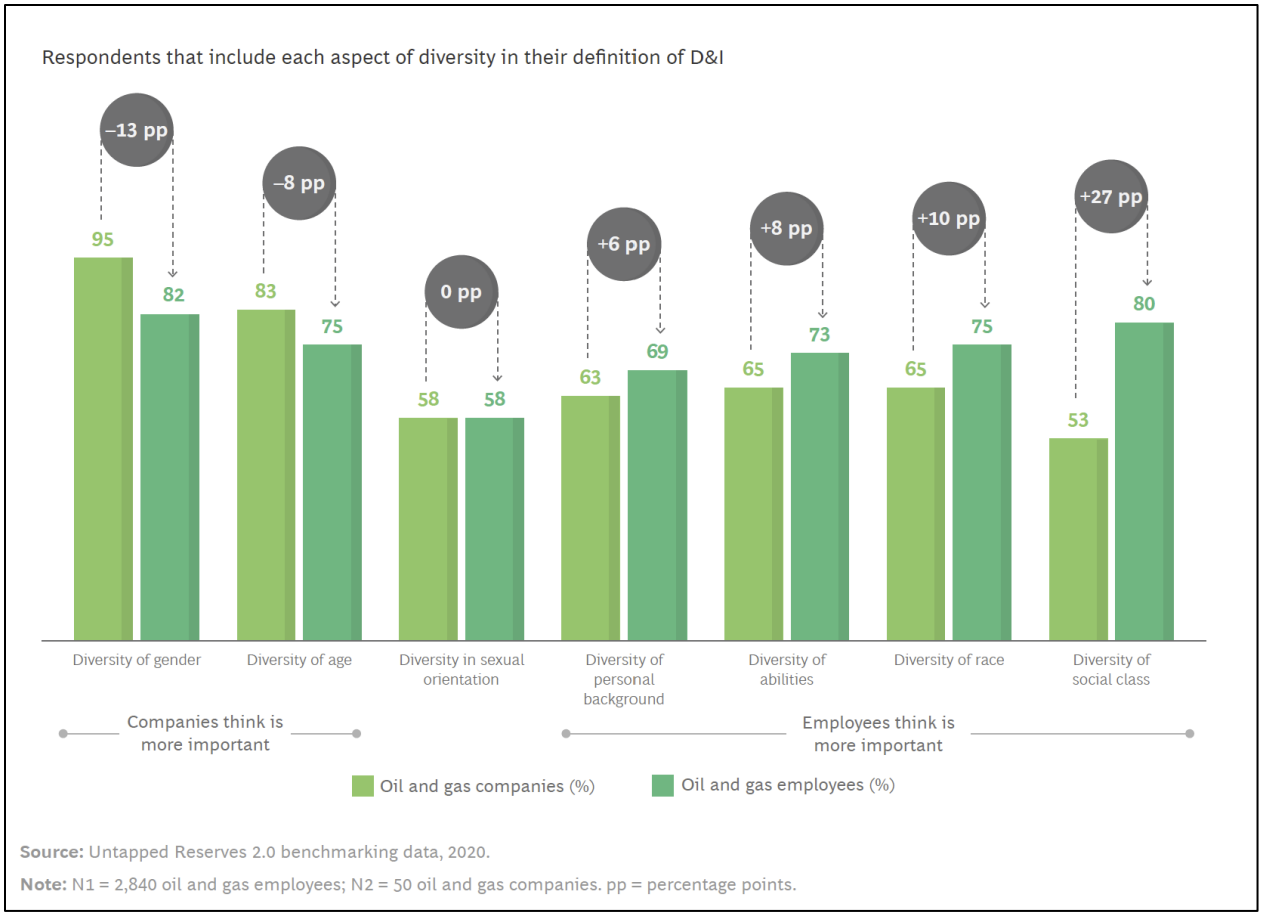

Figure 41. Elements of Diversity and Inclusion according to Employees vs. Employers [20]

Additionally interesting, but perhaps unsurprising, is that "women leaders with traditionally marginalized identities are even more likely to contribute to DEI efforts. Among women at the manager level and above, Black women, LGBTQ+ women, and women with disabilities are up to twice as likely as women overall to spend a substantial amount of time on DEI work outside their formal job responsibilities" [8].

5.3 Race

While both race and ethnicity are independent factors that affect intersectional aspects of a woman's employment, the majority of data available is focused on race as it is a readily visible diversity characteristic. The 2021 McKinsey report "Women in the Workplace" shares information on how non-white women are additionally impacted in the workplace. Figure 42 shows how "representation of women of color falls off relative to white employees and men of color at every level of the corporate pipeline – leaving women of color severely underrepresented at the top" [8].

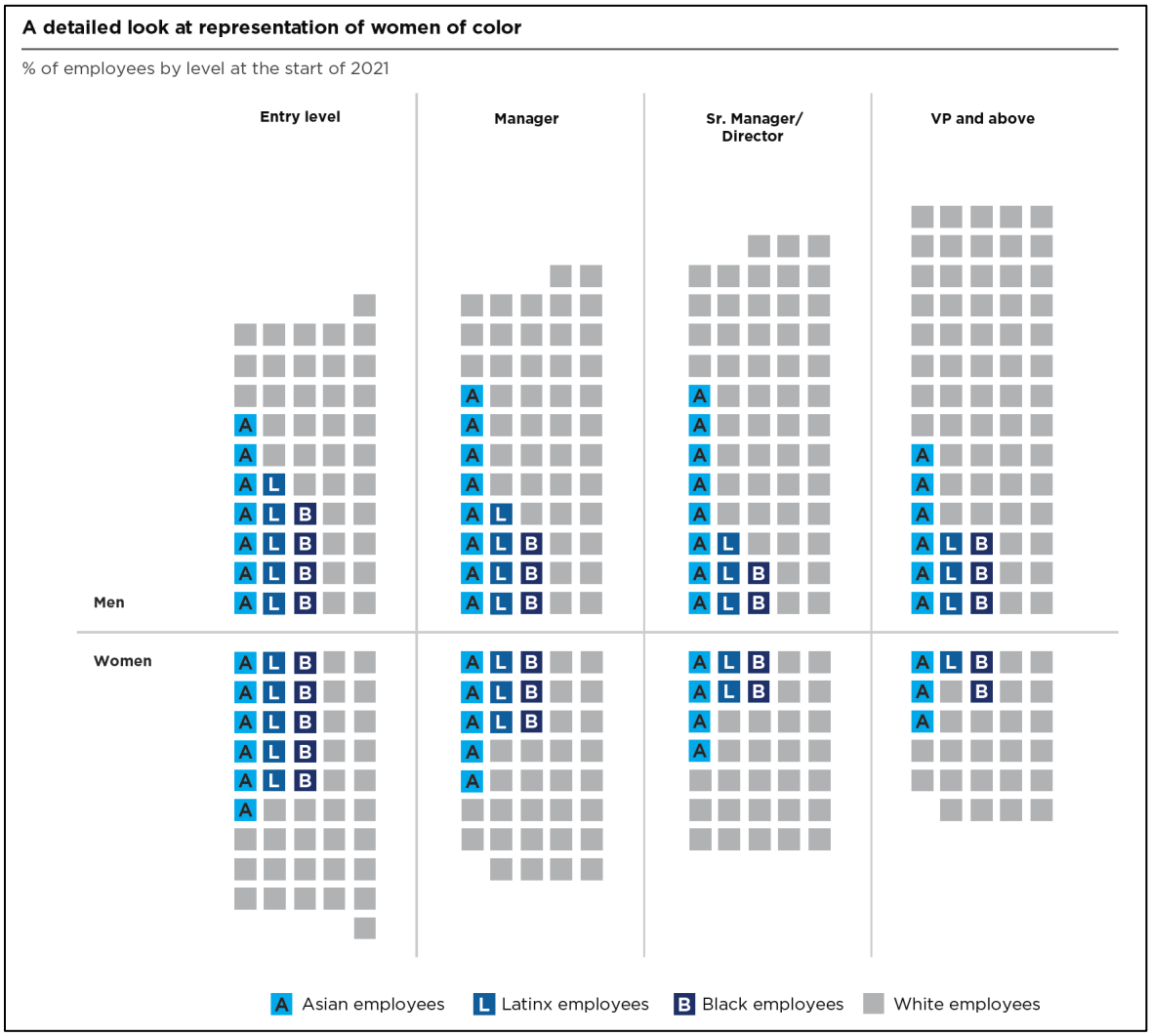

Figure 42. Representation of women of color reproduced from [8]

5.4 Sexual Orientation

Women who identify as LGBTQ+ are "significantly more likely than women overall to experience microaggressions" [8]. Recreated data from the 2021 McKinsey report "Women in the Workplace" shows in Figure 43 the surveyed frequency with which challenges to competence are made to specific demographics. The color mapping across rows is meant to highlight the disparities between the in-group and out-group for each specific type of microaggression. It is fairly obvious when viewed in this green to red scheme that women with disabilities, LGBTQ+ women, and black women especially experience a very large array and degree of microaggressions [8].

Challenges to Competence	ALL MEN	ALL WOMEN	LGBTQ+ WOMEN	WOMEN WITH DISABILITIES	WHITE WOMEN	ASIAN WOMEN	LATINAS	BLACK WOMEN
Being interrupted or spoken over more than others	15%	28%	34%	40%	27%	29%	27%	32%
Having your judgment questioned	24%	31%	37%	46%	31%	25%	29%	38%
Having others comment on your emotional state	12%	18%	25%	30%	18%	13%	16%	21%
Hearing people express surprise at your language skills or other abilities	6%	8%	10%	13%	5%	11%	13%	18%
Hearing or overhearing insults about your culture or people like you	7%	7%	12%	14%	5%	9%	9%	16%
Being confused with someone else of the same race/ethnicity	5%	7%	9%	9%	4%	17%	6%	17%
Feeling like you are expected to speak on behalf of all people with your identity	6%	9%	16%	13%	5%	14%	11%	31%
Having others comment on your hair or appearance	4%	6%	11%	11%	5%	5%	5%	14%

Figure 43. Microaggressions faced by various groups – Chart created from data from McKinsey "Women in the Workplace" [8]

One interesting aspect of sexual orientation as an intersectional component is that it is not easily visually identified in a workplace in many situations. Many LGBTQ+ individuals feel the need to “cover” at work and not be out in the workplace so as to avoid these negative microaggressions and other more insidious forms of workplace harassment and discrimination [34]. As a 2015 American Society of Engineering Education article calls out “Those who hide or downplay their LGBT status may more often be privy to homophobic or heteronormative comments or conversations from colleagues or supervisors than openly-LGBT employees. Additionally, workers who pass, cover, or are stealth are often less likely to feel connected with and supported by their colleagues, less satisfied with their work and more likely to feel exhausted from keeping personal and work lives separate” [34].

5.5 Age

In exploring the promotion gaps mentioned in multiple sections of this thesis, a logical argument follows that age is a factor or at a minimum a relevant statistic to acknowledge when discussing careers for women. Following the already slim representation of female employees in the upper echelons of management at most of the large companies surveyed in the 2021 McKinsey study (Figure 10), it is reasonable to assume that the percentage of older women in those roles is different than the percentages of younger women. The 2020 Boston Consulting Group study highlights an example in one of their case studies, the company highlight has “current female representation across the company is 23.5%, although the figure is 40% in the youngest age bracket (20- to 29-year-olds)” [20]. This higher

percentage of women in roles with less institutional power who are also largely in a younger age bracket means that even for the women that do make it to the top, their views are not necessarily aligned with the views of their younger female employees or coworkers. For instance, the attitudes of the largely white male population in STEM careers studied in the Glass report are shown to be conservative with respect to their feelings around "gender norms", and the women who were promoted to management in companies comprised of such views could also be considered more likely to have held similar views [11]. Now instead of seeing a conservative white man in a leadership role, a young woman, who in STEM is more likely to have much more liberal views around gender norms, may also be faced with a similarly old conservative white female in a leadership position [11]. This promoting of like-minded co-conspirators of the opposite gender, but same age group, class status, and race, can work against the broader swath of women looking to move up in the engineering world.

5.6 Disability Status

"About 1 in 10 working women has a disability", as reported by the 2021 McKinsey "Women in the Workplace Study" [8]. "They are far more likely than women overall to be interrupted, to have their judgment questioned, and to hear that they are too angry or emotional, and they are also less likely to feel supported by their managers. Less than half of women with disabilities feel they have equal opportunity for advancement, and almost a quarter say their disability has led to missing out on a raise, promotion, or chance to get ahead" [8]. An additional interesting set of statistics shows how little focus across corporations there is on disability in Diversity, Equity, and Inclusion (DE&I) conversations with "about 25 percent of employees say their company prioritizes disability in its DEI efforts, compared to more than 40 percent who say their company prioritizes gender and sexual orientation and almost 60 percent who say their company prioritizes race" [8].

5.7 Continued work

As prefaced at the beginning of this thesis and throughout the text, the intent of this section is not to include all aspects of intersectionality, but instead to give an initial glimpse into the significant list of additional aspects of a worker's identity and experiences to ensure that companies and organizations address their employees and members in a holistic manner rather than by fixating on solitary attributes or issues. It does an additional disservice to doubly marginalized groups if they view or perceive that all the attention to equity is put on one specific disenfranchised group. This is especially true if that focus

all goes towards a group that is seen as the next rung down from the main populous, or the ”in-group”. As an example, multiple literature sources throughout this thesis highlight that a large majority of focus in specific industries is still on gender equity and has not spread to other areas. With white women being the largest majority of the racial makeup of women in STEM, it is logical to see how women who make up other non-white groups could feel that the focus from the dominant group, white males, is only on their specific alternate gender counterpart, but does not include them. When women from non-white backgrounds see gender equity initiatives in action (or just in talk), they often observe that the initiatives seem focused on white-gender-equity and not assessing any intersectional experiences. This section is meant to encourage conversation and future work by companies, organizations, and academic institutions in allowing their women to bring their whole selves to every setting and not feel othered in additional ways, unbeknownst to a well-meaning group who thinks they are making honest strides towards equity and inclusion for all.

6 Recommendations

This thesis originally intended to compile multiple literature sources and compile the data within those sources into a systems-level analysis so that the complexity of relationships between aspects of inequity could be explored in more detail. However, upon completion of the interviews for this thesis, and upon talking with company managers who felt they were lacking meaningful direction in making real progress in this area, the creation of this chapter was deemed prudent.

This section details some of the numerous recommendations for institutions and organizations looking to make meaningful changes in improving gender equity. Not all of these are relevant for every organization, as some assuredly have different sets of constraints and considerations that affect the success of any of these opportunities. However, for a company or organization that is serious about addressing many of the aforementioned problems and issues, these recommendations are intended to provide a jumping off point to launch campaigns towards progress. Many of the interviewees for this thesis voiced the concern that their companies were all talk and no real action. These recommendations are not intended to be taken in isolation, nor is any one of them a panacea or a one-size-fits-all solution. Users of this information are urged to consider their own individual organization's needs, desires, status quos, and barriers.

6.1 Framework for systematizing DEI programs

One crucial aspect espoused by multiple sources referenced in the literature review of this thesis is that of creating a detailed and throughout framework for a Diversity, Equity, and Inclusion programs (DEI) or Diversity and Inclusion (D&I) programs. Such programs have become far more popular in recent years as evidence by the uptick in formal program reporting in numerous studies such as the 2021 McKinsey "Women in the Workplace" study [8]. These programs cannot just be for show and must having a meaningful framework in place that demonstrates the elements of the program along with how they will be measured or tracked. Establishing this framework is the first step to showing employees that their concerns and needs are being taken seriously by management.

The general consensus among interviewees who mentioned programs their companies had was "if it's in place and it works, that's great, if it's in place just to say they have something, don't bother". The sentiment is oversimplified for effect, but it highlights the unintentional feelings of ill-will that may become present among female engineering employees if an organization does not make meaningful progress or deliver on intended program objectives. The 2021 McKinsey study "Women in the

Workplace" and 2020 BCG study "Untapped Reserves" both do an excellent job of compiling detailed program structures and recommendations for framing elements [8], [20]. To begin to assess the structural elements of a Diversity, Equity, and Inclusion framework, the BGC report recommends acting on three fronts to address gender inequity specifically [17]:

"Foundational D&I Policies and Program: Companies need to ensure that strong policies and programs are in place so that they can track progress and maximize business performance. For example, they must introduce procedures to ensure that managers are held accountable for achieving D&I goals and to embed D&I values in decision making, in addition to providing basic (and often regulatory) requirements such as maternity/paternity leave, equal pay, and anti-discrimination policies.

Strategic Operating Model and Targeted Interventions: Companies must create a strategic operating model that enables them to attract a more diverse talent pool, retain diverse staff throughout the employee journey, and ensure that diverse individuals advance into senior-level jobs. For example, companies need to ensure that their policies and processes are impartial and gender neutral, and take a transparent, merit-based approach to assessment.

Clear, Sustained Commitment from Senior Leadership: Strong, visible commitment from senior leadership, supported by clear accountability, is a key factor in determining whether male employees consider diversity, equity, and inclusion important. This includes having clear targets and aspirations to signal that D&I is a strategic priority for the organization and to foster accountability within leadership for driving D&I outcomes" [17]

Figure 44 shows this three-tiered framework hierarchy as a helpful visual for an organization just starting out in their definition or redefinition of their commitments.

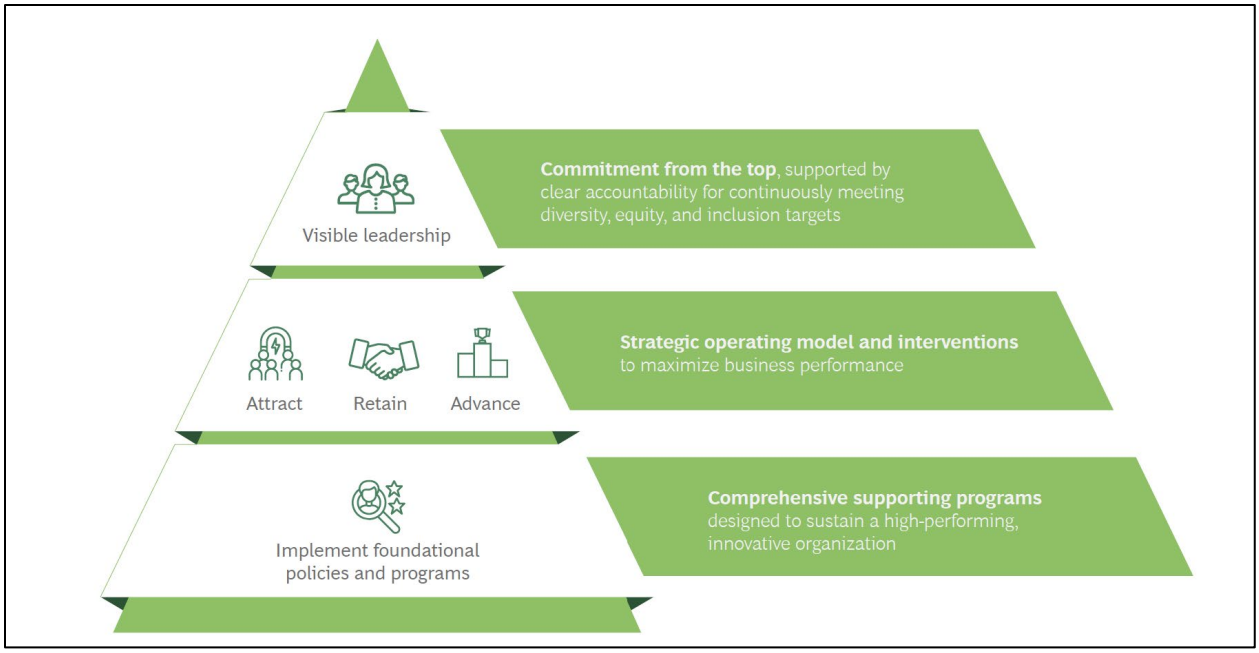

Figure 44. Actions suggested by BCG to work towards gender balance in Oil and Gas companies [20]

Following the understanding of the framework from a high-level, the 2021 McKinsey report shows which types of policies and programs the most successfully diverse companies they surveyed have in place as of time of publishing, as shown in Figure 45 [8]. If an organization is seeking any additional input on why more having diversity in a company is important, there are many resources available that show that companies with more diverse workforces and more diverse boards outperform those without diversity [35], [36].

Type of policy, program, or practice	Detailed policy, program, or practice	Companies leading progress	Companies overall
IMPROVING DIVERSITY AND REPRESENTATION			
De-biasing hiring and performance review processes	Tracking hiring outcomes	100%	71%
	Offering bias training for hiring evaluators	92%	63%
	Providing reminders of how to avoid unconscious bias before the hiring process begins	85%	60%
	Offering bias training for performance review evaluators	69%	47%
	Providing reminders of how to avoid unconscious bias before performance reviews	85%	47%
	Encouraging reviewers to take COVID-19 into consideration when evaluating employees	83%	66%
Tracking internal diversity metrics by gender and race/ethnicity	Tracking and setting numerical goals for representation (e.g., women, people of color)	92%	60%
	Tracking representation of all employees by intersection of gender and race/ethnicity	77%	60%
	– Tracking differences in promotion rates	62%	35%
Holding senior leaders accountable	Holding senior leaders accountable for progress (or lack thereof) on diversity metrics/goals	100%	69%
	– Building diversity goals into performance reviews	77%	48%
	– Providing financial incentives for making progress (e.g., bonuses)	38%	24%
	– Imposing financial penalties for not making progress	38%	9%
IMPROVING INCLUSION			
Focusing on anti-racism, bias, and allyship education	Anti-racism training (i.e., training to actively identify and eliminate racism)	69%	42%
	Training on promoting DEI and/or reducing bias in a virtual environment	92%	55%
	Allyship training or programs	92%	53%
	Exploration of intersectionality as a part of their bias training	92%	54%
Providing mentoring and sponsorship programs for women of color and support for ERGs	Formal mentorship or sponsorship programs for employees from underrepresented groups	85%	52%
	Support for employee resource groups (ERGs)	100%	79%
Providing parental supports and childcare benefits	Paid family leave	100%	84%
	Emergency backup childcare services for parents	92%	49%
	On-site childcare	33%	12%
ACTIVELY WORKING TO REDUCE BURNOUT			
Taking steps to create a sustainable work culture	Increasing mental health supports	92%	60%
	Encouraging new hires to set boundaries around their time availability	58%	33%

Figure 45. Policies, Programs, and Practices in place at top performing companies compared to companies overall [8]

The BCG report also goes more in depth on aspects of diversity programs specific to their levels of hierarchical frameworks for D&I [20]. Figure 46 shows the percentages of oil and gas companies surveyed that have the mentioned foundational policies and programs in place at time of publishing [20].

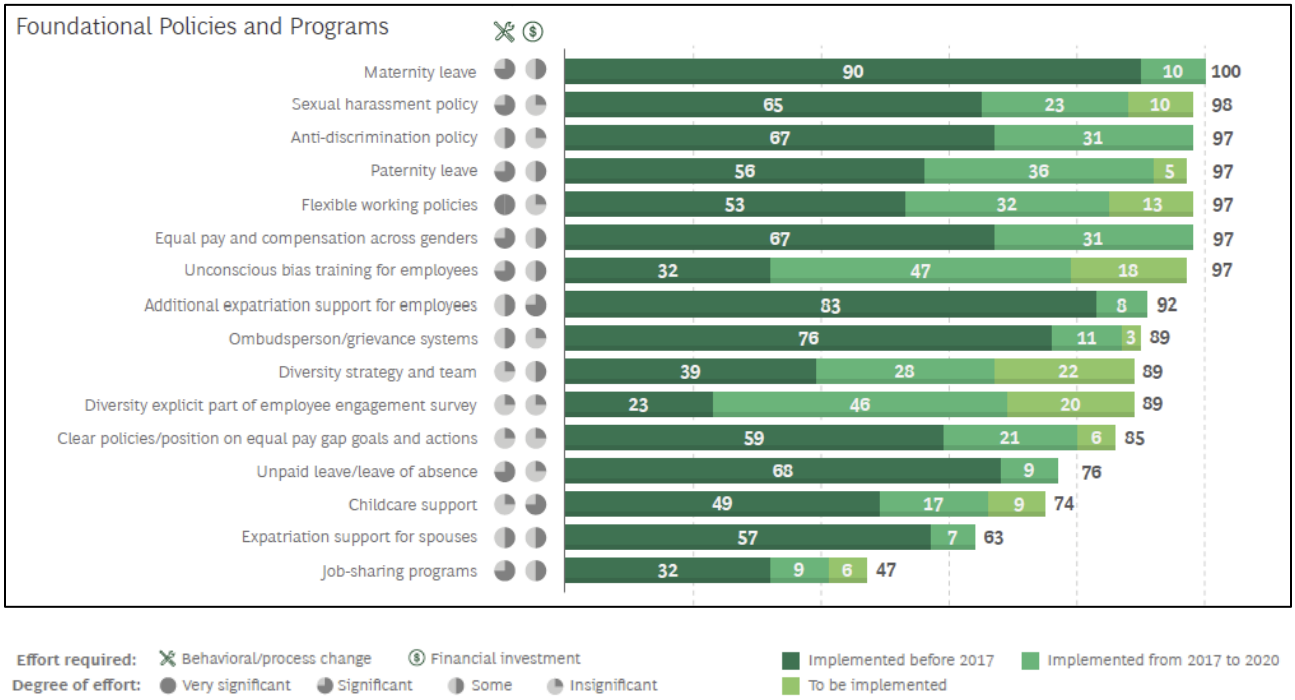

Figure 46. Foundational Policies and Programs surveyed in BCG 2020 study "Untapped Reserves" [20]

The BCG study goes on to show additional data around oil and gas companies that have policies in place related to talent Attraction (Figure 47), talent Retention (Figure 48), Advancement (Figure 49), and Visible Leadership (Figure 50) [20].

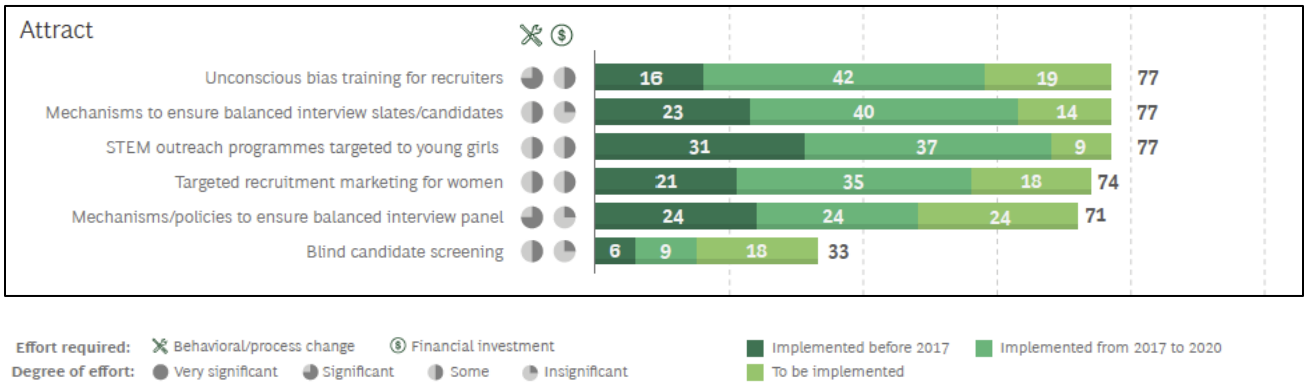

Figure 47. Talent attraction tactics reported in BCG 2020 study "Untapped Reserves" [20]

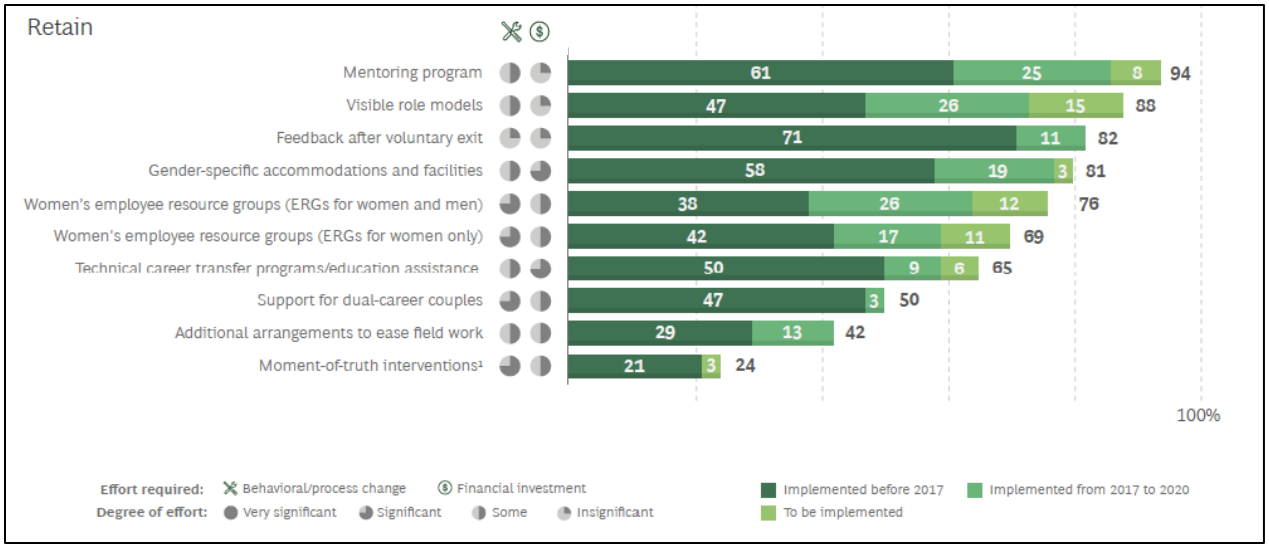

Figure 48. Talent retention tactics reported in BCG 2020 study "Untapped Reserves" [20]

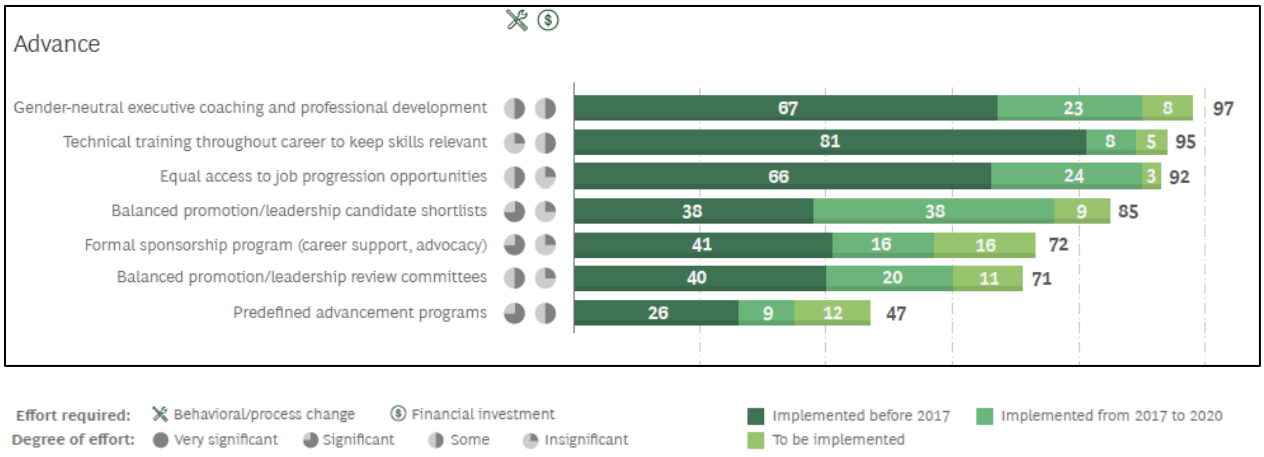

Figure 49. Advancement Mechanisms reported in BCG 2020 study "Untapped Reserves" [20]

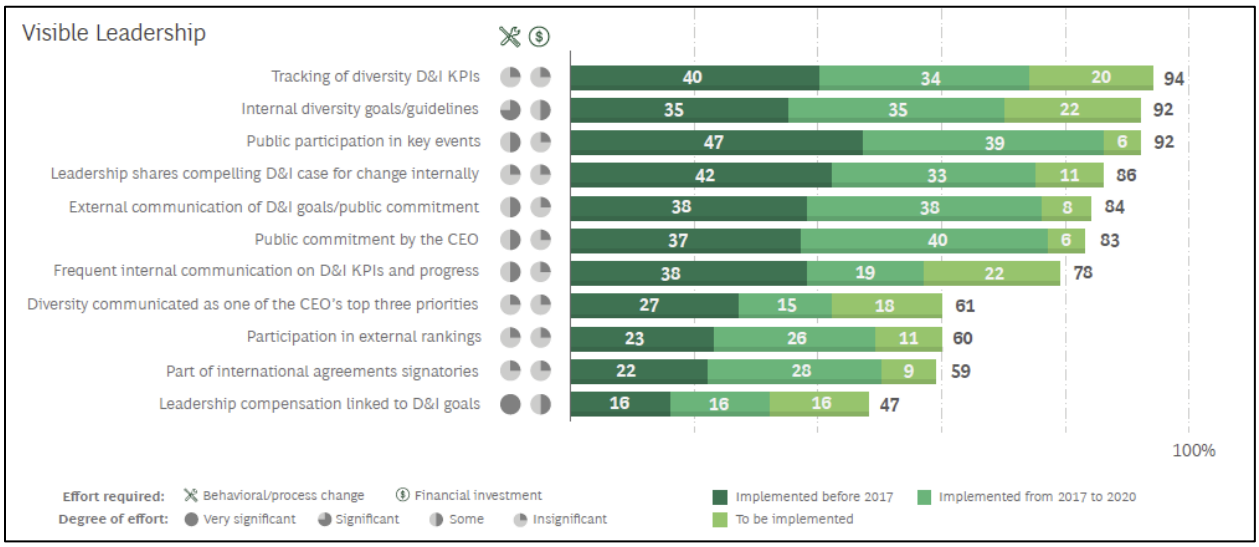

Figure 50. Visible Leadership programs and policies reported in BCG 2020 study "Untapped Reserves" [20]

Not every single facet mentioned in the BCG report, or the McKinsey report is going to work for every organization. It is important to make programs fit for purpose and streamlined so they are actually able to be implemented and understood by the entire organizational structure. These sets of data and report suggestions give an insight into how other organizations are structuring their programs, and how to systematically understand the purpose of each aspect of training, programming, and processes so they are as useful as they can be. One additional idea seen in a few case studies related to reframing an existing "D&I" program to an "I&D" program to show that Inclusion is the most impactful element of the program because diversity is potentially unhelpful to an organization if inclusion is not paramount.

6.2 Unconscious Bias Training

As noted in the 2021 Women in the Workplace study by McKinsey, employees in many companies are receiving more training around anti-racism, unconscious bias, and DEI [8]. As called out in the book Brotopia, the training is a great first step and should continue to spread, but much of the focus is still on naming what unconscious bias *is* but not also addressing what can be done about it [3]. This thesis unfortunately does not have many impactful suggestions for how to improve actions against unconscious bias, other than to call out examples more proactively when unconscious bias rears its head in the workplace. One idea that has been a positive in some coaching is the premise of assuming positive intent. While this is not always truly the case, if the recipient of biased interactions can initially assume positive intent of the perpetrator, they can potentially engage in productive conversation and correction of the actions for future engagements. Granted, this puts the burden of correction entirely on the recipient, which assuredly contributes to further burn out of that person, but it is nonetheless a suggestion for a starting point. Effectively addressing unconscious bias is a topic recommended for future research.

The BCG report "Untapped Reserves" discusses how in certain industries, there are perceptions that women will not accept specific job roles and other general stereotypes. These unconscious biases can greatly affect the career trajectories of many women, and as the BCG report recommends "The best approach for companies to take is to avoid making assumptions about personal circumstances, and instead to ask and offer opportunities equitably" [20]. This is true of nearly all biases applied to any diversity group, so this thesis also urges these words be considered for any and all recommendations from this thesis as well and discuss individual needs, wants, and preferences with each person rather than assuming they want a specific thing because they fit into a specific category.

6.3 Visible Representation

The conversation of "critical mass" is a frequent one in many recruiting spaces, and it is a well-known attribute of being human that if people see people like them in positions of power or in the "in-group" they themselves are more likely to feel accepted and not "othered". What the magic number is for this critical mass at each level of an organization is still a very hotly debated and uncertain item, however. One suggestion this thesis has is related to the discussions around increasing diversity percentages when it comes to dealing with the backlash of the current "in-group". For the United States, in engineering roles, the in-group is still largely white, heterosexual, and male. When they hear discussions about increasing numbers of others who do not fit their group, they often vociferously share their dismay that someone "unqualified" will get the jobs, or that someone will take *their* job. It behooves organizations and management teams to address these concerns head-on rather than think they will go away. One excellent argument made by the Catalyst group is to tell people to not think of the job market as a pie, and someone else taking their piece of the pie, but to rather think of everyone getting more pie overall [37]. This metaphor can be backed up by multiple resources, including some cited in this thesis, related to diverse organizations and companies performing better financially with more diverse members and employees. With respect to the conversation about someone "unqualified" getting the job, these types of backtalk can be more insidious as they lead to conversations about someone "just getting a job because they are a woman", so it is crucial for organizations to be tactful about how they handle conversations around increasing diversity of job slates, improving representation of multiple perspectives, and encouraging teams to look for diverse resumes outside of standardized criteria that was formerly used. One great discussion of this type of retooling is in the BCG 2020 "Untapped Reserves" report related to how women have been historically excluded from expatriate and offshore roles, so to host a job slate that demands that criteria is potentially limiting [20]. A few of the companies mentioned in the case studies in that report have been able to apply growth mindset thinking to reexamine whether those very male-dominated experiences were truly necessary, and they were able to open some roles to much more broad backgrounds that eventually led to even more diverse ways of thinking about some of the historical leadership roles in place in their organizations [20].

One remaining suggestion in the realm of visible representation is that there is a very real feeling of "chicken and the egg" scenario when it comes to seeing more women in engineering management or corporate management overall. The common thread throughout multiple interviews for

this thesis was “we need to see women in management to get more women into management”. This may take some very real and very intentional placement of women in strategic roles that are stretch assignments for them. Organizations need to be willing to promote women with less experience than their male colleagues, but who are prepared to step up to the challenges in front of them. If companies wait until the middle tiers of workers have enough of a “talent pipeline” to feed in naturally to the upper levels of the company, it will take decades longer to meet gender parity, and the engineering workforce will continue to lose significant percentages of women engineers in their first five to ten years because they cannot see any visible path upwards for them and they are fed up with nothing changing [11], [24].

6.4 Promotion Gaps

An initial recommendation related to women’s career trajectory is an easy policy for companies to adopt: Stop using the terminology “leading spouse” and “trailing spouse”. Whether intentional or not, even when used jokingly, this phrasing often gives one person in a relationship the feeling that their career is less important and thus that they are less important. This can create an unnecessary power imbalance, whether the “leading” description is ascribed to a male or female. With more and more dual career couples, and egalitarian relationships becoming the norm over antiquated gender norms, companies need to begin career conversations with all of their employees without forcing partners to choose artificially who is superior from a career perspective.

The article “’Potential’ and the Gender Promotion Gap” by Benson, Li, and Shue goes into great detail around issues with planning for promotions based on an employee’s potential, as discussed in the Literature Review in Chapter 2. Women are often promoted only after outperforming their role’s needs and expectations, while their male counterparts are promoted based on their potential or what they could grow into [18]. This, paired with the social phenomenon mentioned in multiple qualitative interviews for this thesis that women are likely to apply for a role if they meet approximately 90% of the qualifications, whereas men are willing to apply for the role if they meet 60% of the qualifications, and it appears that women’s supervisors are not the only ones selling them short. To help combat this gap created by multiple issues, companies should focus on how they are providing sponsorship for upward career mobility to their female engineers. Male Allyship groups are a phenomenal starting point to allow for some sponsorship to occur organically. The case study in the BCG “Untapped Reserves” report related to the Chevron program in partnership with Catalyst entitled Men Advocating for Real Change, MARC for short, is a prime example of such a program [20]. This allows men to understand the

challenges their female colleagues are subject to every day and enables them to champion for change in the workplace [20]. The next logical step from a fluency-building allyship program such as MARC is to put in place formal mentoring and sponsorship relationships between more senior men and younger females. These relationships will require a large degree of trust and support, so it is crucial that the men in the program are acting from a place of true willingness to support a woman's career and nothing more sinister and uncomfortable such as the sexual harassment discussed at length in this thesis. Sponsorship, mentorship, and awareness are just a few baseline steps to ensuring women don't fall into the "leaky bucket" scenario during their careers.

A final recommendation related to promotion gaps is the continual process of debiasing promotion discussions and performance reviews. The McKinsey report along with other resources in this thesis mention that there are vast differences in how women's performance is reviewed compared to their male equals in an organization. Some tests of unconscious bias even show how differently the same resume is reviewed if it has a male name on it versus a female name [3]. To allow women to progress in their careers at the pace their performance deserves, front-line supervisors need to be trained in unconscious bias and other issues that play into the gendering of performance reviews.

6.5 Focus on the Early Exits

Bridging from the suggestions in section 6.4 on promotion gaps, there needs to be significant management attention on how front-line supervisors interact with young female engineers during their first years in the workplace especially. The article "Why do Women Leave Science and Engineering" by Jennifer Hunt was reviewed in the Literature Review in Chapter 2 of this thesis, but to summarize, the bulk of exits by female engineers were in their first five years of employment [24]. Hunt also concluded that the primary drivers for women to exit engineering were pay and promotion gaps [24]. This evidence pushes back on the incorrect perception from some employers that women leave engineering in their first five years for family-planning reasons. In addition to Hunt's findings, Glass et. Al. discovered that most females in STEM do not actually leave the workforce, they merely transition away from STEM roles for a variety of reasons [11]. The research by Glass discussed the remaining gray areas that likely need more study, especially the "noxious" environment created in organizations and fields where women are tokenized to an extreme by their low representation [11]. As summarized "The focus for future work should be, we believe, on the first few years of employment in STEM jobs, when the greatest attrition out of the field occurs. Our analysis suffers from a lack of detailed information on the characteristics of jobs and the organizational environment in which STEM women labor postgraduation. The interaction

patterns between new STEM entrants and supervisors and coworkers may be especially relevant, along with the skill content of the job and the prospects for future upward mobility. The distinction between organizational provision of work-life amenities and the ability of employees to actually use amenities without negative consequence may also be important in understanding why women might leave fields that initially seem to have better pay and benefits and greater flexibility" [11]. If organizations actually want women to stay past this point of "infant mortality" of their careers, they need to work harder to understand the influence the front-line management has on the overall experience and cultural fit of young female engineers. One thought is that the "death by a thousand cuts" scenario discussed in Chapter 3 could be avoided in the early years of a female engineer's career if her manager(s) truly did set expectations for behavioral and cultural obligations of all of their employees. As the colloquial saying goes "it only takes one bad apple to spoil the bunch", and unfortunately, many of the women interviewed for this thesis with were only a few months into their careers when their first sexual harassment or overt bias experience occurred. If those experiences do not manifest so quickly in their initial experiences in the workplace, and supervisors implement zero tolerance policies when issues do arise, perhaps young women engineers would not flee so quickly into a career they put significant schooling and effort towards.

6.6 Addressing the Pipeline: Motivating young women to study engineering

The following suggestions are resultant from conversations in qualitative interviews around women's motivations for pursuing engineering. Multiple interviewees mentioned their focus being on a career path that offered flexibility in future job roles. There were also multiple mentions of the desire to do something "impactful", that could cause positive impact in the world and for society. Financial stability was a definitive influence on many of the women interviewed and should continue to be highlighted in recruiting conversations. However, a suggestion to companies would be to shift some of the verbal focus during recruiting conversations to the aspects of engineering that are uniquely suited towards solving some of society's toughest challenges. For instance, the "Untapped Reserves" report by BCG highlights that a large portion of oil and gas employees under 30 are passionate about the energy transition [20]. An additional worry of women looking to get into the field of engineering is avoiding being cast alongside the stereotypical male engineer, mentioned in Brotopia, who is antisocial and addicted to their field [3]. Highlighting career aspects such as needing to work collaboratively as a team to effectively solve problems, effective work life balance resulting from somewhat regular hours in many

job roles, and international travel opportunities all appear to be very appealing attributes to many women and should be leveraged as talking points during recruiting and interview sessions.

An additional set of solutions in the academic space arose from conversations with female leaders in academia during the framing conversations for this thesis. A leader of a private institution that acts as a feeder program to many Silicon Valley companies discussed their tactics around allowing students the opportunity to explore a multitude of courses prior to selecting a definitive major their sophomore year. This leader suggested that by allowing women and people of color the opportunity to explore courses, they are more likely to find themselves enjoying engineering curriculum without feeling forced into it and also to see that they are more than qualified enough to undertake the coursework, thus avoiding a large amount of "imposter syndrome" that often develops for people from the "out group" of a setting. Additionally, the school does not limit which majors people can add into a double major. This allows students to not feel as though they are being trapped in a solitary line of study, and they can continue to pursue engineering or other STEM majors while still exploring creative interests such as art and history that are very frequently disallowed from dual degrees at other universities.

In line with allowing students to feel welcomed in engineering coursework, this institution changed their school's mission statement to focus on collaboration and cooperation, which has effected change in enabling students to not feel the air of competition that so often permeates engineering classes. One additional change that the leader mentioned was removing instructors that were not progressive in their thinking and inserting more effective leaders in the faculty space that were also more representative of the demographics they were instructing. What this resulted in was far more females and people of color in faculty. Students entering college were able to see leadership that looked like them and could relate to their lived experiences, and this helped them feel empowered to succeed in those disciplines. These instructors then echoed the school's mission statements and were able to do away with overly competitive language in introductory engineering classes, such as the infamous opening lines to many engineering courses: "Look to your left, now look to your right, only one of you will be sitting here at the end of this year". Phrases like that were perhaps once well-meaning, but they have the adverse effect of making people who are already barely feeling comfortable in that setting to begin questioning whether they should continue on in that field of study. Focusing on language around cooperation, learning from one another, and supporting each other's successes has been far more impactful at this institution in making people feel welcome in STEM fields. From this leader's perspective, these relatively small-seeming changes to pedagogy, visible representation, and administrative protocols around major selection are what have led to them being able to tout 50%

enrollment by women in the engineering, computer science, and physics department: a feat unobserved in nearly any other US based institutions.

6.7 Metrics

As the colloquialism goes “What gets measured gets done”. In the inverse of that, what doesn’t get measured, often doesn’t get done. Along those lines, there is evidence that companies who track their performance relative to diversity, equity, and inclusion metrics often outperform their peers in those areas, as well as often outperform their peers financially [8]. The mechanisms by which organizations choose to track their improvements, or lack thereof, are specific to an organization. However, some ideas stemming from recent McKinsey and BCG reports include tactics such as assessing the maturity of a D&I program [20]. BCG published their “Diversity and Inclusions Maturity Assessment Tool”, a copy of which is shown in Figure 51, but can be viewed much more legibly in the original report [20]. BCG provided the following instructions for use: “The Diversity and Inclusion Maturity Assessment tool consists of a checklist of 12 parameters across five categories, ranging from leadership to career advancement. Each parameter is defined along a five-step scale, where step 1 represents the bare minimum/table stakes action and step 5 represents the current view of a progressive, forward-leaning action (noting that this space and what is considered progressive will continue to evolve). The steps are typically sequential and additive, and they reflect increasing maturity of D&I approaches when read from left to right. Using this tool, companies can create a baseline for themselves today and identify blind spots and areas for further focused efforts and priorities.

We encourage companies to use the tool to plot their starting point on the basis of current programs, and then set aspirations for the progress they would like to make over the next one, three, and five years. The tool can also facilitate discussions with management and boards about what realizing the full potential of diversity and inclusion looks like if they want to be best in class for attracting and retaining diverse talent—conversations that lead to action” [20].

McKinsey shares in their 2021 report some additional ideas for holding management accountable for diversity targets, such as tying metrics to performance reviews and financial compensation packages, as well as actively publishing performance in these areas both internally and externally [8]. Data related to companies that are employing such practices is shown in Figure 52 as reproduced from that report [8].

	Category	Top 12 parameters	1	2	3	4	5
1	Visible leadership	What is included in your definition of D&I?	Includes gender diversity	Includes gender and racial diversity	Includes all visible differences	Includes all visible and invisible differences	Includes equity to bring everyone to a level playing field
2	Visible leadership	What drives your focus on D&I?	The government mandates it	It is a CSR initiative and about social justice	It is part of the ESGs	It makes business sense	It is who we are and is a part of our values
3	Visible leadership	How committed is your CEO to D&I?	HR leads D&I, with no executive sponsorship; disaggregated responsibility with individual managers	Internally sponsors the D&I team; or nominates another Executive sponsor	Includes D&I internally as a top-three priority	Advocates and takes leadership externally in the industry; drives change	Appoints an Executive Leader to own the D&I agenda and dedicates resources to it
4	Visible leadership	How often do you communicate on D&I?	Never	Only on International Women's Day/during Pride month, etc.; only internally	Only on International Women's Day/during Pride month, etc.; internally and externally	Through participation in external conferences, benchmarking exercises, etc.	Report on D&I goals, progress, and actions being planned as part of annual reporting
5	Visible leadership	How do you use D&I targets?	No targets used/use only those mandated by the government	In defining process-based metrics (e.g., mandatory unconscious bias training, ally training once a year)	In defining targets for recruitment and senior leadership roles	In defining target outcomes (e.g., equal retention across diverse groups, engagement scores)	In linking targets to incentives and salary structure of leaders
6	Foundational policies and programs	Which flexible working options do you provide?	None	Work from home	Work from home and flextime	Work from home, flextime, unpaid leave	Work from home, flextime, unpaid leave, job sharing
7	Foundational policies and programs	What is your paid parental leave policy?	Only for women, for birth and adoption, for a government-mandated period	Only for women, for birth and adoption, for more than a government-mandated period	For women and less for men, for birth and adoption, for more than a government-mandated period	For women and less for men, for birth and adoption, for more than a government-mandated period	For everyone regardless of gender, for birth and adoption, for more than a government-mandated period
8	Recruit	How do you ensure diverse and bias-free recruitment?	Do nothing	By targeted marketing to diverse groups	By having gender-balanced interview panels and gender-balanced candidate shortlists	By doing blind screening of résumés	By using technology (e.g., removing bias from job descriptions, using AI for first-round interviews)
9	Retain	Do you have any gender-appropriate facilities?[1]	None	In corporate offices, for men and women	In corporate offices, gender-neutral, for men and women	Everywhere, for men and women	Everywhere, gender-neutral, for men and women
10	Retain	What purpose does your Employee Resource Groups serve?[2]	None supported by company; employees can form them for informal networking	To build affiliation and to network, only for diverse groups, supported by company	For advocacy to leadership, for different diverse groups and allies	To act as strategic partners for business	As a force for good for the community in which the business operates
11	Advance	How do you avoid over indexing on technical and/or international experience for promotion decisions?	Do nothing specific	Include direct supervisor feedback against capabilities required for the role	Include 360-degree feedback against capabilities required for the role	Include an interview with a diverse candidate shortlist	Include assessment by a diverse decision committee
12	Advance	How do you support your diverse employees in advancement?	Do nothing specific for diverse employees	Facilitate mentorship within diverse groups	Provide formal mentorship programs for all	Deploy structured sponsorship programs from midcareer	Deploy structured sponsorship programs for senior levels (CEO to CEO-2)

Figure 51.BCG Diversity and Inclusions Maturity Assessment Tool from [20]

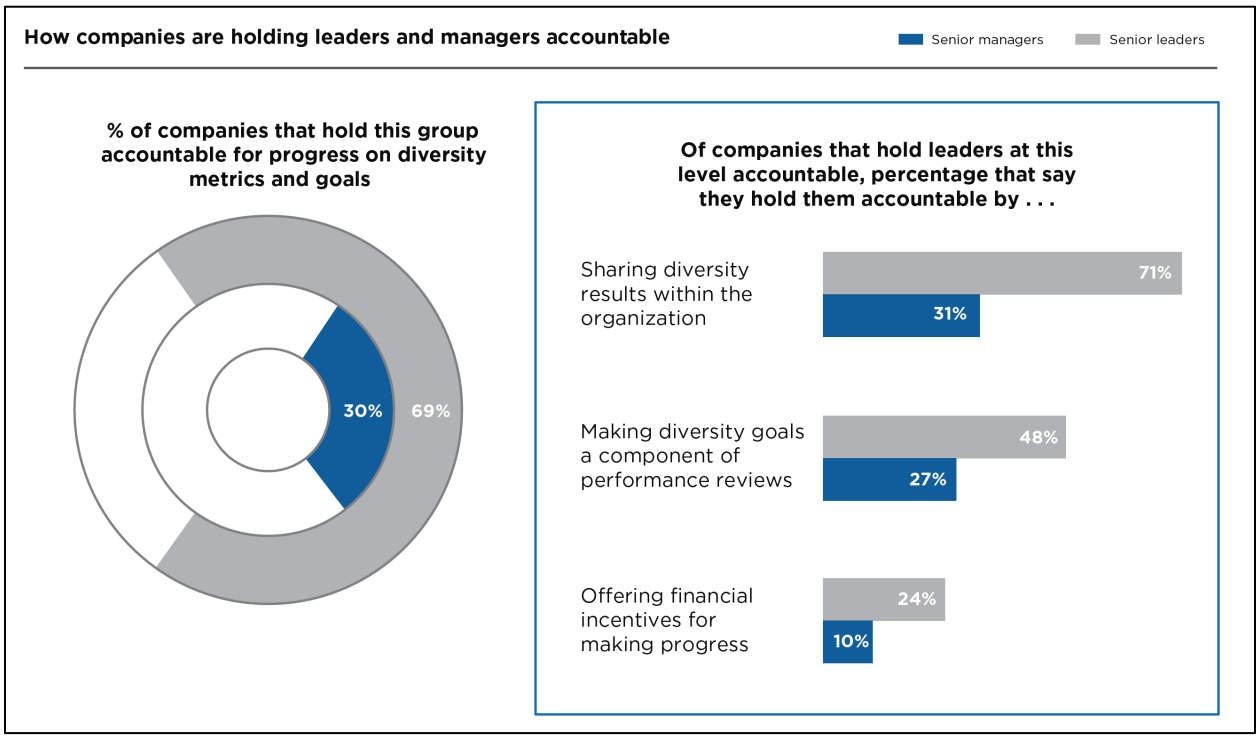

Figure 52. Accountability mechanisms for Diversity Metrics. Reproduced from [8]

Some organizations in the Oil & Gas industry may recall the extreme pushback towards incorporating safety and fatality metrics into compensation/bonus factors and performance rankings in the 80s, 90s, and early 00s. But once management determined that safety was a non-negotiable aspect of their operations, these metrics were inextricably linked to personal outcomes of managers and employees, and real change resulted. This thesis suggests that companies must view diversity and inclusion as a similar non-negotiable and make it personal for managers. If management does not inherently respect and understand the issues at hand, or if they are like the majority of engineering firms where leadership is white and male and they are thus unimpacted and unaffected by many of the issues discussed in this thesis, then some external influence must be exerted on them to force change:

Impact their personal bottom line and they will be forced to care.

7 Conclusions

7.1 Research Summary

The analysis presented within this thesis demonstrated the many complex mechanisms by which elements of gender inequity are intertwined. By examining each individual entity, along with its relationships to multiple other entities, organizations, companies, and academic institutions can take more impactful steps towards equity in their ranks through targeted actions including foundational DE&I programs and policies. The following is a summary of the research questions discussed throughout this thesis.

The following is a summary of the research questions addressed throughout this thesis.

1. **What are the specific individual components of the gender framework with respect to engineering, or in other words, what architectural decomposition does the current system of engineering work hold?**

   Through an extensive literature review coupled with inputs from qualitative interviews with female engineers, the framework of the system that makes up the experience of a female engineer is clearer. Previous literature often focused on single issue effects on retention, promotion, and equity. Additionally, focus of prior literature is often on STEM as a whole, which can lead to overgeneralization of specific influences to women in subdisciplines such as engineering. To form a more complete and holistic view of the experience of a female engineer, themes were explored specific to statistics available in existing reports, along with statistics from industries that are heavily engineering-dominated. Once initial thematic frameworks were understood, inputs from qualitative interviews of female engineers were used to validate the initial framework and further develop the themes into individual system elements in an architectural decomposition. Within literature review and interview outcomes, topics commonly discussed that developed into themes included unpaid labor, sexual harassment, allyship, promotion gaps, visible representation, unconscious bias, workplace benefits and flexibility, child rearing expectations, marital division of labor, and potential for exit from engineering. Focus areas from these themes were them ascribed to the subsystems of job characteristics, family characteristics, partner characteristics, individual level of investment, and intersectional attributes. This architectural decomposition is not a static assessment of the female experience in engineering, but rather a lens by which to view the current state of these specific women in

engineering and their experiences and give greater comprehension to the many interconnected elements that are at play in this complex sociotechnical system.

2. **How do these individual components interface with one another to make up the overall system of the engineering world?**

   The mechanisms by which the individual components, factors, and attributes affecting a female engineer interact are complex, but can be uncomplicated by analyzing some of the most impactful behaviors and aspects. The systemic breakdown of individual factors discussed with respect to research question 1 yielded an initial understanding of the individual elements affecting women in the engineering world. The question at play here regarding interactions involves a significant amount of subjectivity in assessing how strongly one element interacts with another element, and whether that interaction is positive, neutral, or negative. This thesis leveraged a Design Structure Matrix to visually display and assess these relationships and used this tool as a talking point to some of the complexity inherent to this sociotechnical system structure. While it would be impossible to wrap up all the interfaces appropriately into a nice, neat schematic, this thesis is hopeful that by discussing the multi-dimensionality of issues facing female engineers in their places of work and home lives, that organizations and companies can better provide support and intentional resources to help their female employees.

3. **How can academic institutions understand recruitment and retention to better attract and retain female engineering students?**

   To aid in addressing this conversation, interviewees for this thesis were probed on their initial motivations for entering engineering. There was a clear correlation related to being a female engineer and having a parent who is an engineer. However, other clear themes that emerged included the desire to help others through their work as an engineer, eventual job flexibility between roles, and financial motivations. These themes could easily be leveraged in recruiting conversations to encourage women to consider engineering as a career path. Recruiters should be cautious in employing techniques that come off as pandering, but in genuine conversations, they can discuss how their companies solve big problems, help others, and provide job security and flexibility. These topics are also appealing to many male recruits, so this approach is likely to be additive to recruiting success of all genders. Academic institutions need to understand many of the mechanisms that push women out of engineering to effectively retain female engineering

students once they exhibit initial interest in the field. These effects are detailed in the DSM and recommendations sections of this thesis, but some summary aspects include a focus on the pedagogy, instructor and faculty representation, and creative approaches to allowing for later major selection and double major considerations.

4. **How does Intersectionality relate to all these gender-specific topics?**

   The subjects of intersectionality add additional complexity to understanding effects on female engineers in the workplace, but they cannot be avoided if true change is to occur in workplaces, schools, and organizations. Chapter 5 of this thesis discusses the background of intersectionality as a frame of thought, and then delves into the individual attributes that have the most data associated with them from many of the literature sources leveraged in this thesis. The Literature Review, Interviews, and research on the topic of Intersectionality all contributed to the way that intersectional attributes are handled in the Sociotechnical Systems Analysis of this thesis in Chapter 4. This systems analysis worked to focus primarily on the issue of gender but leaving out intersectional components entirely would be a mistake. As such, the systems analysis categorized these attributes separately but still addressed them in the Design Structure Matrix assessing the overall experience of being a female in the engineering world. Intersectionality is a topic warranting much future research and data collection, and unfortunately as the McKinsey study mentions, the large majority of people working on DE&I initiatives are the same people that are most impacted by DE&I issues and shortcomings of their organizations [8]. To effectively bring about change, allyship will be a crucial component of bringing intersectional issues to a place of understanding and improvement.

5. **How can companies address the systemic issues at play in their own workforce?**

   This thesis offers multiple data-backed suggestions on how companies can proceed to influence real change within their organizations. First and foremost, a company must have a framework in place to systematically understand and design their Diversity, Equity, and Inclusion programs and processes. Each process and program must be intentionally managed and measured so as to not seem purely performative to the workforce, especially those most impacted by the issues. This thesis then advises on addressing specific issues relevant to unconscious bias, visible representation, and promotion gaps. Two hot button topics of the “talent pipeline” and “leaky bucket” are also discussed, with recommendations on how to recruit more women into the

engineering world in the first place, as well as how to prevent or at least understand the early exodus of female engineers in their first five years on the job. Following these recommendations, this thesis shares some ideas on how to measure the impacts, or lack thereof, of the programs and policies discussed. “What gets measured gets done” and this thesis wants companies to recognize that if they are not measuring their progress, they cannot truly claim to be making any.

6. **What future lines of research would be most effective at improving the existing inequities related to gender in engineering?**

   This topic is discussed in section 7.3 Future Research and will share some ideas on statistically relevant data that can be collected or shared more readily to help organizations make data-driven decisions and processes focused on improvement. Continuing to review frequent reports such as the McKinsey “Women in the Workplace” report or the BCG “Untapped Reserves” report is an excellent first step for managers to stay apprised of changes in the working world that are likely to affect their organizations. For example, the most recent versions of both aforementioned reports begin to look at some of the data trends resultant from workplace changes during the COVID-19 pandemic. The working world will undoubtedly continue to change and evolve, and it should be excepted that managers be required to stay aware of what is changing from a statistical perspective so they can recognize if any similar trends are occurring in their own organizations.

7.2 Scope Limitations

The extent of research available on just women in engineering alone is relatively limited, leading to the literature review primarily aggregating information from relevant topics including STEM-wide research, corporate-wide research, ad data related to specific industries, specifically focusing on industries known to have a large engineering population. In order to adequately assess some of the phenomena discussed in this thesis, the potential for collecting data on solely women in engineering may be useful. Additionally, the author would have greatly liked to interview more female engineers had time allowed. A broader group, especially with inclusion of more intersectional diversity attributes, would potentially yield further insights into some of the phenomena discussed in this thesis.

7.3 Future Research

There is much left to be explored on the intersectional components of the topics addressed in this thesis. As mentioned throughout this thesis, significant literature has been written around broad topics with single issue focus, and that is true of gender, race, and many other aspects that make up a person's identity. Understanding the individual issues is a helpful first step, but to truly influence change, the complex interwoven relationships of all attributes of a person's being must be understood. With more companies understanding the terminology of intersectionality and realizing the benefit to be recognized when employees feel included and empowered, more future research should be put towards understanding the impact that crucial intersectionality of attributes has on a person's experience in the workplace.

An additional topic mentioned for future research is around unconscious bias. It is easy enough to learn how to spot bias and identify it, but then what? The effectiveness of different responses to unconscious biases in an organization over time would be a very interesting field of study. Unconscious bias contributes heavily to the feeling of fatigue over a long period of time for the recipients of said biases, so it would be potentially impactful to gauge the effect of unconscious bias in a workplace on the recipients in a time-based manner through measures including their mental health, their level of perceived inclusion in an organization, and their likelihood to leave their company or field.

One item that arose from examining the wealth disparities in Harris County/Houston that are tied to the Oil and Gas industry presence there is for companies in this industry to ask themselves is whether their gender and racial gaps are contributing to even greater inequities in their broader communities [17]. The data in the Harris county report draws clear correlations between the white, wealthy, male-dominated workforce in this region and the significant wealth gaps for women and people of color [17]. Understanding how gender inequity in specific industries effect the communities around them would be a very insightful topic for future study.

A final additional line of research suggested would be examining how to effectively engage white, male, heterosexual male allies in the workplace. As mentioned, the majority of the work done in the DE&I spaces at companies is done by the people impacted by the issues: women, people of color, people with disabilities, and LGBTQ+ individuals [8]. However, to effect real change, the largest "in-group" population of the existing engineering world must be aligned with desiring progress to enable it to happen in an effective timeline. Research into the most effective means for encouraging allyship would be fruitful in this regard.

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APPENDIX A: Interview Demographics Form

Katherine Papageorge MIT Master's Thesis - Interview Demographics Collection

Thank you greatly for your interest and enthusiasm in participating in an interview for my MIT master's thesis. As mentioned in the initial interest form, my thesis is intended to explore, at a systems level, the gender biases experienced by female engineers. I can give you more background on the intent of the System Design and Management program at MIT if you would like, please don't hesitate to ask.

Demographics input:

I received a phenomenal level of initial interest and as a result, I will not have an opportunity to interview everyone who initially responded. This preliminary demographic collection form will help inform my interview pool selection as I want to ensure a diverse group of interviewees related to all criteria I am seeking to explore. If you are selected for an interview, I will email you in the coming days with a link to my Calendly page where you can schedule a one hour time slot of your choosing. If you are not selected, I will notify you and extend my heartfelt thanks for your offer to contribute. This form will additionally enable me to skip some of the preliminary background during our interview slot. You will see that some questions are required in this form, while others are not. This is to help me sort through the responses and aggregate data, but I've left some of the more personal topics as optional so we can discuss them verbally later on if you would prefer. All responses to this survey will be purged along with all other records of our discussions upon the conclusion of my thesis in August 2022.

Prepping for the interview:

Don't just tell me what you think I want to hear. Not all biases present negatively, so I encourage you to keep an open mind and share any and all experiences that you think may help me paint a clarified picture of the systems in place that you have experienced throughout your life. I want you to lead the conversation in whatever direction you would like, and am going to use some targeted questions at the start to get some baseline data points to compare to legacy data sets, but from there much of my content will be more loose in question structure.

Continuous Feedback:

If you have any questions at any time, or ever become uncomfortable in this process, please inform me immediately and we can cease the discussion and I will purge your records immediately. As a reminder, all names will be scrubbed from the data collected. I cannot thank you enough for your help in this endeavor!

1. First Name *

2. Last Name *

3. Age *

4. What do you identify as your race? (Based on Census classifications) *

- [ ] White
- [ ] Black or African American
- [ ] American Indian or Alaska Native
- [ ] Asian
- [ ] Native Hawaiian or Other Pacific Islander
- [ ] Other
- [ ] Prefer not to say

5. What do you identify as your ethnicity? (Based on Census classifications) *

- ◯ Hispanic or Latino
- ◯ Not Hispanic or Latino
- ◯ Prefer not to say

6. What is your marital status?

- ◯ Married
- ◯ Widowed
- ◯ Divorced
- ◯ Separated
- ◯ Never married

7. What is your income level? (of you alone, not including a partner or spouse)

- ◯ $0
- ◯ $1 to $9 999
- ◯ $10 000 to $24 999
- ◯ $25 000 to $49 999
- ◯ $50 000 to $74 999
- ◯ $75 000 to $99 999
- ◯ $100 000 to $149 999
- ◯ $150 000 to $199 999
- ◯ $200 000 to $249 999
- ◯ $250 000 to $299 999
- ◯ $300 000 to $349 999
- ◯ $350 000 and greater
- ◯ Prefer not to answer

8. How many children do you have?

9. Do you have any dependents not included in your count of children?

10. When did you graduate with a degree in engineering? (Year) If you do not hold any any engineering degree, please denote below. *

11. What is your highest degree level achieved? (does not need to be only engineering degrees) *

- ◯ Bachelor's degree (for example: BA. BS)
- ◯ Master's degree (for example: MA, MS, MEng, MEd, MSW, MBA)
- ◯ Professional degree beyond bachelor's degree (for example: MD, DDS, DVM, LLB, JD)
- ◯ Doctorate degree (for example, PhD, EdD)
- ◯ Other

12. How long have you worked, or did you work, as an engineer? (Years)

13. Are you currently employed?

- ◯ Yes
- ◯ No
- ◯ Actively seeking new employment

14. Are you currently employed as an engineer or in an "engineering" specific role?

- ◯ Yes
- ◯ No

15. What countries has your primary work experience been based in?

16. Where is your company headquartered (country), or if you are no longer working, where was the company of your longest tenure headquartered?

17. Anything else you want to tell me ahead of a potential interview?

Figure 53. Interview Demographics Collection Google Form

APPENDIX B: DSM Subsections

The legend for how to interpret the DSM can be viewed in Figure 38. DSM Legend: How to read interaction designations and further detailed instructions are throughout section 4.2 System Design Structure Matrix.

Figure 54. DSM Subsection showing impact of Job Characteristics elements on other Job Characteristics elements

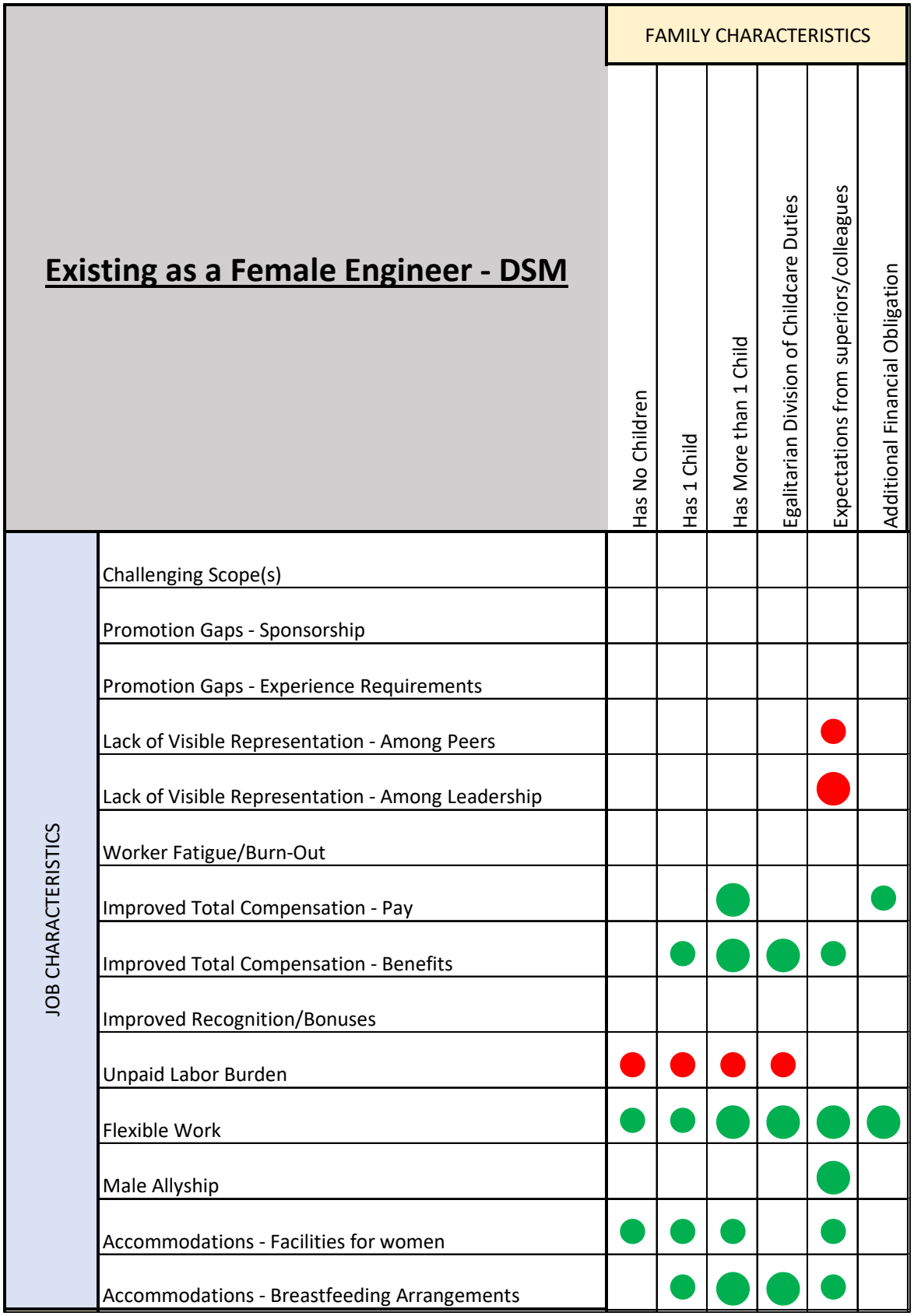

Figure 55. DSM Subsection showing impact of Job Characteristics elements on Family Characteristics elements

Existing as a Female Engineer - DSM		PARTNER CHARACTERISTICS						
		Married	Single/Never-Married	Divorced	Spouse in same field	Egalitarian Division of Household Labor	Spouse working significant overtime	Stigma from colleagues
JOB CHARACTERISTICS	Challenging Scope(s)							
	Promotion Gaps - Sponsorship							
	Promotion Gaps - Experience Requirements							
	Lack of Visible Representation - Among Peers							
	Lack of Visible Representation - Among Leadership							
	Worker Fatigue/Burn-Out			●				
	Improved Total Compensation - Pay					●	●	
	Improved Total Compensation - Benefits	●	●	●		●	●	
	Improved Recognition/Bonuses							
	Unpaid Labor Burden	●	●	●		●		
	Flexible Work	●			●	●	●	●
	Male Allyship							●
	Accommodations - Facilities for women							
	Accommodations - Breastfeeding Arrangements							●

Figure 56. DSM Subsection showing impact of Job Characteristics elements on Partner Characteristics elements

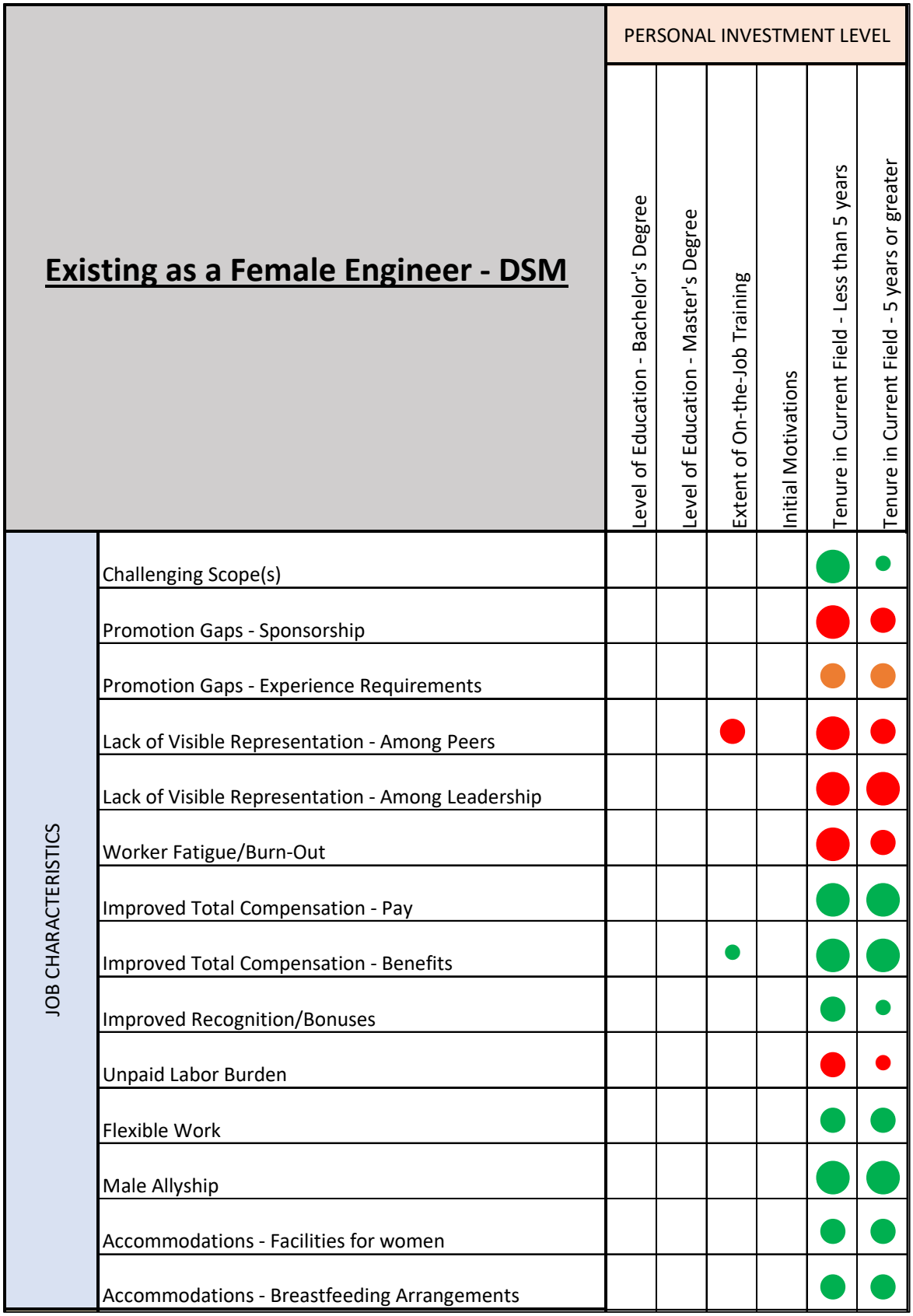

Figure 57. DSM Subsection showing impact of Job Characteristics elements on Personal Investment Level elements

Existing as a Female Engineer - DSM		INTERSECTIONAL ATTRIBUTES					
		Personality - Adherence to Gender Norms	Personality - Stubbornness (specified for DSM)	Race (being non-white for case of this DSM)	Age	Sexual Orientation	Disability
JOB CHARACTERISTICS	Challenging Scope(s)						
	Promotion Gaps - Sponsorship						
	Promotion Gaps - Experience Requirements						
	Lack of Visible Representation - Among Peers						
	Lack of Visible Representation - Among Leadership						
	Worker Fatigue/Burn-Out						
	Improved Total Compensation - Pay						
	Improved Total Compensation - Benefits						
	Improved Recognition/Bonuses						
	Unpaid Labor Burden						
	Flexible Work						
	Male Allyship						
	Accommodations - Facilities for women						
	Accommodations - Breastfeeding Arrangements						

Figure 58. DSM Subsection showing impact of Job Characteristics elements on Intersectional Attribute elements

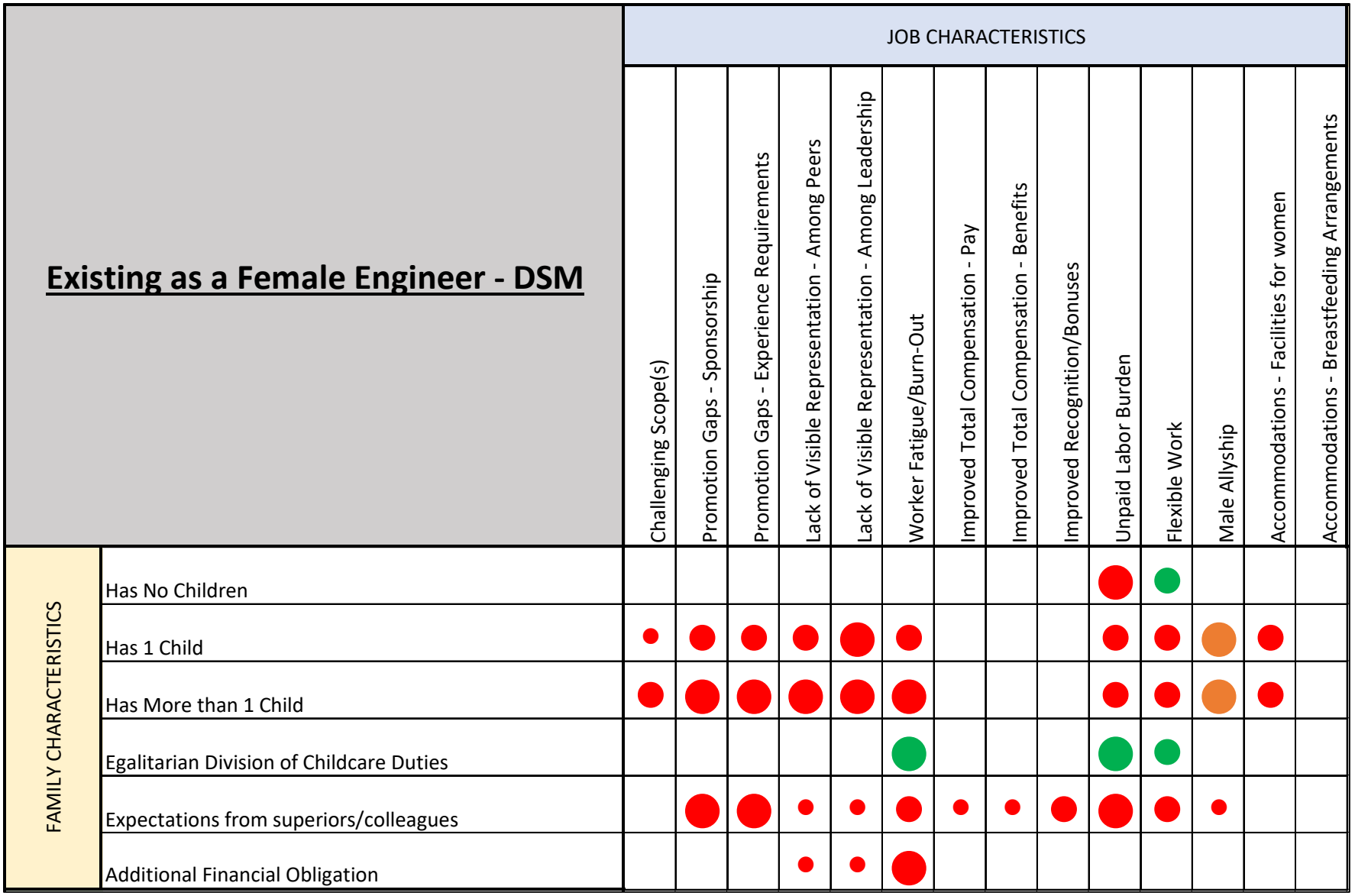

Figure 59. DSM Subsection showing impact of Family Characteristics elements on Job Characteristics elements

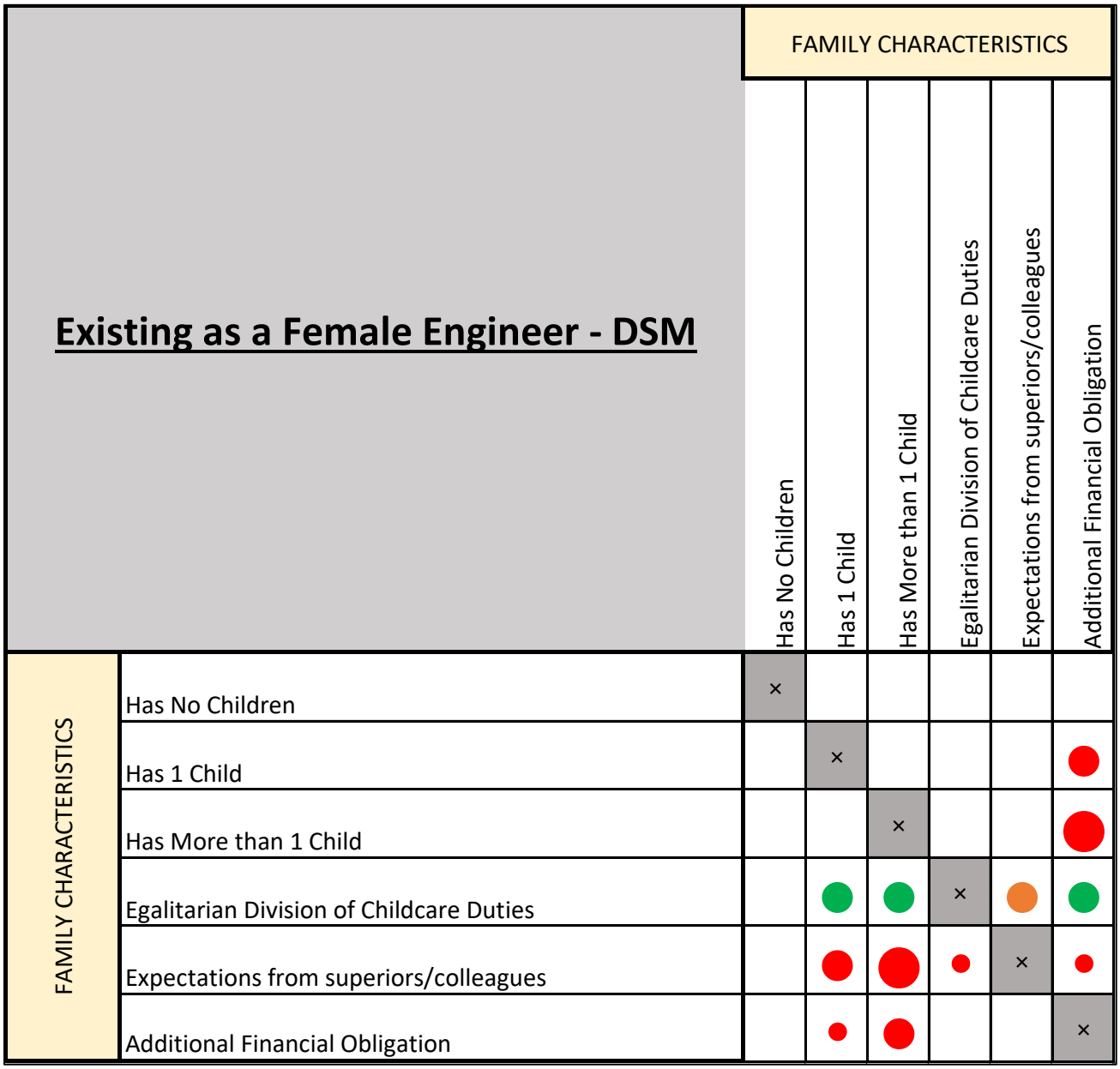

Figure 60. DSM Subsection showing impact of Family Characteristics elements on other Family Characteristics elements

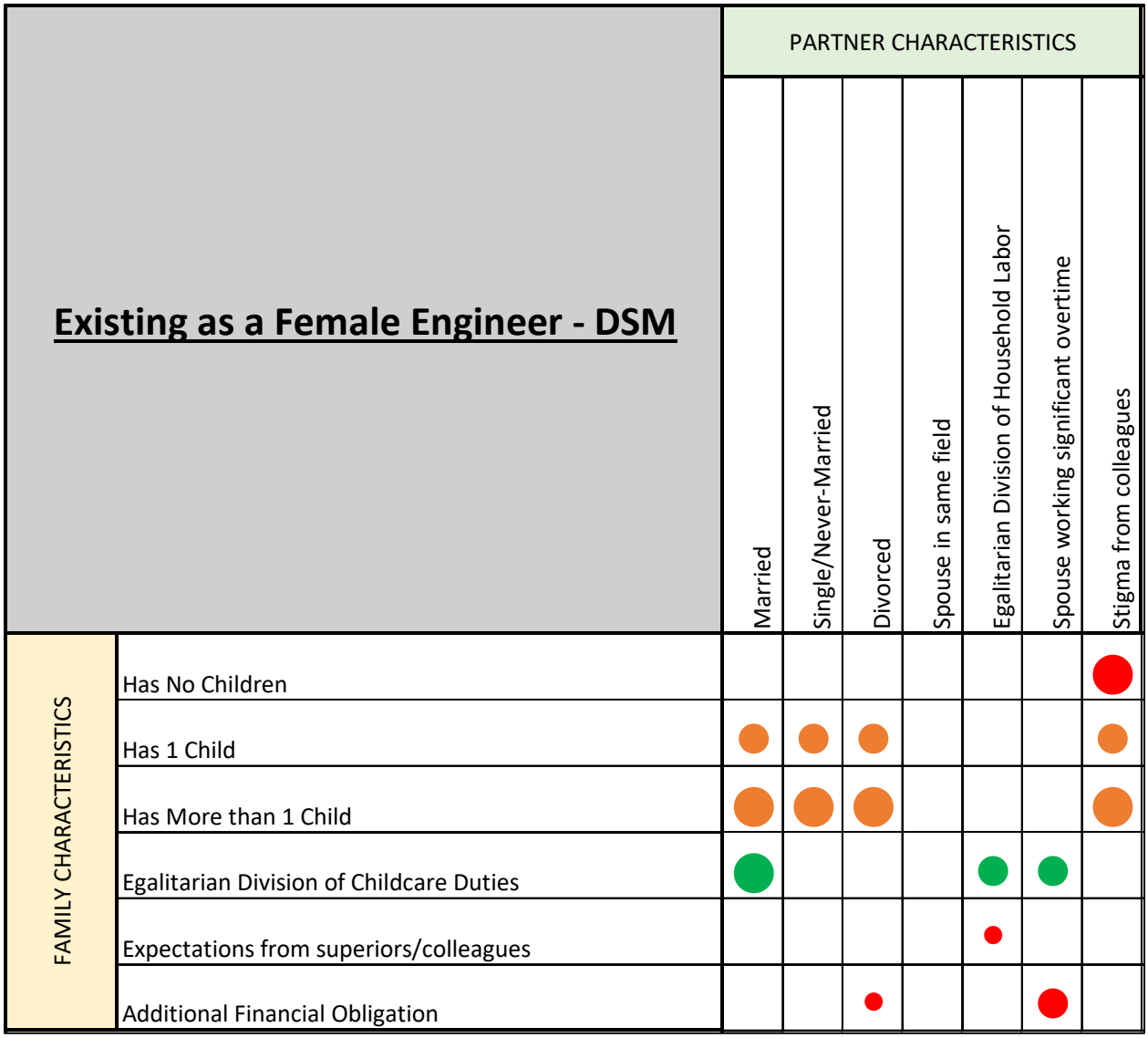

Figure 61. DSM Subsection showing impact of Family Characteristics elements on Partner Characteristics elements

Existing as a Female Engineer - DSM		PERSONAL INVESTMENT LEVEL					
		Level of Education - Bachelor's Degree	Level of Education - Master's Degree	Extent of On-the-Job Training	Initial Motivations	Tenure in Current Field - Less than 5 years	Tenure in Current Field - 5 years or greater
FAMILY CHARACTERISTICS	Has No Children			●			
	Has 1 Child					●	●
	Has More than 1 Child					●	●
	Egalitarian Division of Childcare Duties					●	●
	Expectations from superiors/colleagues					●	●
	Additional Financial Obligation					●	●

Figure 62. DSM Subsection showing impact of Family Characteristics elements on Personal Investment Level elements

Existing as a Female Engineer - DSM		INTERSECTIONAL ATTRIBUTES					
		Personality - Adherence to Gender Norms	Personality - Stubbornness (specified for DSM)	Race (being non-white for case of this DSM)	Age	Sexual Orientation	Disability
FAMILY CHARACTERISTICS	Has No Children						
	Has 1 Child						
	Has More than 1 Child						
	Egalitarian Division of Childcare Duties						
	Expectations from superiors/colleagues						
	Additional Financial Obligation						

Figure 63. DSM Subsection showing impact of Family Characteristics elements on Intersectional Attributes elements

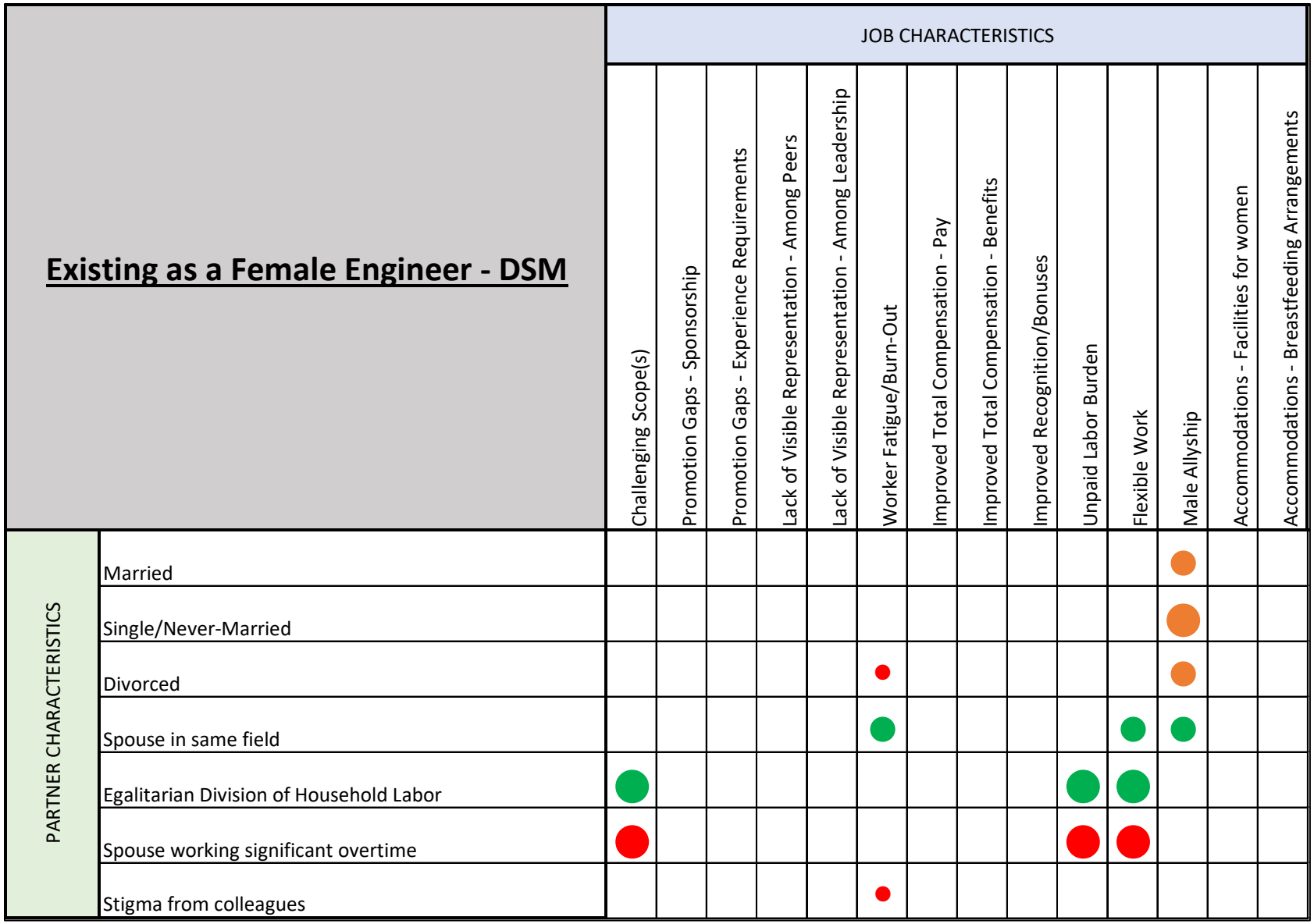

Figure 64. DSM Subsection showing impact of Partner Characteristics elements on Job Characteristics elements

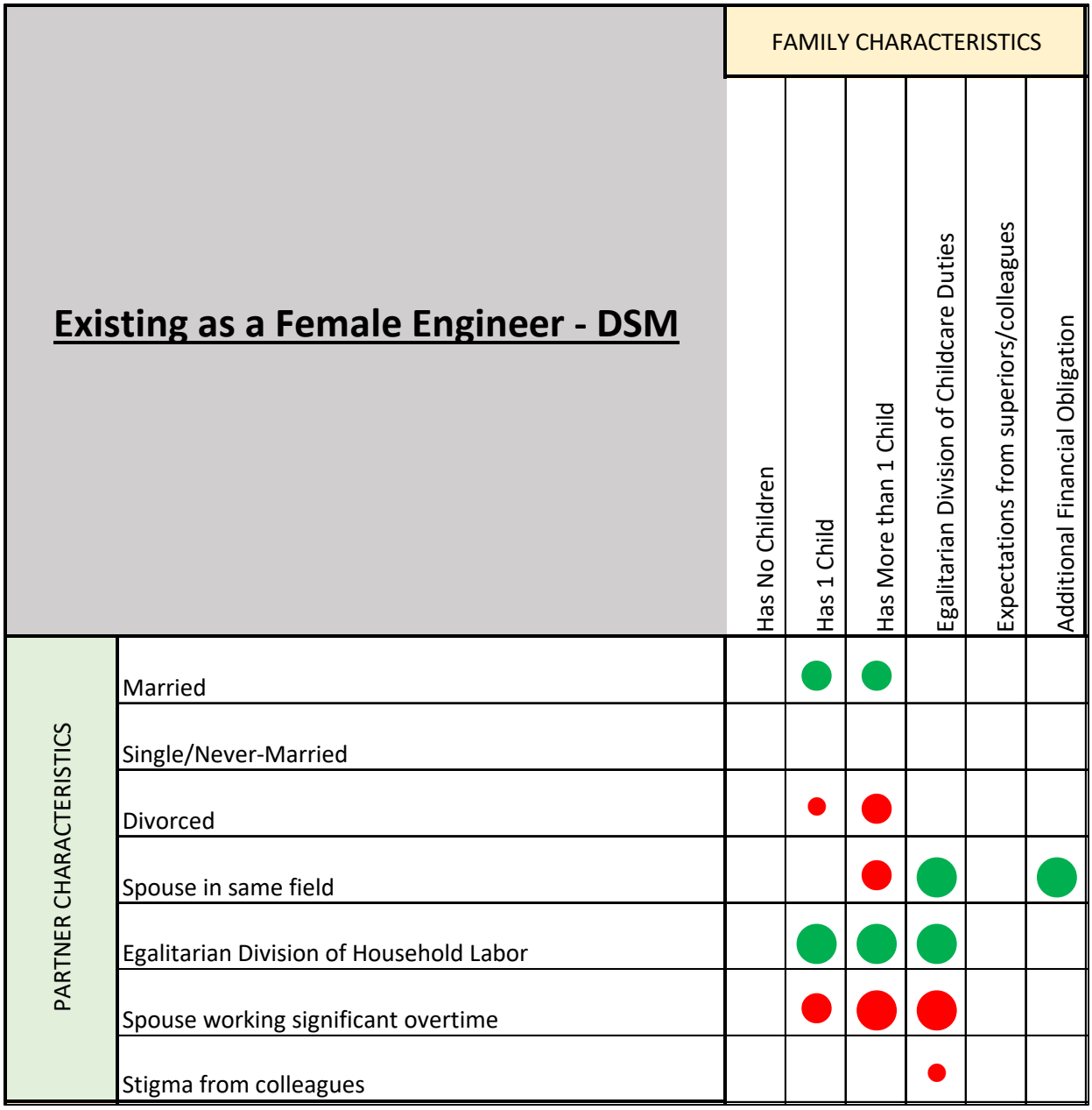

Figure 65. DSM Subsection showing impact of Partner Characteristics elements on Family Characteristics elements

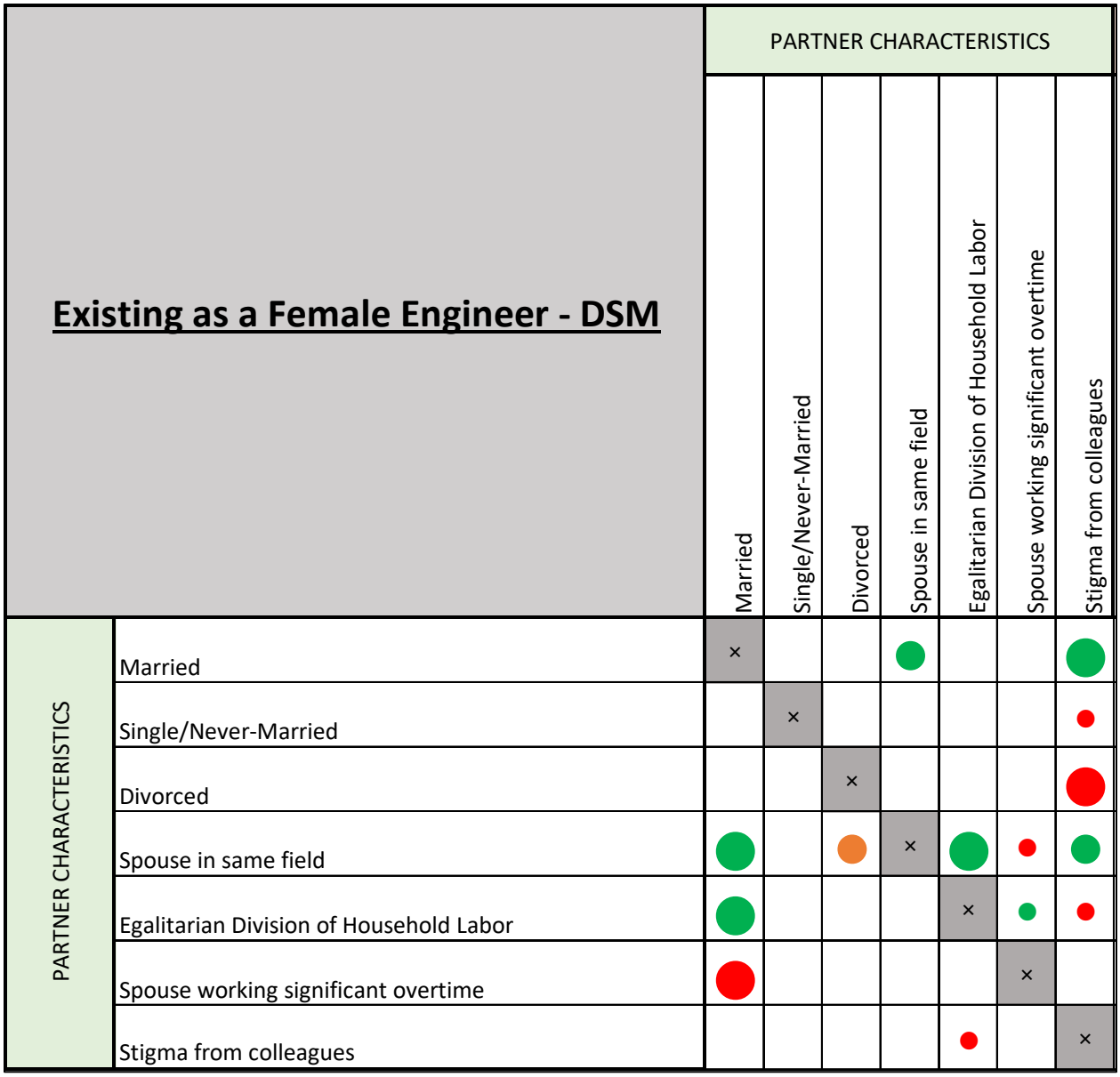

Figure 66. DSM Subsection showing impact of Partner Characteristics elements on other Partner Characteristics elements

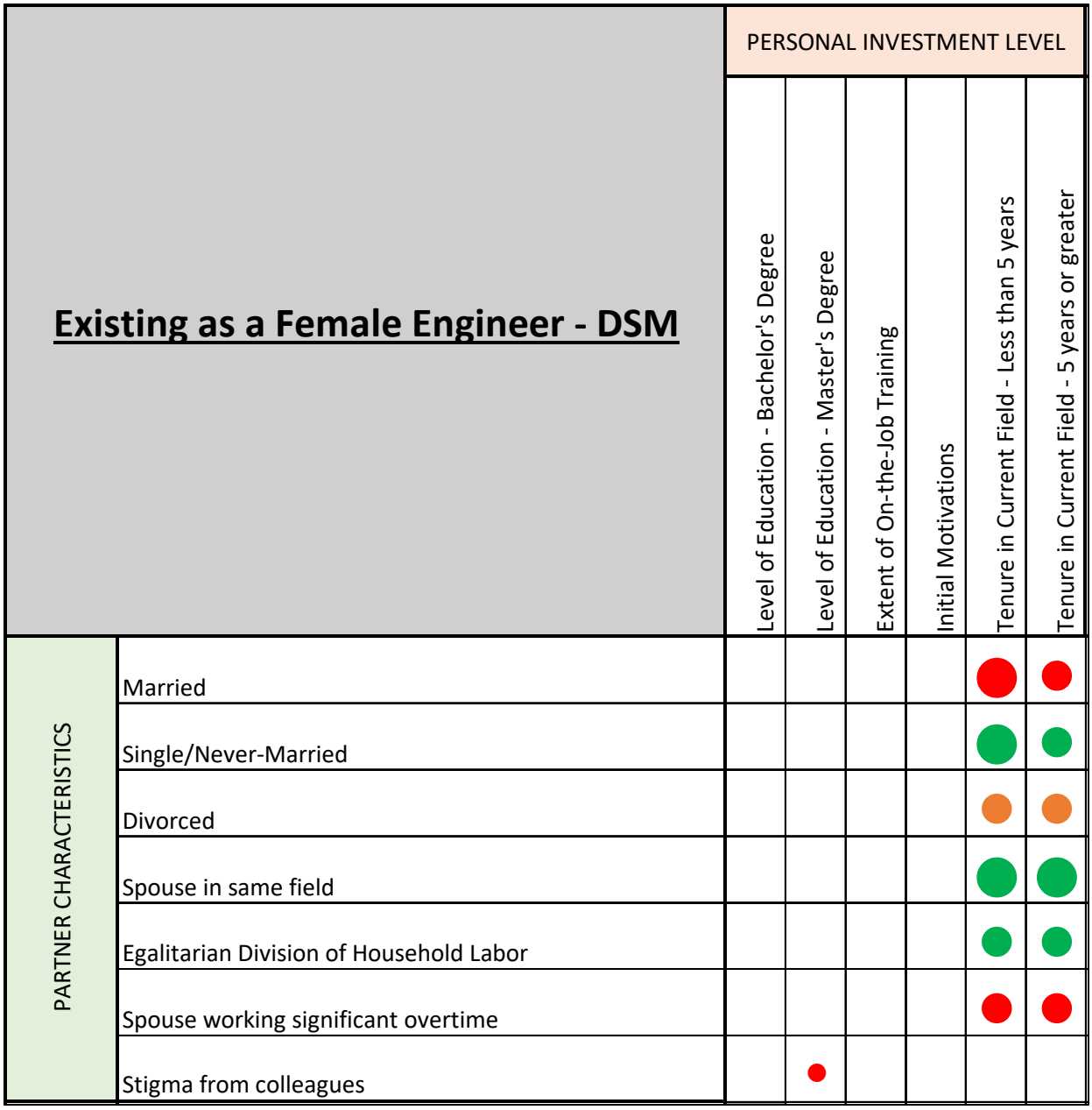

Figure 67. DSM Subsection showing impact of Partner Characteristics elements on Personal Investment Level elements

Existing as a Female Engineer - DSM		INTERSECTIONAL ATTRIBUTES					
		Personality - Adherence to Gender Norms	Personality - Stubbornness (specified for DSM)	Race (being non-white for case of this DSM)	Age	Sexual Orientation	Disability
PARTNER CHARACTERISTICS	Married						
	Single/Never-Married						
	Divorced						
	Spouse in same field						
	Egalitarian Division of Household Labor						
	Spouse working significant overtime						
	Stigma from colleagues						

Figure 68. DSM Subsection showing impact of Partner Characteristics elements on Intersectional Attributes elements

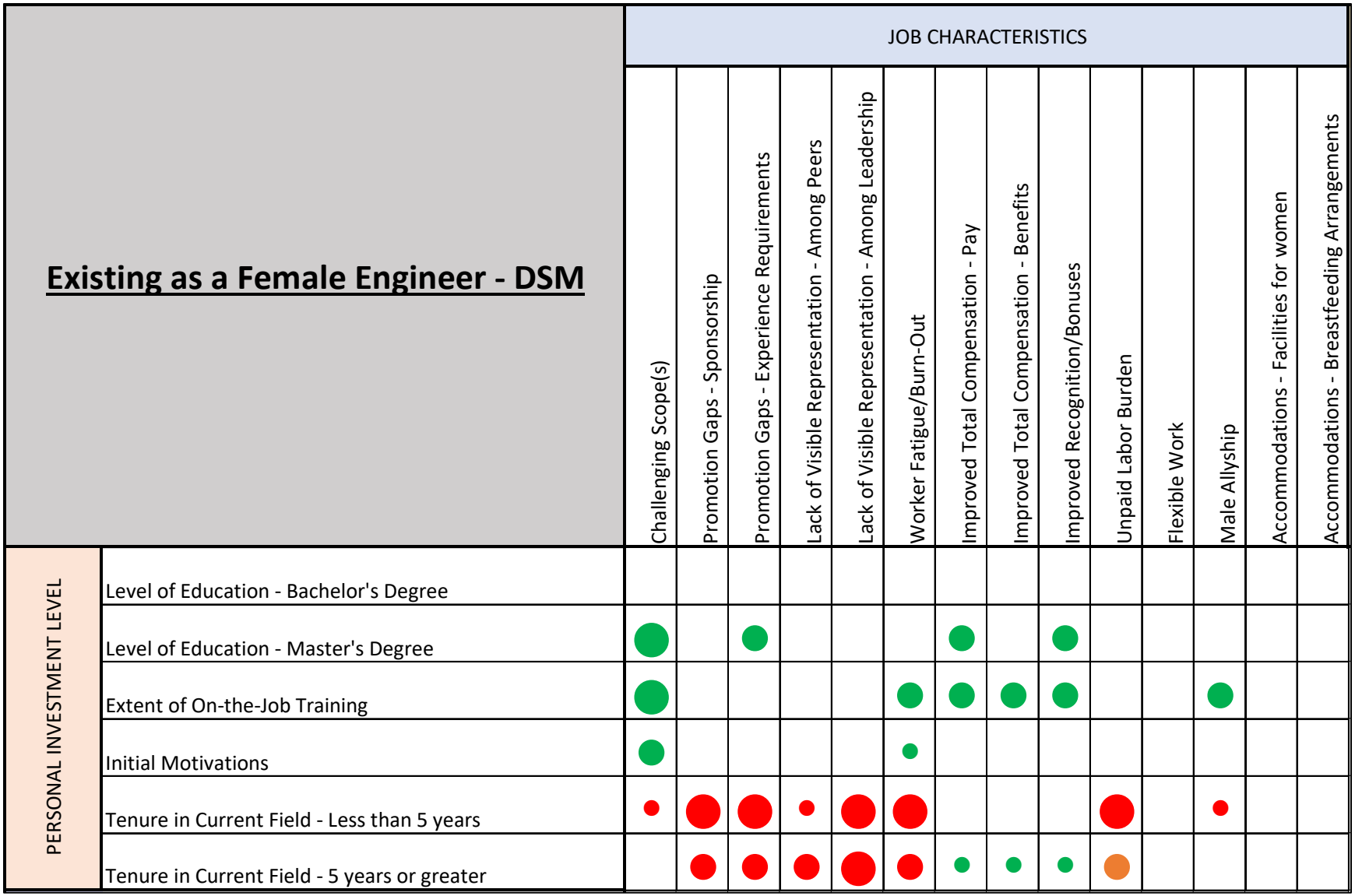

Figure 69. DSM Subsection showing impact of Personal Investment Level elements on Job Characteristics elements

Existing as a Female Engineer - DSM		FAMILY CHARACTERISTICS					
		Has No Children	Has 1 Child	Has More than 1 Child	Egalitarian Division of Childcare Duties	Expectations from superiors/colleagues	Additional Financial Obligation
PERSONAL INVESTMENT LEVEL	Level of Education - Bachelor's Degree						
	Level of Education - Master's Degree						
	Extent of On-the-Job Training						
	Initial Motivations						
	Tenure in Current Field - Less than 5 years						
	Tenure in Current Field - 5 years or greater						

Figure 70. DSM Subsection showing impact of Personal Investment Level elements on Family Characteristics elements

Existing as a Female Engineer - DSM		PARTNER CHARACTERISTICS						
		Married	Single/Never-Married	Divorced	Spouse in same field	Egalitarian Division of Household Labor	Spouse working significant overtime	Stigma from colleagues
PERSONAL INVESTMENT LEVEL	Level of Education - Bachelor's Degree							
	Level of Education - Master's Degree							●
	Extent of On-the-Job Training							
	Initial Motivations							
	Tenure in Current Field - Less than 5 years					●		
	Tenure in Current Field - 5 years or greater	●						

Figure 71. DSM Subsection showing impact of Personal Investment Level elements on Partner Characteristics elements

Existing as a Female Engineer - DSM		PERSONAL INVESTMENT LEVEL					
		Level of Education - Bachelor's Degree	Level of Education - Master's Degree	Extent of On-the-Job Training	Initial Motivations	Tenure in Current Field - Less than 5 years	Tenure in Current Field - 5 years or greater
PERSONAL INVESTMENT LEVEL	Level of Education - Bachelor's Degree	×					
	Level of Education - Master's Degree		×				
	Extent of On-the-Job Training			×			
	Initial Motivations				×		
	Tenure in Current Field - Less than 5 years					×	
	Tenure in Current Field - 5 years or greater						×

Figure 72. DSM Subsection showing impact of Personal Investment Level elements on other Personal Investment Level elements

Existing as a Female Engineer - DSM		INTERSECTIONAL ATTRIBUTES					
		Personality - Adherence to Gender Norms	Personality - Stubbornness (specified for DSM)	Race (being non-white for case of this DSM)	Age	Sexual Orientation	Disability
PERSONAL INVESTMENT LEVEL	Level of Education - Bachelor's Degree						
	Level of Education - Master's Degree						
	Extent of On-the-Job Training		●				
	Initial Motivations	●	●				
	Tenure in Current Field - Less than 5 years						
	Tenure in Current Field - 5 years or greater						

Figure 73. DSM Subsection showing impact of Personal Investment Level elements on Intersectional Attributes elements

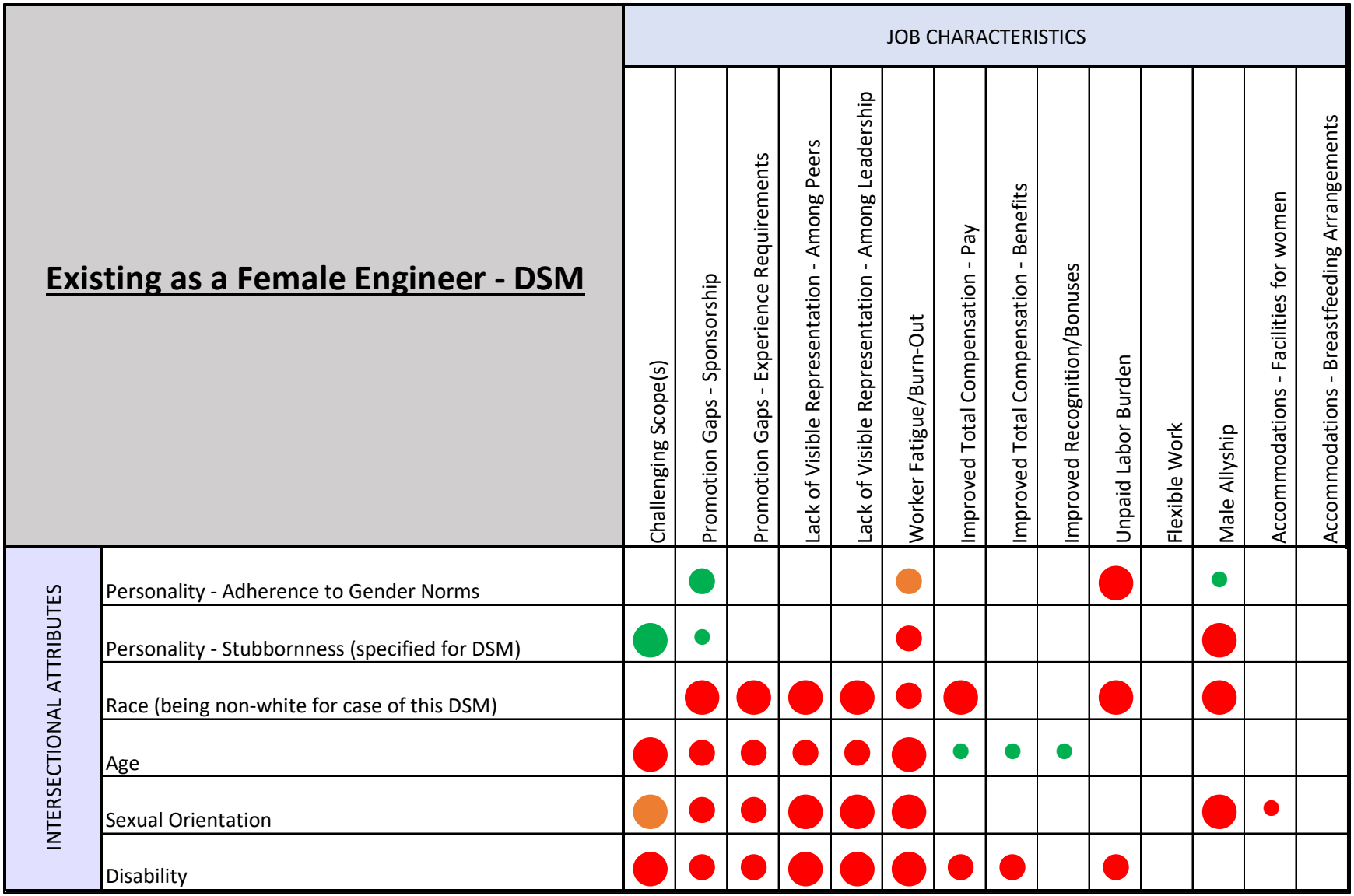

Figure 74. DSM Subsection showing impact of Intersectional Attributes elements on Job Characteristics elements

Existing as a Female Engineer - DSM		FAMILY CHARACTERISTICS					
		Has No Children	Has 1 Child	Has More than 1 Child	Egalitarian Division of Childcare Duties	Expectations from superiors/colleagues	Additional Financial Obligation
INTERSECTIONAL ATTRIBUTES	Personality - Adherence to Gender Norms		●	●	●		
	Personality - Stubbornness (specified for DSM)				●		
	Race (being non-white for case of this DSM)				●		●
	Age						●
	Sexual Orientation		●	●			●
	Disability						●

Figure 75. DSM Subsection showing impact of Intersectional Attributes elements on Family Characteristics elements

Existing as a Female Engineer - DSM		PARTNER CHARACTERISTICS						
		Married	Single/Never-Married	Divorced	Spouse in same field	Egalitarian Division of Household Labor	Spouse working significant overtime	Stigma from colleagues
INTERSECTIONAL ATTRIBUTES	Personality - Adherence to Gender Norms							
	Personality - Stubbornness (specified for DSM)							
	Race (being non-white for case of this DSM)							
	Age							
	Sexual Orientation							
	Disability							

Figure 76. DSM Subsection showing impact of Intersectional Attributes elements on Partner Characteristics elements

Existing as a Female Engineer - DSM		PERSONAL INVESTMENT LEVEL					
		Level of Education - Bachelor's Degree	Level of Education - Master's Degree	Extent of On-the-Job Training	Initial Motivations	Tenure in Current Field - Less than 5 years	Tenure in Current Field - 5 years or greater
INTERSECTIONAL ATTRIBUTES	Personality - Adherence to Gender Norms						
	Personality - Stubbornness (specified for DSM)						
	Race (being non-white for case of this DSM)						
	Age						
	Sexual Orientation						
	Disability						

Figure 77. DSM Subsection showing impact of Intersectional Attributes elements on Personal Investment Level elements

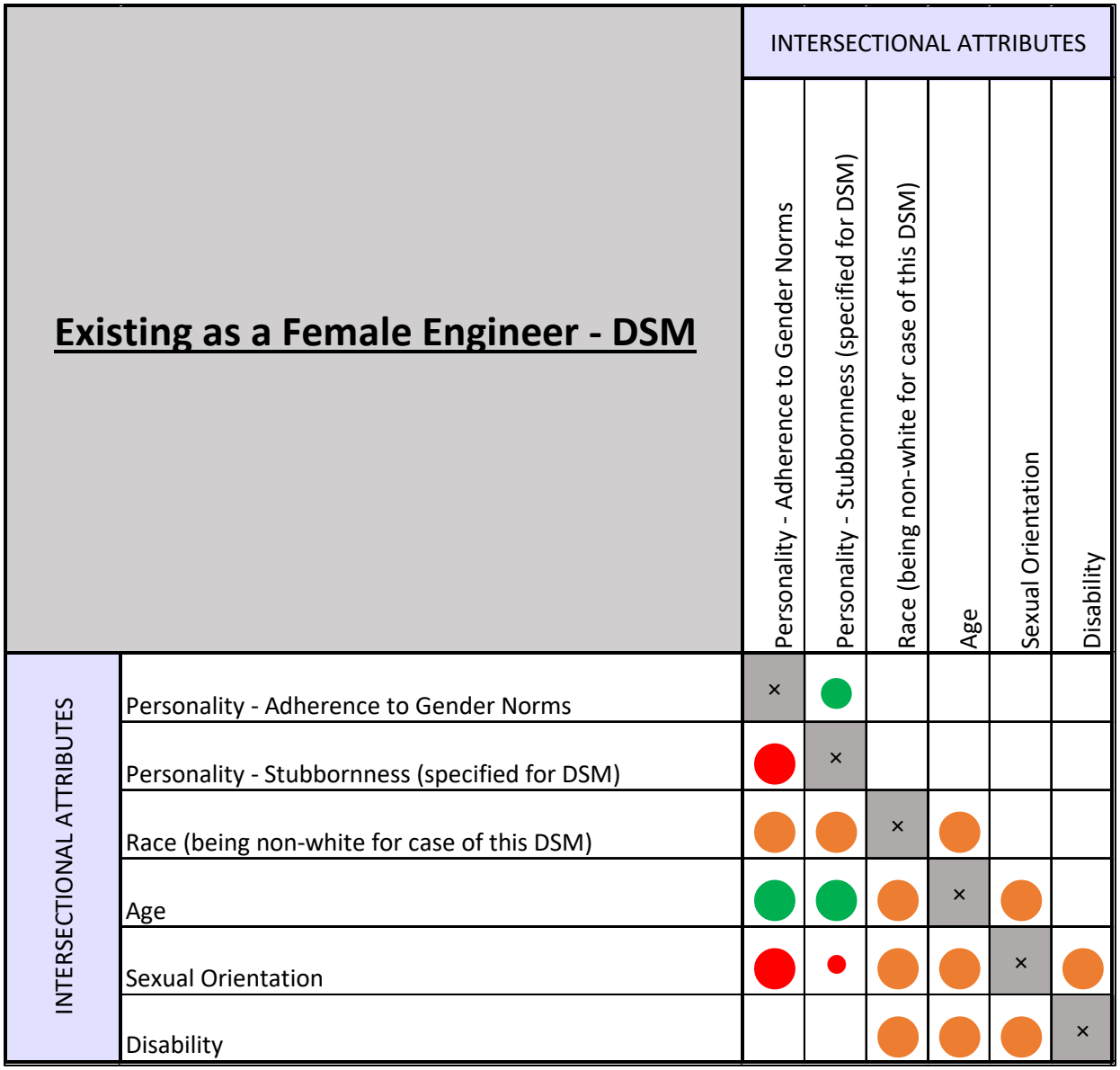

Figure 78. DSM Subsection showing impact of Intersectional Attributes elements on other Intersectional Attributes elements

APPENDIX C: Additional Resources

The below resources are recommended for anyone looking to learn more about the topics discussed in this thesis as well as for those looking to influence change in their organizations.

- Society of Women Engineers (SWE): https://swe.org/
  "The Society of Women Engineers is the world's largest advocate and catalyst for change for women in engineering and technology" [38]

- International Council on Systems Engineering (INCOSE) has a subgroup called Empowering Women Leaders in System Engineering (EWLSE) and they hold a repository of significant information on women in the workplace: https://www.incose.org/incose-member-resources/ewlse/resources [39], [40]

Figure 79. Screenshot of INCOSE EWLSE resource page [40]

- Catalyst Organization: https://www.catalyst.org/

  Focused on building “workplaces that work for women” [37]. Snapshot of the “About Us” page Is shown in Figure 80 [41].

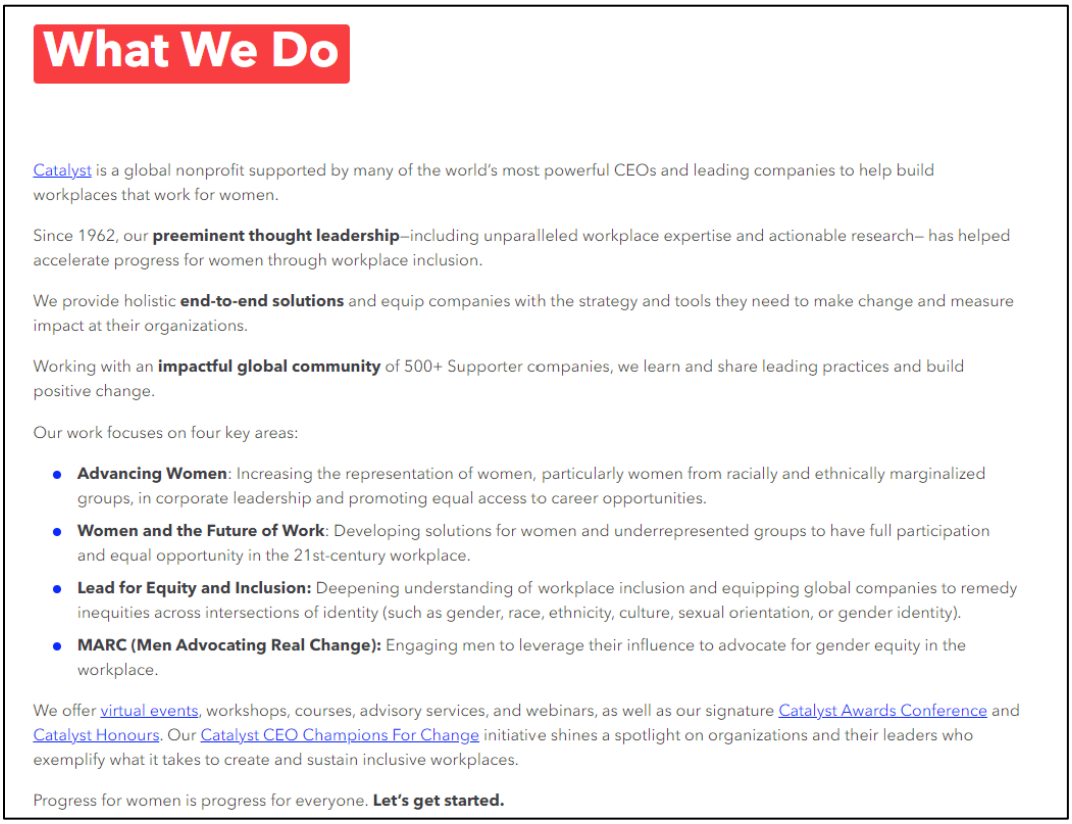

Figure 80. "About Us" Page from Catalyst website [41]

- The Organisation for Economic Co-operation and Development (OECD) “s an international organisation that works to build better policies for **better lives**. Our goal is to shape policies that foster prosperity, equality, opportunity and well-being for all” [42]. The OECD has a Development center targeting key themes of growth and one of those themes is gender. Resources linked to this work can be found here: https://www.oecd.org/development/gender-development/ [16]

- The Institute of Electrical and Electronics Engineers (IEEE) has a USE chapter with a book offering entitled “Women in Engineering” comprised of “24 individual narratives, written by successful women engineers and technologists”: https://ieeeusa.org/product/women-in-engineering-complete-collection-books-1-24/ [43]

- The International Federation of Engineering Education Societies (IFEES) in partnership with the Global Engineering Deans Council has a series entitled “Rising to the Top” where female leaders in engineering throughout the world share their stories about the journey to success in their organizations (Figure 81) [44].

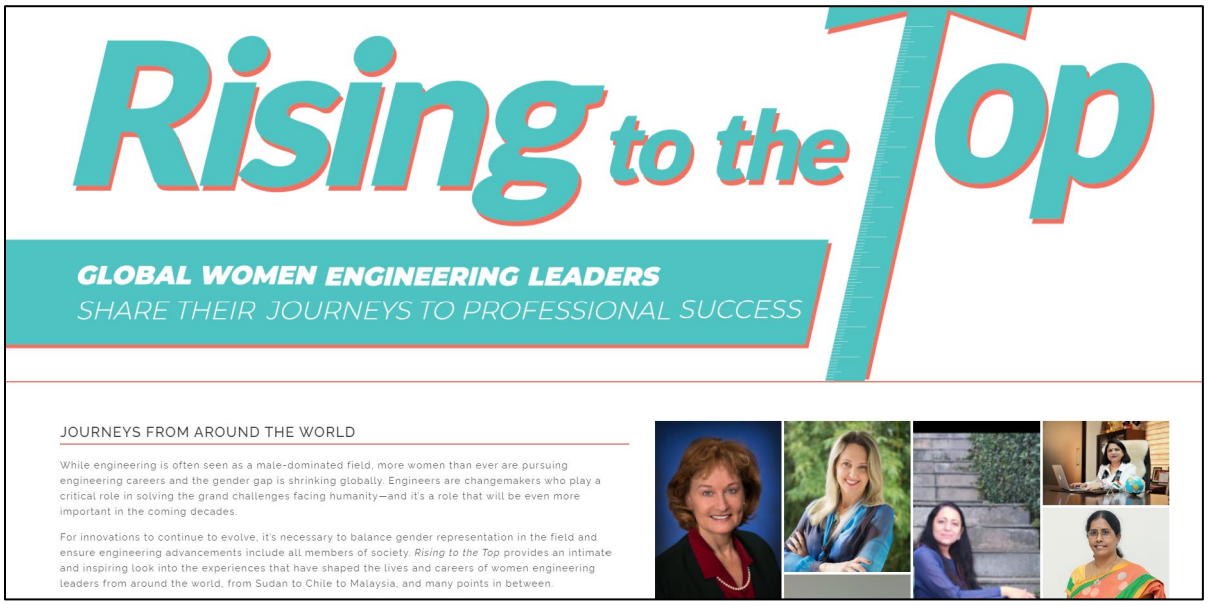

Figure 81. Screenshot of the "Rising to the Top" Series [44]