Career Goals and Decisions:

An Intersectionality Approach

by

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Abstract

This project explores the career paths to date of seven graduates of the University of Waterloo's Mechanical Engineering program, and examines the influences that led them to choose their university program. I particularly considered the participants' status as members of underrepresented or overrepresented groups, using the contexts of the history of the profession of Mechanical Engineering and prior research on underrepresentation in Science, Technology, Engineering, and Mathematics fields. I used semi-structured interviews and an intersectionality framework to investigate aspects of identity, interests, and career influences. I found three key themes among the participants: human influences, including information sources, role models, and mentors; influences of educational and outreach activities; and personal interests and aptitudes. I use the uncovered themes to recommend a combination of future studies and outreach programs.

Acknowledgments

This thesis would not have been possible without the assistance of a number of people. Dr. Jamie Magnusson, my supervisor, has provided guidance and support throughout the development and implementation of this project. Her influence has been instrumental in my intellectual development over the past few years and her guidance on this thesis has led it to the piece of work it has become. Dr. Dorothy Goldin Rosenberg's suggestions and insights have been both fascinating and invaluable. I would also like to thank my participants for their time and their thoughts, as this could not have been possible without them. Michelle Goldberg, Joanne Bacon, and Krystyna Wykurz have all provided administrative assistance without which this thesis would not exist. Last but not least, the support of my spouse Chris, the patience of my children, and the confidence of my family made it possible for me to keep pushing through and get this done.

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1 Introduction and Theoretical Framework

1.1 Thesis statement and Broader Context

The decision processes and influences that bring students to Engineering as a preferable or feasible career are highly varied, and I argue in this thesis that although some themes are common regardless of personal history, others are unique to students from either overrepresented or underrepresented groups, and I use the common themes to argue in favour of expanded outreach programs, particularly to underrepresented groups. North American society has long represented itself as providing a 'land of opportunity' – a place where anyone may prosper. Stripping away the rhetoric reveals a more complex situation in which equal treatment and equitable treatment are often confused, which when combined with longstanding systemic oppressions results in significant effects of underrepresentation along lines of race, gender, and socioeconomic status. The outlooks and experiences of those who have chosen to pursue paths in which they'll be underrepresented are an important element in creating a broader understanding of how the present systems work and what can be done to encourage a more equitable and diverse division of labour throughout our society.

Necessary background for understanding the issue includes a survey of the importance of underrepresentation issues (Chapter 1.3), an introduction to Intersectionality Theory (Chapter 1.4), a review of the current extent of demographic underrepresentation (Chapter 1.5), and placement of underrepresentation into the historical context of Engineering (Chapter 1.6), followed by an assessment of the issue from an intersectionality perspective and an overview of past research into underrepresentation (Chapter 1.7). The interviews taken for this study use the idea of underrepresentation, the historical context, and intersectionality to frame the experiences of the participants into common and uncommon themes influencing past and present educational and career goals and decisions.

In this thesis, I explore a gap in the existing bodies of research through personal interviews into how themes of identity and lived experience have shaped the historical and present career goals

and trajectories for several Mechanical Engineering graduates from underrepresented and overrepresented groups (Chapters 2 Methodology and 3 Results). Interview questions into experience are founded on an effort to understand whether some themes may be common across racial, class, and/or gender lines, and whether other themes are not shared, as viewed through personal experiences and reflections (Chapter 4 Discussion). The stories shared are used to generate recommendations for further research and for improvements to outreach activities (Chapter 5). In recognition of the effects of local variances in demographics and dominant subcultures, this thesis is primarily focused on effects in Southern Ontario, broadening the literature review to Canada or North America when localized research for context is not available or when local influences or impacts are expected to be shared with effects in the greater regions.

1.2 Why I am interested in taking up this issue

I entered the faculty of Engineering at the University of Waterloo knowing implicitly that as a woman I would be in a minority group, but mentally questioned why it should matter, why women are so underrepresented, and what was different about me specifically that would lead me to such a situation. Over time, I discovered that my childhood poverty and my parents' lack of university experience placed me into another minority, leading me to question why that should be so as well, and again wondered what made my path different from others 'like me'. Through my university career (as a student and as an employee through the co-op program), I began to notice gender effects both subtle and significant, from being told in an interview "it's about time we hired a female", to noticing the differences in locations of and amenities available in washrooms, to observing the gravitation of women away from 'traditional' types of jobs in Mechanical Engineering.

I was introduced to more formal study of issues of equity and social justice through my studies in Higher Education, which I initially took up to pursue my strong interest in financial accessibility and my curiosity into issues of gender-based underrepresentation. Through these studies I began to question racial underrepresentation in addition to my own experiences with gender- and class-consciousness, as well as how these themes may intertwine, intersect, and interlock for individuals, and focused my attention on the historical context and present effects of the underrepresentation in my own field of Mechanical Engineering.

1.3 The Importance of Issues of Underrepresentation

There are two common themes to arguments on why underrepresentation in Science, Technology, Engineering and Mathematics (collectively referred to as STEM) is problematic: the economic arguments (which have some variation in approach) and the social justice argument. The commonly publicized economic argument posits that:

- *Since* there is an increasing demand for skilled workers in science and technology fields, *and*
- *Since* the population of the 'traditional' demographic in those fields (white/male/middle-class) is not growing at the same pace as the job market,
- *Then* the new workers must come from traditionally underrepresented groups (people of racial or ethnic minority groups and women, each typically implied to be a homogenous group).

The logic of the popular economic argument assumes a situation in which employers and employees benefit alike, as skilled applicants will be employed in good and relevant jobs and employers can be more productive by utilizing more skilled workers.

A critical variation on the economic argument (often dismissed by the greater public as being unnecessarily cynical), postulates that employers may instead act on the following logic:

- *Since* there has been a contraction of new science and technology jobs due to the recession, *and*
- *Since* the threatened 'wave of retirements' of baby-boomers continues to not materialize, *and*
- *Since* the traditionally underrepresented groups of women and racial minorities have historically been paid less than white males (an effect influenced by many small multiplicative factors), *and*
- *Since* low starting salaries propagate through the career ladder to lower lifelong pay (including lower net increases at each step for the same percentage increase),

- *Then* employers can profit from a larger pool of applicants to entry level jobs who are willing to be paid less because they want any job relevant to their skills.

Under this logic, employers exploit desperate or deluded workers by quietly downgrading the economic rewards of in-demand jobs at the entry level. Consequently, people of privileged backgrounds opt out and choose higher status/higher rewarding fields, and those who are left to pursue the downgraded professions may either retain outdated perspectives on the social standing (and relative compensation) of the fields or remain in the fields because they need the job and can't afford the opportunity cost of changing fields.

The social justice argument rejects the importance of economic drivers, instead focusing on principles of equity. The equity perspective is less linear or direct than the economic arguments, rather relying on a series of interrelated observations and truisms:

- Active and passive barriers prevent people from developing basic interests, career paths, or high achievements in high-reward fields such as science and Engineering.
- A vicious circle is present in which a lack of role models or mentors results in a lack of applicants which results in a lack of role models or mentors.
- The greater expense to enter high-reward fields (including both immediate financial impact and opportunity cost) can be an actual or perceived barrier for students of limited means.
- Disproportionate representation in elite fields results in disproportionate representation in more proletarian fields, leading to cyclic reinforcements of limited choices for underprivileged and marginalized groups.
- Different groups may perceive different problems or solve common problems differently, resulting in better and more equitable solutions to challenges.
- Equity cannot be achieved when opportunities are forcibly limited.
- Equity is inherently good – by allowing all people to develop their skills to the best of their abilities, all of society benefits.

The equity argument is premised on the concept that fairness to the individual results in benefits to all of society, is less immediately concerned with the generation of wealth for the individual, and is not at all concerned with the generation of wealth for other entities. When the two distinctly different approaches vis-à-vis basic assumptions and priorities (i.e. the economic and social justice perspectives) result in the common conclusion that underrepresentation is problematic, it may be surmised that the goal of reducing underrepresentation in elite fields is imperative.

1.4 Intersectionality Theory

Intersectionality is one theoretical framework that is gaining in prominence for equity work, particularly for underrepresented groups in a wide variety of settings and situations. Intersectionality is a critical theory uniting feminist, anti-racist, Marxist, and other themes of social justice using the idea that groups of people are not homogenous under any label (such as 'women' or 'African-Americans' or 'the poor'[1]), and recognizes that any life theme includes some form of power relations (Brah & Phoenix, 2004). The theory suggests that different systems of oppression are interlocking and mutually constitutive (Grillo, 1995), and acknowledges that experiences are not consistent and stable over space, time and across contexts (Solorzano & Yosso, 2002; St.Denis, 2007). Furthermore, these themes will intersect differently and may be experienced in different forms depending on salience and individual histories. The theory of intersectionality does not suggest that multiple additive labels is a solution, nor does it advocate that divisions into smaller pigeonholes can be the answer to the failings of unidimensional activism (Bowleg, 2008); instead it criticizes the traditional forms of activism for historically attempting to speak for all members of a group by ignoring or silencing some voices in favour of addressing the needs of more privileged members of the group (Mohanty, 2003; St.Denis, 2007). Intersectionality theory addresses the imbalance in power relations by recognizing that within the shifting and interacting life themes, an individual may be

[1] While gender, race, and class are the most common themes of focus in much intersectional work (and are the ones I focus on in this thesis), the philosophy has also been applied to work that considers sexual orientation, dis/ability, urban/rural location, age, and any other label that may be applied to a group of people.

concurrently privileged and penalized, and may be simultaneously oppressor and oppressed (Collins, 1998; Davis, 1981).

Like other forms of critical theory, intersectionality is most easily understood as a philosophy or outlook. Its basic principles are easily applied as a lens when reading or otherwise consuming the work of others, whether in academic, mass-media, or more casual publications such as blogs. *Doing* intersectionality in primary research is more challenging, and the question of what intersectional methodology may be is one that has plagued researchers more expert than I (Christensen & Jensen, 2012; Hankivsky & Cormier, 2011; Jordan-Zachery, 2007). The focus of intersectionality as an interpretive rather than a creative framework is not unprecedented. Standpoint theory, considered to be a progenitor theory for intersectionality, is a form of analysis of research (particularly of science) that posits that a researcher's identity and background affect the questions asked and how they are answered (Haraway, 1991; Harding, 2004). The aspect of intersectionality most clearly originating in standpoint is the concept of lenses. Standpoint theory proposes that that one's perspectives on any issue or event are shaped by individual experiences and social locations, lenses through which one perceives the world (Harding, 1991). Some of these lenses would include race, gender, dis/ability, and social class.

The important evolution in intersectionality over standpoint is the recognition of the importance of the inextricability of life themes (Crenshaw, 1991). I grew up a poor white girl: I know I encountered barriers based on my gender, I know there are barriers I encountered that could have been (re-)moved by money or the cultural capital that comes from being raised in the middle- or upper-class, but I have no lived knowledge of the barriers I may have avoided simply by being born white and in Canada. Different barriers exist for single identities and for multiple identities – all women are minorities in most areas of STEM, and both men and women of many racial or ethnic minorities are underrepresented in most areas of STEM, but women of colour are often far more severely underrepresented and face both additional and different barriers than white women or men of colour in many STEM fields. Different aspects or experiences may be more or less prominent in various situations, but no theme can be removed or ignored entirely, and each theme may be experienced differently in different contexts.

The concept of intersectionality is used throughout this thesis to address existing research on underrepresentation of various groups in STEM fields and other elite professions, in developing

the questions for the interviews, and as a lens for understanding the responses. Intersectionality theory is a useful tool for understanding information both qualitative and quantitative, but it requires a story to interpret. Looking at why Mechanical Engineering in particular is a highly homogenous field requires review of several related themes. I propose a quantitative definition of underrepresentation in a current context. I then frame the definition and scope of underrepresentation in a current context by reviewing a brief history of the field of Mechanical Engineering, to understand how the profession has developed through such striking historical exclusions. I also provide an overview of some of the relevant literature on underrepresentation in STEM fields to show how this particular thesis addresses a gap in the existing bodies of research.

1.5 Underrepresentation in STEM Fields

Since the academy serves as a gateway for many STEM professions, the demographic breakdowns can be expected to lead industry by a few years, with industry diversifying at a slower rate than the student population due to the greater number of entrants to the professions than retirements or other exits from the workforce.

Using data from the U.S. Department of Education's National Center for Education Statistics[2] on post-secondary program, sex[3], and race (National Center for Education Statistics, 2011), I took a ratio of the number of students in a given demographic (such as Hispanic Males) in a program or field[4] to the total number of students in the same program to get the percentage of students in each program for each identified group (by sex and race). I then divided the resulting number by the overall share of the population of 18-24 year olds as defined in the U.S. Census (United States Census Bureau, 2000)to get a sense of the degree of representation for each demographic bloc in each program. Under this schema, a group may be overrepresented in a field but still be in the minority in that field – e.g. Asian men represent only 2% of the population at large, but 9%

[2] Canadian data including race was not readily available; it is expected that there may be some regional variation but that overall effects should be similar.

[3] I use the term sex instead of gender here to reflect the usage in the source.

[4] A field is defined here as a set of related programs, such as Engineering and Architecture

of the recipients of bachelor's degrees in Engineering, Architecture, and associated fields; thus they are more prevalent (overrepresented) in these fields than in the general population but still contribute less than one tenth of the Engineering workforce, so they continue to appear as a minority. Figure 1 and Figure 2 respectively show details of the degree of representation for men and women of particular racial categories for different fields. Representation in a field on par with representation in the overall population is shown by 100%, values over 100% show overrepresentation, and values under 100% show underrepresentation compared to the general population. I use this ratio because while it's relatively easy to see qualitatively that women are underrepresented in fields like Engineering[5], it is harder to qualitatively assess the presence (or lack thereof) of members of groups that are already in a minority in society.

[5] Though there is some research that shows that women are perceived to be the majority of the population in a setting where they comprise only a third of the members shown (or where they speak more than 30% of the time in a group), which exemplifies why a quantitative definition is necessary for this measure.

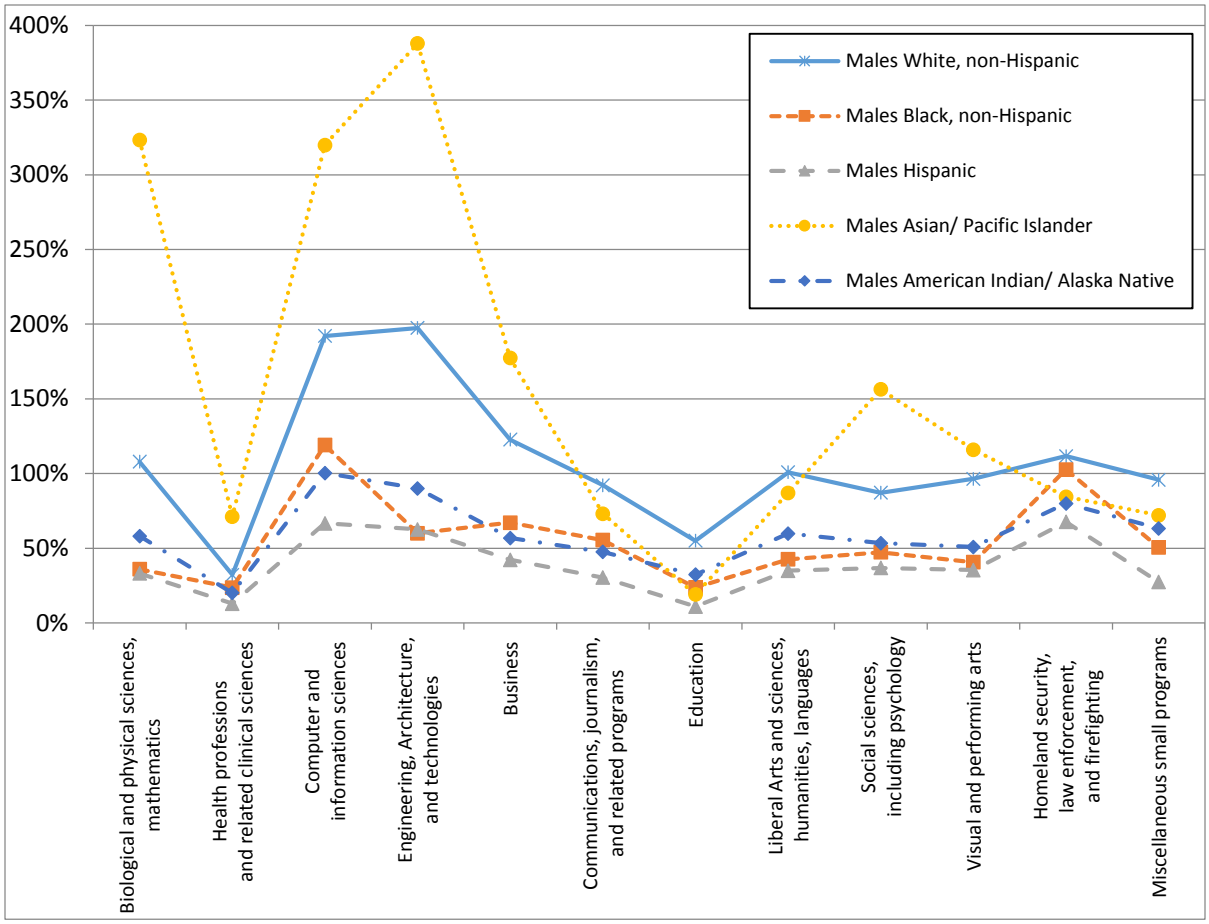

Figure 1: Representation of Men, by Race, in Postsecondary Education Programs

Figure 1 shows that white men, the perceived 'default' in North American society, tend to be represented in comparable proportions to their representation in the general public in most programs (including Liberal Arts, Social Sciences, Biological and Physical Sciences, Business, and Communications); they are somewhat underrepresented in Health Professions[6] and Education, but are overrepresented in Computer Science and Engineering. Asian men follow similar but more extreme enrollment patterns – where white men are overrepresented, Asian men are extremely overrepresented. In almost all cases where white men are underrepresented, Asian

[6] Dominated by Nursing and other Allied Health programs, as this chart shows only the Bachelors level of higher education

men are more extremely so. American Indian/Alaska Native[7] men follow similar trends and patterns to white men, but at significantly lower levels of representation in all fields than white men. The underrepresentation of black men is severe in all fields except Computer Science and Security/Law Enforcement/Firefighting, categories which show 'expected' levels of representation compared to the general population; they are not overrepresented in any field. Hispanic men experience severe underrepresentation in all fields, showing at best 60% representation in any category.

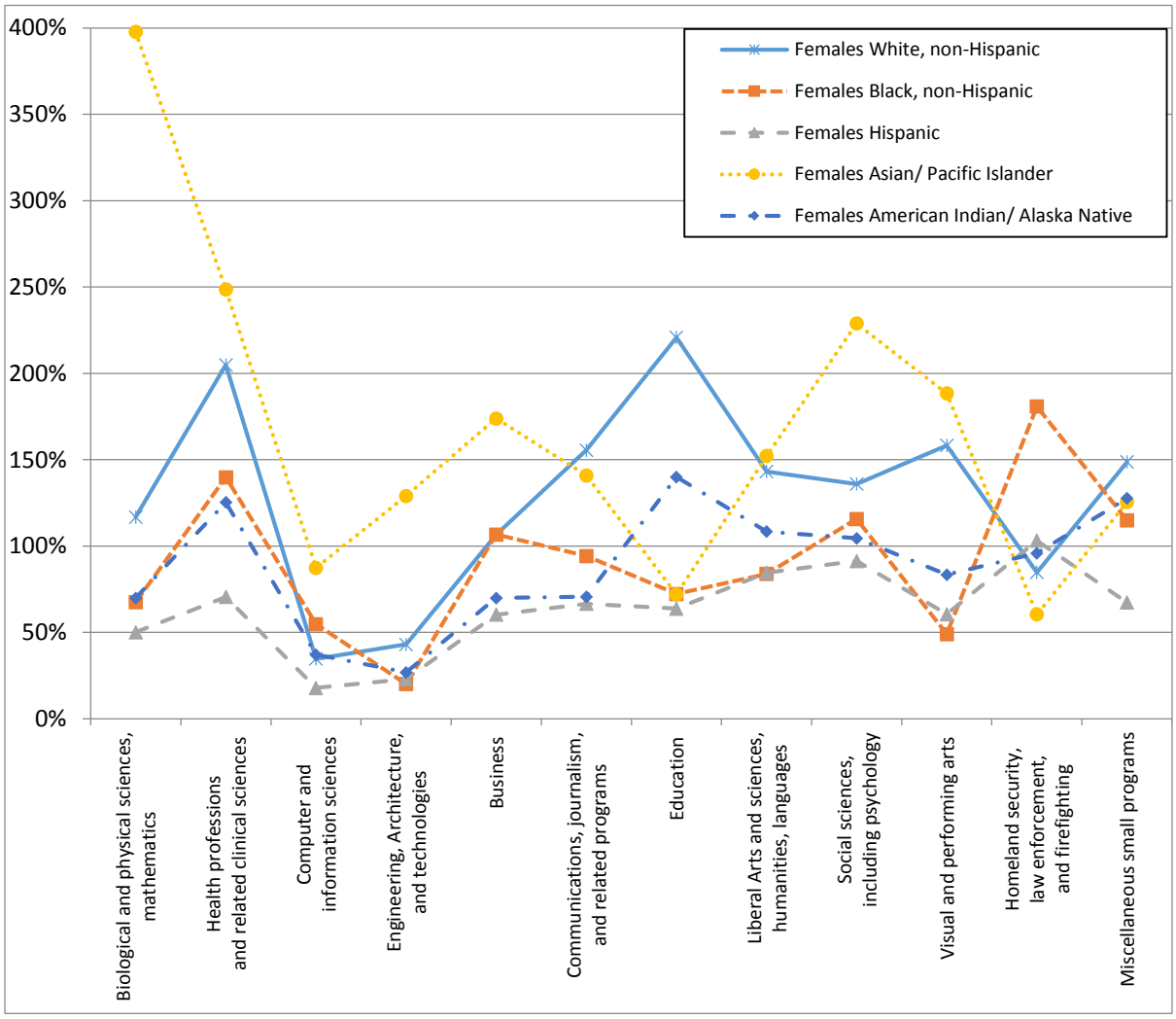

Figure 2: Representation of Women, by Race, in Postsecondary Education programs

[7] Terminology taken from NCES and Census

Figure 2 shows that racial trends for women are different than those for men. White women are significantly overrepresented in most fields, with the exceptions of Computer Science and Engineering. Asian women are overrepresented in all fields except Education and Security/Law Enforcement/Firefighting. Black women's university representation approaches parity with their population proportion in Business, Communications, and the Social Sciences; shows significant underrepresentation in most of the Sciences, Engineering and Visual Arts, and that they experience moderate overrepresentation in the health professions and security fields. Like Hispanic men, Hispanic women are underrepresented in all fields, massively so in most fields, approaching parity only in the Liberal Arts, Social Sciences, and Security-related fields. American Indian/Alaska Native women's representation levels trend similarly to those of white women, but as American Indian/Alaska Native men lag white men in all fields, American Indian/Alaska Native women lag behind white women in all fields except those where white women are also severely underrepresented.

The figures above describe racialized and gendered representation levels, but these require some historical context. Most fields in post-secondary education began as exclusively white male domains (Bix, 2004; Frehill, 2011). Beginning with the opening of women's colleges and (historically) black colleges (HBCs), women and racial minorities gained access to some fields (those deemed suitable for their social positions at the time). Over time, most previously segregated schools and programs were opened to all students[8]. Despite 'universal' access to all programs, different programs have seen different levels of uptake by women over the past few decades[9]. Figure 3 shows relative enrollment levels of women in selected Bachelor's level programs over time (National Center for Education Statistics, 2011). Some Bachelor's programs, including Health Professions and Education, have historically been and continue to show highest participation by women (Health Professions at the Bachelor's level are dominated by Nursing and allied health programs). Contrary to common expectations that result from

[8] Some US colleges remain completely or largely segregated either through official policy (some women's colleges, and a few men's colleges) or unofficial practice (combining recruiting, admissions, and hiring practices with demographics to result in a relatively racially homogeneous population) – these limited campuses do not affect the overall accessibility to any particular STEM program

[9] Historical enrollment details by race/ethnicity for different programs are only available back to 1995, so comparable charts for race are not shown.

grouping Mathematics in with Science, Technology, and Engineering (under the STEM umbrella), Mathematics and Statistics have traditionally maintained enrollments close to parity. Other programs have gone from low representation to approximately equal numbers, including Biological Sciences, Physical Sciences, and Business. Computer and Information Sciences have shown a remarkable trend, with women's enrollment peaking near 40% of degrees awarded in the early 1980s, and subsequently declining to less than 20% of enrollment. The 1980's figures are consistent with early opinions that women were better at computing tasks due to their attention to detail and dexterity (Light, 1999). The representation of women in Engineering has slowly risen from negligible levels in the early 1970s to nearly 20% in the late 1990s, but the trend has since stalled, with women's enrollment maintaining a level of approximately 15-20% of Engineering students.

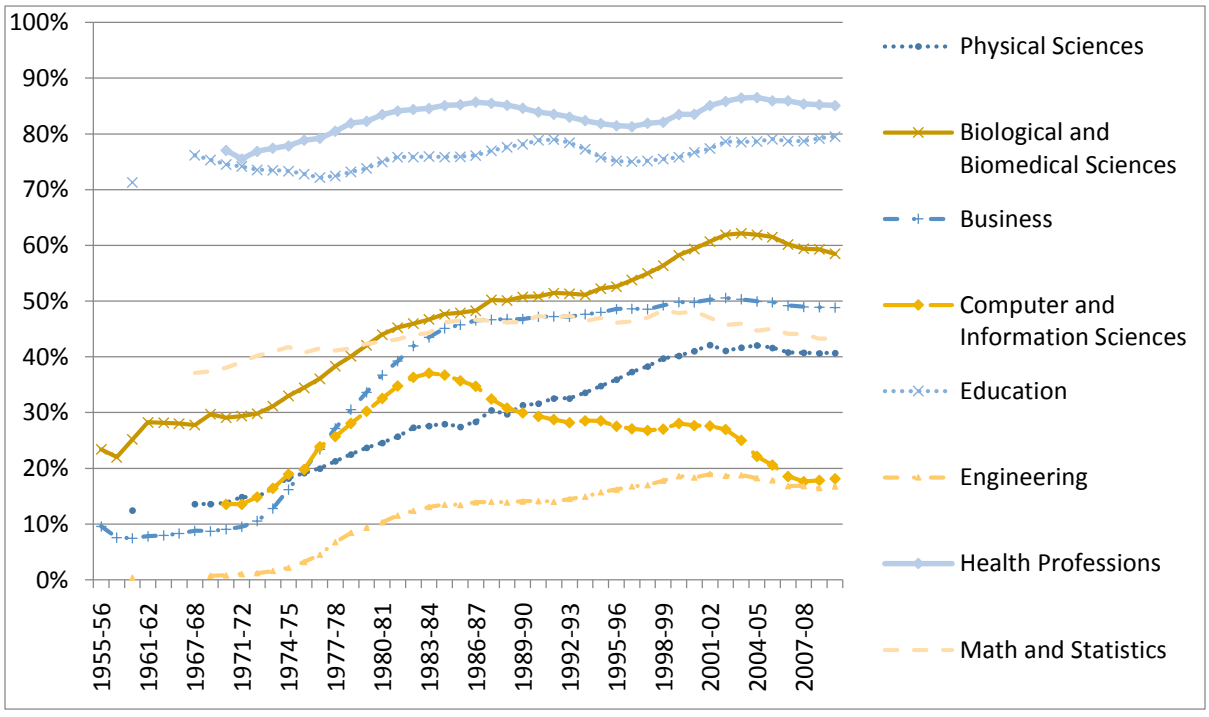

Figure 3: Percent of Enrollment Identified as Female, by Program, over Time

A third dimension to consider in representation issues, one inextricably intertwined with race and gender, is socioeconomic status. The data collected by NCES used in the analyses above does not include information on class, but since the SAT is widely used as a gateway or barrier to postsecondary education, especially at elite colleges, the demographics collected by the College Board (the creators/administrators of the SAT) may reasonably be used in conjunction with the

analyses on race and gender from the NCES data to elucidate a more comprehensive depiction of representation. Figure 4 shows that there is no recognizable correlation between SAT score and degree to which various racial groups are represented (as calculated for Figure 1 and Figure 2, above) in Bachelor's programs overall, and that inter-racial differences are more significant than differences between the sexes (data from National Center for Education Statistics, 2011; The College Board, 2011).

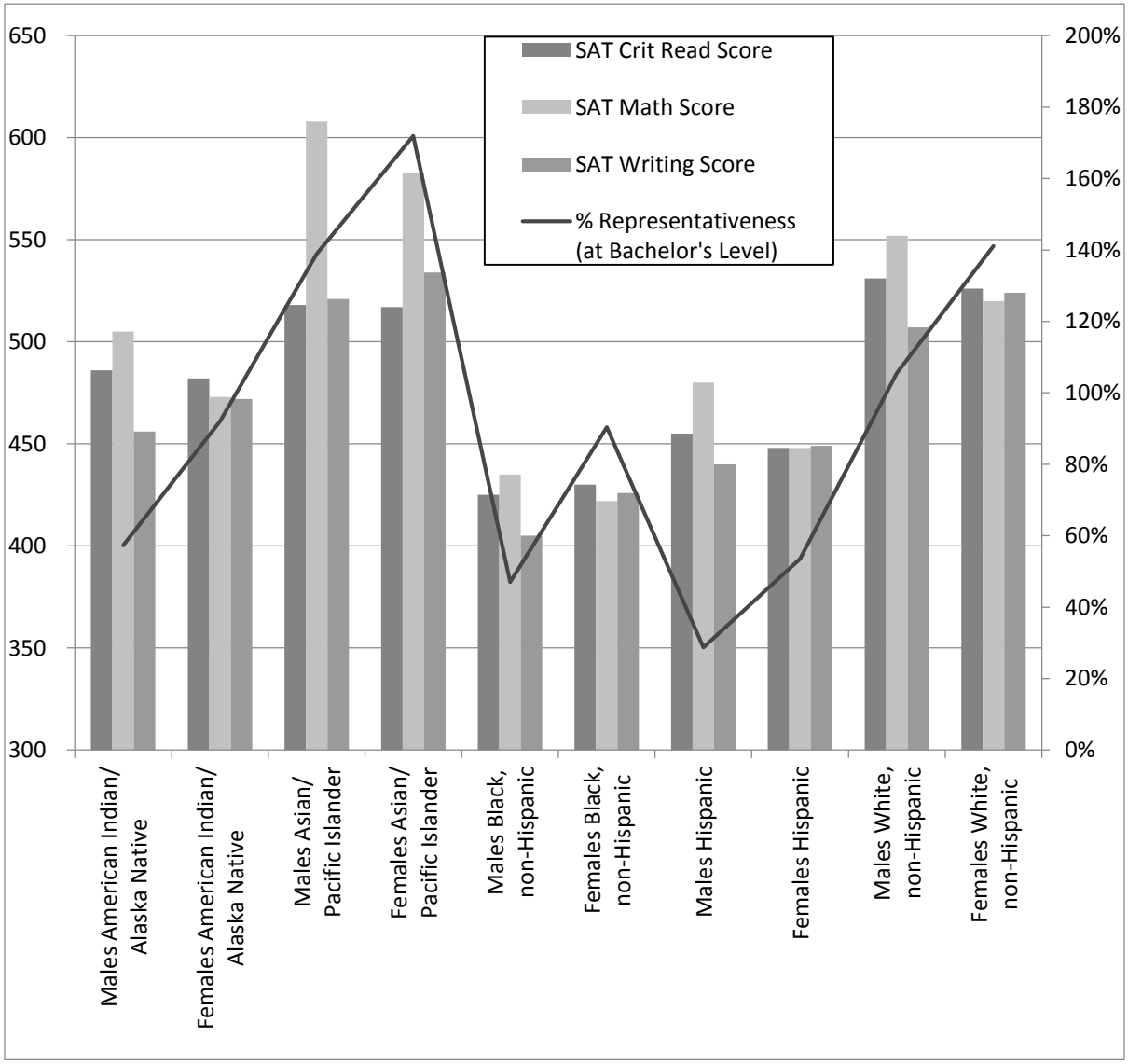

Figure 4: SAT Scores and Overall Representativeness in Bachelor's Programs

A comparison of Figure 4, above, with Figure 5 and Figure 6, below, shows that socioeconomic status (including both family income and parental education levels) appears to be a significant

factor in test results (data from The College Board, 2011). It is not feasible with the information publicly available to perform higher level analyses to attempt to disentangle the relative effects of race and class on an aggregate basis (recognizing that racial minorities are significantly overrepresented at lower ends of any socioeconomic scale), and it is recognized that the two themes are not possible to separate on an individual level either.

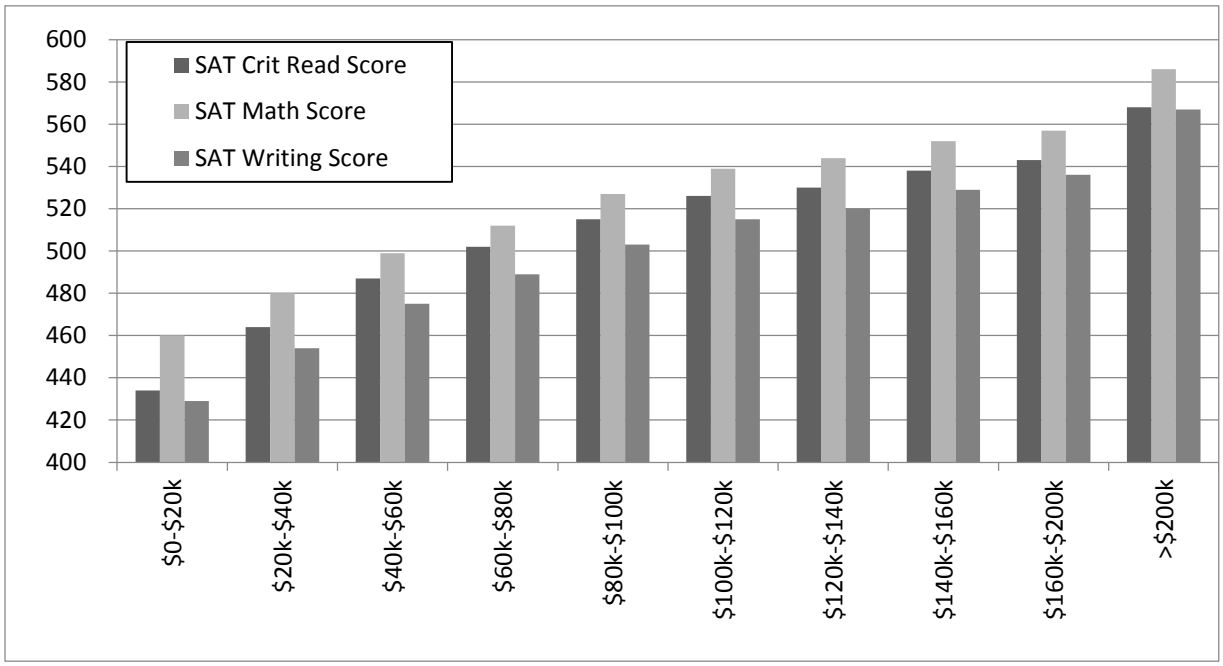

Figure 5: SAT Scores by Family Income

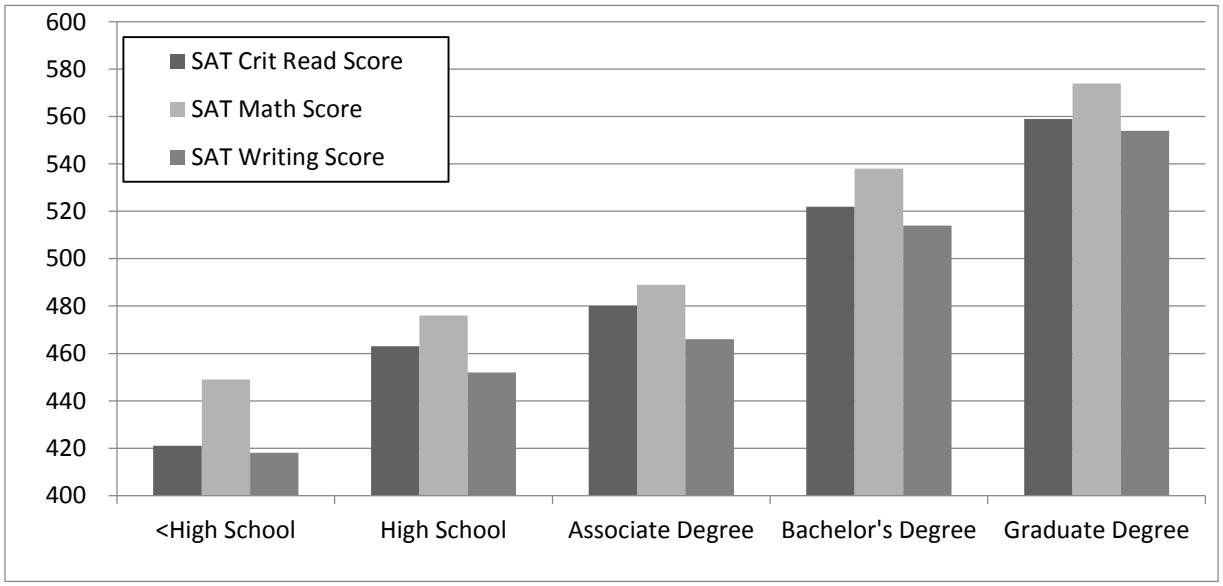

Figure 6: SAT Scores by Parental Education Level

The data on underrepresentation from NCES above shows Engineering to be a fairly homogeneously white/male domain compared to the overall population. The analysis also shows that race or sex taken separately are not good predictors of academic skills[10] and that test scores don't adequately predict enrollment for underrepresented racial groups (for example, Hispanic Males show higher test scores but lower degrees of enrollment than Black Males, and although Black Females' scores are comparable to Black Males', the women enroll in Bachelors' programs at much greater rates). Furthermore, the SAT data shows that socioeconomic factors are significant influences in test scores. Taken together, these observations lead me to question the reasons for the disparities in enrollments. Of interest to this study specifically, other research places Engineering as a solidly middle-class profession. To understand the current lack of diversity in Engineering we must examine the history and structures of the profession.

1.6 A Brief History of Mechanical Engineering

Engineering today is divided into a variety of disciplines and sub-disciplines: Civil, Chemical, and Mechanical Engineering have deep historical roots, while Computer, Electrical, Environmental, Management, Nanotechnology, Software, and other fields of Engineering have evolved and split from the more ancient forms as they have been invented and grown to a point where differentiation is practical. Aspects of Mechanical Engineering specifically can be traced to many crafts through history, including metallurgy/smithing, clock making, military science (weapon and vehicle development), carpentry/woodwork/coopering, and more, all centered on the production of goods for a purpose. As technology has evolved, the scope of Mechanical Engineering has grown to include engines, robotics, and the technologies of mass-production. The nature of this work, emphasizing the practical over the aesthetic, is inherently well suited to supporting the needs of capitalist enterprise.

The process of professionalization is much more recent. Historically, the crafts upon which Engineering operations were based were considered skilled trades, in which a young man would be apprenticed and in which he would spend his entire working life (generally in a particular

[10] Or at least test-taking skills

craft or sub-field, such as 'blacksmith')[11]. Since the advent of the industrial revolution, many modern inventions initially proposed by scientists or scholars from elite backgrounds were brought to mass production by engineers (e.g. Needham, 1986; Savery, 1827). Knowledge was historically tacit, embodied, and learned through on-the-job experience. As the demand for skilled and compliant engineers increased, the manufacturing industry lobbied universities and colleges for vocational programs to train technically competent managers to support their needs (Noble, 1979, Chapter 1), with support from advocates of institutionalized vocational training (Flexner, 1910). The practical, industrial applications of Engineering training (as opposed to the "pure knowledge" purposes for the traditionally more elite Liberal Arts and theoretical science programs) located Engineering as a distinctly 'middle class' program in the academy (Daniels, 1971, p. 280).

As the industrial revolution advanced and the manufacturing industry expanded, the role of academically trained engineers evolved from one of designing and/or making items to include supervising those who did the actual work (the skilled tradesmen, and the semi-skilled and unskilled labourers on the shop floor) (Noble, 1979, Chapter 3). While the engineers are not the basic controllers of the means of production, they do facilitate it by controlling the detailed processes and methods to be used to produce any particular item.

Mechanical Engineering in industrial facilities is only one aspect of the profession's links to capitalist structures; academic Engineering is also inextricably entwined with industry in both funding and interest. Research in Engineering is probably the best-suited of all faculties to industrial partnership, sponsorship, and control: as 'Applied Sciences' the work is inherently closer to marketable products (or the processes to produce them) than the liberal arts, social sciences, or physical sciences. The triple-helix model, in which universities, governments, and industry work together for technological innovation (Etzkowitz & Leydesdorff, 2000), accurately describes the funding and research paradigm for many Engineering researchers.

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[11] The profession of Engineering in North America is directly descended from European, and particularly British, traditions. As such, this history is focused on the British trades and structures, and it is to be expected that in other contexts (such as China or Saudi Arabia) more local traditions would be more relevant to their current organization of professions, which may vary from those seen in North America today.

The educational aims of Engineering faculties have also historically been strongly influenced by industry, which sees Engineering programs as a training ground for skilled employees (Noble, 1979). This influence is perceived by many students as a benefit, as Engineering is seen as a highly vocational university program rather than as a path for personal growth. In a Canadian context, this applied nature may indicate that Engineering might be more logically placed in the Community College sector, however its status is as a semi-elite profession organized in conjunction with Universities. A compromise has been generated in the form of Technologist and Technician programs, which are technically oriented semi-professional programs oriented towards filling the niche between academically trained engineers on the management track and the labourers ad tradespeople who operate machinery and produce goods.

For students at the University of Waterloo (UW), where the co-operative education program is mandatory in all Engineering programs, the industrial linkages are even more prominent than at many schools. The work terms are seen as an ideal way to explore different industrial paths, to gain relevant on-the-job training, and to find a good and relevant job on graduation. The form of co-operative education used at UW alternates four-month work terms with four-month school terms throughout the course of the degree, providing an interesting cultural dynamic: students absorb the cultures of their workplaces and bring them directly back to the educational institution. This effect may lessen any cultural detachment, evolution, or reorientation that may occur from the divergence of the academic side of Engineering from the industrial side, and may strengthen the 'traditional' outlooks in the field by limiting the ability of the academy to develop a more equitable culture that students may bring to the workplace.

Implementation of a formal licensure program in the U.S. began in the 1930s, in an effort to drive a set of minimum requirements for the profession (Noble, 1979, p. 242). The requirements for licensure in Ontario today include completion of an accredited university program followed by several years of professional practice under the supervision of a licensed engineer, passing a written 'Professional Practice Exam' on ethics and law, and that the applicant be of 'sound character'(Professional Engineers Ontario, 2013). Each of these requirements is set by the accrediting body, and has specific implications for gatekeeping and limitations on who may join the profession. Current and historical demographic trends for university Engineering degree completion were discussed above (see The Importance of Issues of Underrepresentation, starting page 3), and research on some reasons for underrepresentation is discussed below (see Bodies of

Research on Underrepresented Groups in Engineering, page 22). The professional experience portion includes two assessments: a review of the types of work done (as described by the applicant) by the accrediting body, and approval by the applicant's direct supervisor and other licensed referees. This is one of the strongest barriers, and while it may have the appearance of neutrality, is highly biased against more precarious forms of employment and underemployment (which have been found in other industries to have more members of underrepresented groups than more traditional forms of employment), and the reliance on human evaluation makes it subject to implicit as well as explicit biases (Berdahl & Min, 2012; Bertrand & Mullainathan, 2003; Biernat & Kobrynowicz, 1997; Greenwald, Poehlman, Uhlmann, & Banaji, 2009; Heilman, Wallen, Fuchs, & Tamkins, 2004; Hill, Corbett, & St. Rose, 2010; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012; Norton, Vandello, & Darley, 2004; Phelan, Moss-Racusin, & Rudman, 2008; Rudman & Kilianski, 2000; Steinpreis, Anders, & Ritzke, 1999). The exam requirement includes two areas of study: Engineering Ethics and Engineering Law. Both of these areas are targeted at immediate considerations and effects rather than considering broader perspectives, and may be subject to some of the same criticisms of other forms of standardized testing (Buchan-higgins, 1996; Fleming & Garcia, 1998; Walpole, 2005). While the final requirement, to be 'of sound character' is currently superficially neutral[12], historically there have been explicit restrictions from professional licensure under similar requirements (Bernstein, 1994; Walsh, 1977; Williams, 1982). While licensure is essential in some areas of Engineering (for example, in construction, where there is an explicit duty of care in the interest of public safety), yet in others (such as Software Engineering) it is seen as a credential of little value. The manufacturing industry often bridges these two extremes depending on corporate culture and the specific role.

A Mechanical Engineering degree can lead to a number of different career paths, broken along lines of both task and organization type; each path comprises elements of both a task and an

[12] Though the requirements to be clear of a criminal record do have particular racial and socioeconomic implications, I strongly doubt that the intent was to restrict access on racial or economic lines; it is likely a correlation that has not been considered by the accrediting council. Furthermore, as this restriction is applied after the completion of a university Engineering program, may not exclude many affected by the racial and socioeconomic effects in the justice system due to a negative correlation between early criminal activity and university attendance.

organization type. Tasks or job roles can generally be fit into three types: design/analysis, which may be described as 'actual Engineering'; project management, which generally follows the principles of 'scientific management' of both people and the physical processes of production; and training/education of younger engineers-to-be. Roles may include multiple task types, but are typically dominated by one type.

The direct influence of commercial interest in Mechanical Engineering is highly varied, and can largely be split along lines of private and public[13] institutions, where private companies are typically organized around maximizing profits and public institutions are organized to provide services to the general public. The workplaces most directly concerned with commercial success are in the manufacturing industry, producing components (defined as objects which have an end destination of a consumer) and/or producing machinery (which has the end destination of a manufacturing facility, which in turn produces the components or assemblies to be purchased by the consumer) – this comprises the bulk of the work of mechanical engineers. A related field, also driven by commercial interests, is mechanical work in the construction industry, primarily related to heat transfer and efficiency in buildings. On the public service side are the engineers who work in the energy industry (generation and distribution). The energy industry, incidentally, is the location of a rare instance of unionized engineers. Bridging the two ends of the spectrum between commercial and public service is those few who work in Engineering education, training students in publicly funded educational institutions to perform Engineering tasks for commercial interests.

The professional structure of Engineering (particularly in manufacturing) has substantial similarities to many other elite professions. There are several complementary roles to Engineers within production: Technologists, usually certified, are typically graduates of a college program; Technicians are graduates of a shorter technical program who may have a different 'lesser' type of certification; skilled trades such as machinists are the direct professional descendants of the craftsmen of yore; and unskilled labourers, who perform basic tasks that require little prior training or experience (often on an assembly line). All of these groups were historically closed

[13] Public in the sense of publicly funded by government(s), rather than the sense of publicly traded/available on the stock market

to women and non-white men[14], and were opened to members of marginalized groups gradually and starting with the least-skilled/least-desirable positions (typically first to non-white men; then to white women in cases of emergency, such as wartime; then finally to non-white women when and if all other groups became semi-established in the role), with the most elite levels maintaining the most exclusive workforce through various barriers to entry, including academic certification (for which the institutions providing the certification implemented their own barriers, see Bix, 2004; Frehill, 2011) and industrial experience. All of these groups continue to comprise populations with significant variances from the demographics of the overall surrounding society.

Many engineers and other professionals would envision the power structures between the workgroups as a fairly linear hierarchy (Figure 7). Many tradesmen and more neutral observers would describe it in more parallel or complementary terms, with some differences in the groupings (Figure 8). These conceptualizations of power relations between roles vary by industry – in many automotive manufacturing plants, for example, there is significant ambiguity between the roles of licensed engineers, unlicensed engineers and technologists (O'Grady, 2009), though many licensed engineers have greater organizational entitlement. Different workplaces place different values on the relative knowledges of academically trained staff (particularly engineers) compared to experientially trained staff (particularly skilled trades). It is not uncommon for there to be a degree of antagonism between engineers (who may place little value on the years of practical experience that the tradesmen have)[15] and members of the skilled trades (who may encounter problems caused by an engineer's overreliance on academic theory and lack of knowledge of practical concerns as they relate to production)(Noble, 1979).

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[14] Where 'white' is socially rather than visually defined, and may have excluded ethnic groups that 'earned their whiteness' later, such as Eastern European/Caucasian immigrants (Noble, 1979, p. 57)

[15] This disrespect of practical experience is particularly notable in the context of the professional experience requirement for licensure.

Figure 7: An 'Elite' Engineer's Conception of Professional Hierarchy

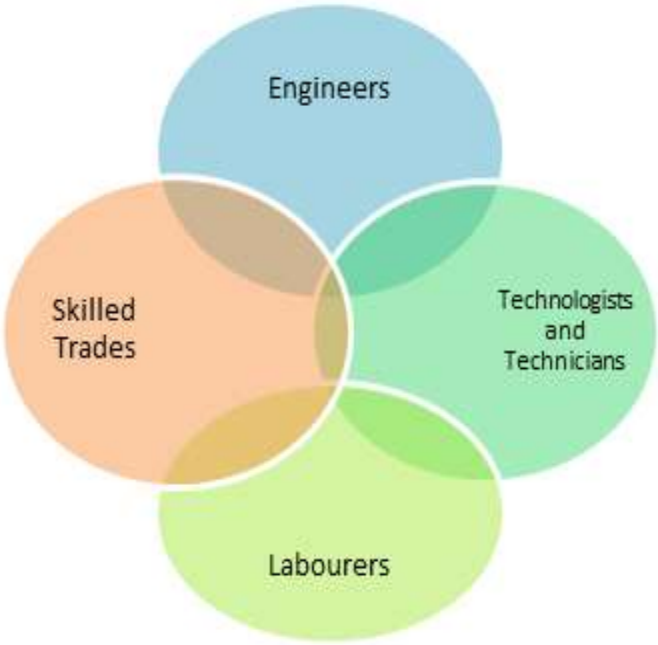

Figure 8: A More Practical View of the Complementary Roles in Production

The process of diversification of the field of Mechanical Engineering has been slow. It began as a white, male, middle-class profession, and remains largely the same today (Perrucci, 1969; Trow, 1958) (see also analysis above), at least partially through inertia – "if engineers are male, and maleness is part of Engineering, then it's tough for men to accept women into the profession" (Franklin, 2004, p. 8). Having explored the current picture of underrepresentation and how it has been maintained over time (at least in an academic setting), it is necessary to look at causes of underrepresentation. Many scientists and engineers have asked the same questions I have: "why is this field so homogenous?", and particularly from members of underrepresented groups (like me) "why are there so few people like me in my field"?

1.7 Bodies of Research on Underrepresented Groups in Engineering

There are different ways to consider intersectionality in the vast bodies of research on underrepresented groups in STEM[16]. In the literatures on underrepresentation in STEM, there is a small body of work that directly addresses intersectionality (Ortbals & Rincker, 2009; Riegle-Crumb, Moore, & Ramos-Wada, 2011), however the term is also used to identify its absence in the remainder of the literature (Adams et al., 2011; Riley, Pawley, Tucker, & Catalano, 2009). Most of the studies that address multiple modes of oppression are limited by their adherence to the paradigm of multiple labels and treat their study participants as a (smaller) homogeneous group, such as rural women or African American women (Beoku-Betts, 2004; Jacobs, Finken, Griffin, & Wright, 1998). Other studies acknowledge the limitation and justify it with a statement that the small numbers of women and even smaller numbers of women of colour make it difficult to study the smaller groups with any statistical power[17], or that the scarcity of multiply-underrepresented individuals makes confidentiality impossible to maintain.

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[16] There are several streams of research addressing similar questions, with little cross-reference between the streams; though certain subfields have arisen to address the flaws in a parent area, the parent area typically does not address the criticisms of the newer stream, preferring to participate in the echo chamber that has been cultivated to protect their preferred hypotheses.

[17] Much of the research on causes of underrepresentation is highly positivistic and quantitative, in which statistical power is relevant.

Though there is a lack of true intersectional work, intersectionality may be used as a critical lens when reading research developed from other frameworks. Many have tried to answer the question of "Why so Few?" with respect to women in Science and other STEM fields, with varying degrees of specificity and focus (Bystydzienski, 2008; Ceci & Williams, 2007; Hill et al., 2010; Rosenbloom, Ash, Dupont, & Coder, 2008; Rossi, 1965; Tietjen, 2004; Valian, 1999). There are a wide variety of approaches and hypotheses attempting to explain the current and/or historical lack of diversity, on axes of both cause and effect.

Many of the studies on underrepresented groups use the pipeline metaphor, which describes career paths as a pipeline through which people must travel through the courses of their careers, and from which many members of marginalized groups 'leak' out, resulting in fewer members from the underrepresented group(s) at each career stage (see Figure 9 for a graphical representation) (Alper, 1993). Everyone is in the pipeline in elementary school, some gradually leave or 'leak out of' the pipeline through course selection in high school, some pursue non-science-related majors in college or university (or don't pursue post-secondary education at all), some don't pursue careers in related fields after leaving school, and few who begin work in science fields either in industry or in academia are promoted to supervisory/high level roles. An associated premise is that people from underrepresented groups are more likely to leak out of the pipeline at each stage than those from overrepresented groups. The model has been criticized as excluding those who take alternate career paths (Muller & Metz, 2002; Xie & Shauman, 2003), however with the progressive gatekeeping and barriers to entry against non-traditional routes, the metaphor remains apt for most people's career paths[18]. The pipeline metaphor is most often applied to women in science and Engineering (WISE), but is also occasionally used for other underrepresented groups.

[18] I highly support the objective of programs aiming to break down these barriers and increase the numbers of routes into STEM fields, however that is tangential to the issue in this thesis, which looks only at the traditional route of entry to Engineering via an accredited university program.

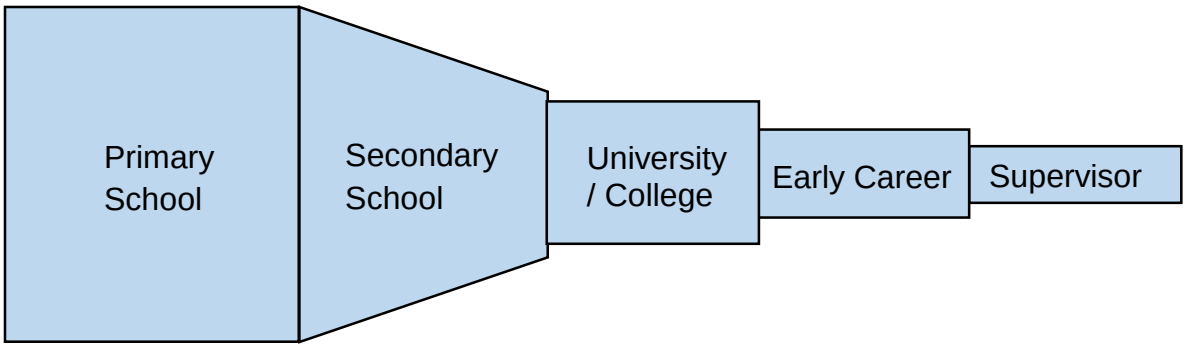

Figure 9: Pipeline Graphic

On the severely positivistic and reductionist end of the spectrum of bodies of research are the advocates for a biological source for the underrepresentation of women in the 'hard sciences', typically focusing on either hormonal differences or brain structure differences between the sexes(Aleman, Bronk, Kessels, Koppeschaar, & van Honk, 2004; Baron-Cohen, 2007; Cohen-Bendahan, van de Beek, & Berenbaum, 2005; Connellan, Baron-Cohen, Wheelwright, Batki, & Ahluwalia, 2000; Gurian & Stevens, 2004; Haier & Benbow, 1995; Hampson, Rovet, & Altmann, 1998; Jardine & Martin, 1984). Biological studies generally do not follow the pipeline metaphor, and typically assume that the necessary skills and aptitudes for pursuing a high-level science career are innate and unchangeable; thus, they often focus on infants or small children or on fully developed adults, rarely looking at developmental stages between. The studies on innate qualities generally focus only on sex and comparable work does not exist for the notable racial disproportional representation that is seen in the same fields; the studies also often focus only on the extreme elite end of achievement (where pipeline effects are most strongly seen), though they do not typically consider any class-related effects. Biological research into sex differences is subject to significant criticism on methodology, conclusions, and relevance, particularly by those who are cognizant of the significance of environmental or social influences on human development (including those who advocate for the reality of intersectionality effects) (Cherney, 2008; Epting & Overman, 1998; Fine, 2010; Frings et al., 2006; Halari et al., 2006; Jager & Postma, 2003; Klein & Hodges, 2001; Leonard et al., 2008; Liben et al., 2002; Nash & Grossi, 2007). Considering that the biological stream is performed exclusively by people trained in the 'hard' sciences, it is not surprising that many of the researchers in this area are white, male, and are located in 'elite' institutions; furthermore, most of these researchers are likely unaware of the concepts of standpoint theory or intersectionality and therefore do not consider the principles in

their research paradigms, nor do the researchers challenge the implicit assumptions on which their work is founded.

Sometimes critical but still highly positivistic are those who credit social and environmental factors as stronger forces in causing underrepresentation than biological influences. Social and environmental studies look at many different points through the pipeline, looking for strong causes of drops in participation, from early childhood through elementary school (Beilock, Gunderson, Ramirez, & Levine, 2010; Bodovski & Farkas, 2008; Neuman, 1986; Tiedemann, 2000; Vasquez, Teferi, & Schicht, 2003), high school (Dimitriadis, Fine, & Lavia, 2010; Klapwijk & Rommes, 2009; Lupart, 2000; Sackett et al., 2012; Van de gaer, Pustjens, Van Damme, & Munter, 2008; Watt, Eccles, & Durik, 2006), college (Hilton & Lee, 1988; Murphy, Steele, & Gross, 2007; Robinson & Mcllwee, 1991; Xie & Shauman, 2003), and beyond (Hunt, 2010; Paletz, Peng, Erez, & Maslach, 2004; Valian, 2005). Research into social influences on women's underrepresentation is often performed using feminist principles, though with many different ideological leanings under the umbrella of feminism and a wide range of degree of familiarity with formal understanding of feminist theories (Rosser, 1998). The social stream of research is the most likely to consider intersectionality, but often doesn't do so – papers frequently describe a monolithic bloc. Some work focuses on a smaller group such as rural women, black women, or Latinas (Gonzáles-Figueroa & Young, 2005; Hanson, 2007; Jacobs et al., 1998); others look at the relative importance of different factors for different sub-groups within one underrepresented group (for example, young black women and young black men). Themes considered in the social research include family influences and parental expectations, school structures and teacher expectations, mentorship, and gendered, racialized, and classed social expectations for interests and aptitudes (Bender & Saskatchewan School Trustees Association, 1994; Eccles & Jacobs, 1986; Eliot, 2009; Fagot, Leinbach, & O'Boyle, 1992; Harker, 2000; Hungsinger & Jose, 1993; Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Jacobs & Eccles, 1992; Ma, 2009; Tenenbaum & Leaper, 2003; Thompson & Ungerleider, 2004; Viernstein & Hogan, 1975).

Bridging the two causal research fields are researchers who (again, frequently from a positivistic framework looking for the strength of influences that can be generalized to large groups) investigate specific traits, aptitudes, and attitudes that may influence interest in the sciences, irrespective of whether the causes for the trait are intrinsic or extrinsic. Spatial skills are widely

considered to be important to math and science achievement(Casey, Nuttall, & Pezaris, 2001; Humphreys, Lubinski, & Yao, 1993; Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995). High achievement (typically defined through test results) and mediating factors on test achievement such as stereotype threat or risk-taking behaviours also belong to this category of research (Cohen, Garcia, Apfel, & Master, 2006; Dweck, 2007; Ginsburg & Miller, 1982; Linn & Hyde, 1989; Logel, Iserman, Davies, Quinn, & Spencer, 2009; Morrongiello, Midgett, & Stanton, 2000; Nguyen & Ryan, 2008; Schmader, Johns, & Forbes, 2008; Sinclair, Hardin, & Lowery, 2006; Steele & Ambady, 2006; von Schrader & Ansley, 2006). Test-based research is the most likely to consider multiple social contexts through use of results from international tests, and is often used to counter biological arguments on sex differences[19](Hyde & Mertz, 2009; Hyde, 2007; Mullis, Martin, & Foy, 2005; Organisation for Economic Co-operation and Development, 2005). Self-efficacy, enjoyment, and life goals are three life themes consistently found in models of influences of persistence in science and Engineering fields (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010; Chang, Chen, Greenberger, Dooley, & Heckhausen, 2006; Concannon & Barrow, 2009; Eccles, 1994; Farmer, Wardrop, & Rotella, 1999; Fels, 2004; Riegle-Crumb et al., 2011; Shull & Weiner, 2002). Like the social and environmental influences discussed above, trait- and interest-based research is amenable to considering multiple dimensions of identity, but often doesn't.

Research on the effects of underrepresentation often considers the traits associated with increased likelihood of pursuing science careers, but tends to be focused more on initiatives and programs designed to improve diversity rather than looking at the fundamental causes of underrepresentation and marginalization (Bouville, 2008). Effect- and recruiting-based research is most often performed by the university programs that feed the STEM professions (Hawkes, Morrison, & Raghavendra, 2007; Healy, G., Kirton, G., & Noon, 2011; Hoh, 2009; Karukstis & Gourley, 2010; Seiler, 2006). This stream of research is typically prospective and initiative-based, and often does not follow up retrospectively on the long-term effects of the programs designed to improve diversity. The programs are often designed by faculty members with personal interest in improving diversity (usually rooted in personal experience), but whose

[19] Criticisms which have been largely ignored by biologically oriented researchers.

backgrounds tend to be from Engineering and science; thus, they are likely to be unfamiliar with the other bodies of research that investigate the ‘whys’ of underrepresentation, and the resulting programs are often not underpinned by any particular theoretical framework other than personal observation (Rosser, 1998).

2 Methodology

Much of the work referenced above, especially the work focused on proving/disproving innate differences, is based on large-scale surveys or test results, or experiments of sufficiently large size to yield statistically significant results. These kinds of results tend to be persuasive to people trained in the traditional, positivistic modes of science and Engineering, and people inclined to believe in the power of this paradigm (particularly those in positions of power) reiterate and reify the claims. People who have been thoroughly indoctrinated in positivistic modes of thought are more likely to dismiss qualitative work as being isolated cases rather than as emblematic of systemic issues, however dismissal by the hegemon does not negate the true value of narrative research. Personal stories and narratives are better suited to discuss various forms of subordination of structural oppressions than many quantitative methods (Solorzano & Yosso, 2002). In this project, I use the concept of intersectionality as a framework for understanding the histories of the participants and how they've arrived on the career paths they're following.

The big, systemic research programs that examine causes and effects of underrepresentation are valuable for 'average of averages' analysis, but are often not applicable on an individual level, and the lack of consideration of multiple threads of identity oversimplifies the analysis. The value of narrative and qualitative research (beyond the explicit incorporation/recognizance of intersectionality as a concept) is in depth rather than breadth. Allowing the participants to tell their stories brings information that may not have been considered by the researcher, who in the systemic studies may be blinded or limited by their own hypotheses, and who typically lack the opportunity to find or pursue unexpected details due to the structure of their research. Qualitative research complements quantitative work by putting a human face and a story to the graphs and tables and models generated in the larger scale work, which can make an argument for change more compelling by embodying the necessity for the changes in question in a personal manner. These interviews allow me to bring the stories of my peers into the literature, and intersectionality theory allows me to bring the relevance of their identities and experiences to the fore. The strategy of intersectionality-informed interviewing and analysis provides a dataset

that yields deep and personally important meanings when compared to broader survey techniques, and brings lived experience that is lost in more quantitative methods.(Solórzano & Yosso, 2002)

A series of seven semi-structured interviews was conducted with graduates of the 2005 and 2006 Mechanical Engineering (Co-op) program from the University of Waterloo, all of whom began their university careers in September 2000. This group was selected for several reasons: to see how a group with a shared university background experienced the university program they had in common and how they were drawn to this common program in the first place; students who graduated in 2005/06 are transitioning from early- to mid-career roles, allowing some insight to their progress through the pipeline after university; and there were students from a variety of socio-economic and ethno-cultural backgrounds available for interviews. Semi-structured interviews were planned to allow a balance of ensuring the target questions were asked with allowing for interesting tangents to be followed.

The pre-screening process included individually emailing known members of the target classes (people who began the Mechanical Engineering program at the University of Waterloo in the fall term of 2000), with overemphasis on members of underrepresented groups. The screening included a brief description of the project, an overview of the interview process, and provision of letters of consent for review. Interested participants responded by email and interviews were set up at their convenience. Interviews were held during June and July 2012 at locations chosen by the participants, including three in-person interviews and four video-conference interviews (chosen by the participants due to geographic conflicts during the study period, or convenience due to scheduling challenges arising from family responsibilities). Audio and video recordings were taken (with participant permission) in all interviews except one, in which the recording failed. Detailed field notes were taken during each conversation.

The interview questions were designed and sequenced to gain an understanding of the aspects of identity most salient to the participants, to understand their career paths and past goals and interests, and to discover experiences that have helped to shape their career achievements. The series of questions as a whole is intended to understand how themes of identity (including gender, race, and class) have influenced the participants' career trajectories, and whether there were common themes or experiences between members of underrepresented groups and

overrepresented groups in Mechanical Engineering. The basic framework for each group of questions follows. Questions within each group were at times reordered or skipped based on preceding responses or conversational flow.

The first grouping of questions relates to personal identity. Leaving these questions open-ended was intended to gain a sense of the aspects of their identities that the participants considered most salient to their lives. Asking for both description and definition was anticipated to encourage reflection and a deeper sense of identity than a simple list of demographic characteristics, and to assess which aspects of identity were most salient to their daily experiences.

1. How would you describe yourself?
2. How would you define yourself?

The second block of questions relates to personal interests and past and present career goals. Some of these were intended to understand the participants' passions and how their careers relate to (or balance against) what they enjoy doing; other questions were directly related to their career development: past, present, and future. For most participants, we had casually discussed their current careers before the interview in the pre-screening; in cases where I didn't know what they were currently doing professionally, I also asked about their current position in the context of their current career goals.

3. What do you do in your free time/outside of classes/for fun?
4. When you were little, what did you want to be when you grew up?
5. Why did that seem interesting to you?
6. When did you decide on Mechanical Engineering (ME)?
7. Why did ME sound interesting?
8. What is your current career goal (if any)?
9. What are some reasons you'd like to be a <career goal>?
10. How did you decide you wanted to be a <career goal>?
11. Have you pursued licensure?
12. What other careers have you thought about (both positively and negatively)?
13. What kind of career research have you done (types of resources consulted, advice from others, etc.)?

The next few questions were designed to see if the participants had any experiences they considered "unusual" that might have set them apart or helped influence them towards a field in

which they'd be underrepresented, and whether there were any specific family influences that might have helped them towards their current careers. I expected that the responses from members of overrepresented and underrepresented groups would differ most strongly in this section.

14. Did you do anything unusual when you were growing up (foreign exchanges, space camp, etc.)?
15. Was there anything unusual about your childhood/youth (medical issues, gigantic family, moved a lot, etc.)?
16. Would you say that there was an expectation that you would go to university?[20]

After understanding participants' career histories and trajectories, I wanted to get participants to describe their demographic identities to complement the themes self-described as important in the earlier questions, recognizing that less salient themes may still be important to career development. Leaving this section until after they had described their identities and career processes was intended to ensure that earlier responses were informed by the life themes most salient to their sense of self, rather than priming their responses with the themes that I as an outside interviewer might consider relevant. I also wanted to ensure that they could define their demographics in their own language rather than predefining options for them.

17. How would you describe your:

    a. How would you describe your gender identity
    b. How would you describe your Race/Ethnic identity/background
    c. Which generation came to Canada, and when
    d. What is the primary language at home (parental home, current home)
    e. How would you describe your family's financial situation as you were growing up?
    f. What was the family configuration in your home (who lived with you)?
    g. What did/do your parents do for a living?
    h. What kind of schooling did your parents have?

The final question was chosen to bring the participants' careers back to their minds in context of their life themes and family histories. The open ended nature of the question would also let them discuss anything else that might not have fit in response to earlier questions.

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[20] Question 16 was at times asked with the "career research" questions, and at times after the "childhood" questions.

18. What else do you think has been important in your career development?
    a. (May include people, conversations, activities, experiences, events, etc.)

On completion of all the interviews, I manually compiled and reviewed the notes and recordings together (primarily using Excel) to group responses by question. The groupings were used to assess any recurring themes across participants within a question, as well as to draw a narrative from each participant's responses.

3 Results

Although the interview questions were sequenced to encourage priming with the self-identified important life themes rather than themes defined by the interviewer, a summary survey of the overall demographic information, including both historical and present statuses for each participant, is useful for framing the responses to the other questions. The following paragraphs summarize in brief the discussions held during the interviews, and a summary is provided in the tables that follow. Table 1 shows the gender, racial, immigration, and financial backgrounds for the participants. Table 2 describes parental backgrounds and support, while Table 3 reviews the self-descriptions and self-definitions from the participants. Table 4 reviews the participants' extracurricular activities, and Table 5 summarizes the self-descriptions and self-definitions provided by each participant. Table 6 describes the current personal and professional status for each participant.

The first demographic question, regarding gender identity, was expected to have binary results of male or female, though it was recognized that alternate responses would be possible. Two respondents elaborated on their answers to the question on gender identity. Anne followed her immediate and forceful statement of "female" with a softer clarification of "I guess that's it," while Zahra's response was more detailed: "This is a tough question. Others would see me as female, but I don't see the difference between me and a man. I am a part of this world."

The next group of questions was used in conjunction with each other to establish a brief understanding of ethnic or racial identity, including how the participant self-identifies racially or ethnically, as well as time of the family`s immigration to Canada, and the language spoken in the family home (both of which to contextualize cultural perceptions and experiences). Four participants expressed moderately specific identities (two of whom used the specific as a modifier to a generalized category), and the remaining three kept to fairly vague synonyms of

White[21]. Of the four white participants, each had a different variations of ethnic identity: Caucasian, Caucasian/British, Caucasian/"European Mutt" and "Don't have one - White, I guess" the last of which illustrates well the pervasiveness of whiteness as normative in North American society.

Asking about the participants' families' time of immigration was meant to contextualize the prior question on racial/ethnic background. Participants who immigrated themselves were expected to have experienced Canadian society differently than those whose parents had immigrated before they were born, and the children of immigrants were expected in turn to have had potentially different influences than those whose families had been in Canada for generations. The reasons for immigration were also expected to be potentially influential on career development. Of those who did not immigrate themselves, several participants noted different times of immigration for different parts of their families, which causes the result of the numbers not adding to seven participants. Of those whose parents immigrated to Canada (whether before or after having children), the reasons for leaving their homes and for coming to Canada specifically varied. Alex revealed that his parents came here for university, met here, and didn't return to the West Indies. Anne mentioned that her parents moved their family from China looking for more opportunity, partly for themselves but especially for their children. For Zahra, who moved from the Middle East, she noted that there were a number of factors influencing their decision to come to Canada specifically and at that time in particular, including the first Gulf War, her parents' facility with the English language, Canada's opening of immigration at the time, and a general trend among her family's friends and neighbors. On inquiry, she described that her parents and older sister did not have any trouble finding work in their professional fields (accounting, science teaching, and medicine), or having their qualifications recognized. After identifying that at that time, things were easier for immigrants than they are now, she said "with hard work, your qualifications will be recognized in Canada." The families of the two participants who

[21] The vagueness may be related to the structure of racial and ethnic questions on many surveys, in which White is typically described as Caucasian (misapplying the term Caucasian to apply to all Europeans rather than just those from the Caucasus, and disregarding variation in the experiences of North Americans vs. Western or Northern Europeans vs. Mediterranean Europeans vs. Eastern Europeans vs. white people who grew up in areas dominated by non-white racial groups, and the historical differences in earning of whiteness between different European groups within North American society). In contrast, other ethnicities tend to be broken down to more detail (Asian may be broken into South Asian, Chinese, Japanese, and Korean, for example).

immigrated themselves (both during their middle-school years) continue to speak their first languages at home. All remaining participants speak English at home (which is also the long-term language of their families).

Class and socioeconomic status is a more nebulous concept, with multiple dimensions that can affect experience, including both social factors (such as parental education and place of residence) and economic factors (such as family income and cost of living). Many of the influencing factors, both social and economic, are interdependent and interlocked, and as such cannot be analyzed separately. Since perceptions as children can be highly subjective, and since financial factors can be highly variable depending on local and individual contexts, and since it is personal experience that is of interest for this thesis, the question on the economic side of the socioeconomic issue was intended to be considered subjectively. These questions typically led to ancillary discussion on the local context for the participants childhood (suburban or rural, family structure, etc.). Most of the participants described their family's financial status as they grew up as being pretty comfortable, middle class or above average. Of those who didn't, Alex noted that his family definitely did better as time went on. Marissa, a farmer's daughter, noted that their fortunes varied by year – some years were pretty tough, and they were never wealthy, but "some years were more okay, and some years were less." Anne described her situation growing up as "getting by – we couldn't afford expensive things, but we weren't lacking," and that although they were far from living a life of luxury, her mother could afford to not work. It was only the participants whose backgrounds weren't described as "pretty comfortable" who elaborated on their answers.

The participants' assessment of their families' financial status was supplemented with a survey of their parents' educations and occupations. There was a great deal of variety in parental education, ranging from partial high school to graduate degrees. In three cases, mothers returned to school after their children were grown in order to advance their own careers (with the more advanced level noted by * in the table). Alice, James, and Anne had stay-home mothers (of which Alice and James' mothers had university degrees before having children). Three mothers were teachers (Alice's mother stopped working when she had children, Zahra's mother teaches Chemistry, and Dan's mother teaches ESL and acts as librarian). Alex's mother worked part time (nights) as a nurse, and her son noted (unprompted) that she did most of the housework. Three participants had fathers who were Engineers – Alice, Dan, and Alex. Two fathers had

other math-oriented professions (Zahra's and James' fathers were an accountant and a business analyst, respectively). The two remaining fathers, those without higher education, both worked – one as a farmer and one as a general contractor/labourer (Marissa and Anne's fathers, respectively). Alex noted that his father had two bachelor's degrees (in Engineering and Physics) as well as a master's (only the highest degree is shown).

The ancillary discussions around the socioeconomic questions yielded several interesting observations. It is notable that many of the participants came from larger-than-average families (with 3 or more children in the home), that a majority of the childhood homes housed extended families (with grandparents, and/or cousins, and/or unrelated children living with the core family either part time or full time), and that all participants came from two-parent homes (most of which remain so today). Participants both with and without stay-home mothers noted that they felt their mothers' employment status was unusual at the time they were growing up. James elaborated on this observation, noting that it was particularly unusual for his mother to have opted out of the workforce given her university degree in Mathematics.

The demography section of the questionnaire was intended to be fairly comprehensive, to fill in gaps that may have been left from the participants' self-identification at the outset of the interviews. I began the conversations with open-ended questions on identity to ensure that the themes most salient to each participant were the ones informing their responses, expecting a possible range of responses on the first question from demographic list to personal mission statement. When asked "How would you describe yourself", every participant reacted with surprise - some mild, some came to a complete loss for words, some asking for clarification as to what I meant. On reflection, I believe that since they were expecting an interview on career goals, being asked a question that seems more suited to a blind date might be startling. Once the participants recovered from the surprise, responses to this question came in three types: demographic list (2 participants), list of personality traits (5 participants), and an outline (partial or full) of current major life roles (4 participants); most participants combined two or three of the response types.

The second question, "how do you define yourself" had two purposes: it was intended to encourage a degree of deeper self-reflection to compensate for the possibility of reductive demographic lists in the first question, and to narrow down the life themes that were most

important to each participant. I expected the responses to be more complex than the self-description, working from the connotations of description as superficial and definition as more deeply fundamental to the core of identity. Participants answered this question in three different ways, with some overlap with the first question and with some combination between the second and third response types: a complete rejection of the premise of the question (1 participant), a description of significant social roles or activities (4 participants), and a description of important personal qualities (4 participants). In some cases, the responses overlapped with the first question (2 participants), and in others their personal definition used completely different ideas from their self-description (4 participants). As with the personal descriptions asked earlier, the level of detail presented varied. Marissa's simple response of "As a Mom" was the briefest of responses, though that role is anything but simply defined. Dan's definition has shifted – while he used to be focused on both family and friends, having a child has drawn his focus closer to the family he's started. Not all of the parents defined themselves as that role – Anne defined herself instead as "A good person wanting to learn as much as possible and enjoy life," though her earlier self-description had included her role as a parent. Those without children had a broader range of self-definitions. Zahra described herself as "a citizen of the world – I belong to everywhere". James defined himself as "a human being" and "a scientist", as well as someone who "tries to think about everything; tries to make the best decisions and do the best thing in whatever situation". Alex stated that he does "identify myself by my activities" as well as being "relatively easy going, a jack of all trades."

Questions on extracurricular activities (past and present) were asked as a transitional question, to gain insight into how the participants' personal lives and identities relate to or balance their work lives, both presently and historically. I was interested in historical extracurriculars partly as another aspect of identity[22] (which were partly supported by the self-descriptions discussed above), but also to see if there were any themes of activities (traditional or non-traditional), or types of engagement that might lead to early introductions of Engineering concepts that could have influenced the participants towards choosing Engineering as a career path. My expectations were mostly not met. Most of the women had participated in competitive athletics

[22] It was expected that voluntary activities may be a better indicator of attitudes and interests than their paid work due to the economic pressures that can force less than-ideal employment situations.

of one sort or another, both team- and individual-based, as well as some more artistic activities (such as piano). The men were mostly involved in more artistic or technical activities, such as drama, flying, or music. Strong examples of direct childhood free-time influences towards career goals were Alice and Dan – their fathers (both engineers) were both also hobby pilots and flying became a family activity; Alice also shared a love of science fiction with her father, which was a key influence in her aspiration to become an astronaut.

Current free time activities showed a strong division between the participants with children and those without. Participants with children joked about the base premise of free time – the 'second shift' was significant for all of the parents (male and female) in the group, and what little leisure time was left tended to be devoted to quiet, relaxing activities. Those without children all discussed a wide range of hobbies and activities, all of whom included both physical activity (mostly individual activities, such as running and cycling, but also several class-based such as martial arts, yoga, and circus arts) and other 'active' hobbies (such as traveling, playing music, pottery, and cooking). Parents and non-parents alike enjoyed more sedate activities such as reading (particularly non-fiction) and 'hanging out'.

Once a context of identity and interests had been established, I shifted the topic towards career paths. I asked each participant a series of questions on their career goals at several points in their lives: as children, their intent when they applied to university, and their current goals. I expected that there would be several common themes, and this was borne out in the participants' responses. Several participants had only ever had one aspiration as children based on a common passion (becoming an astronaut), while others had aimed to become a teacher as a concrete objective in the absence of a passion. Other participants had gone through many ideas, though they typically had common elements across the ideas. Dan, for example, wanted to be a garbage man, a firefighter, a pilot, or a tool and die maker (amongst other ideas) – "generally, something mechanical with my hands." James went through different scientific ideas – food scientist, astronaut, archaeologist, and finally an engineer. Anne had wanted to be a "businesswoman" as a child – she had more of an idea of what success looked like while she growing up than what activities she wanted to do in her professional life.

Most surveys of career interests focus on what a student is actively pursuing. I thought it would be interesting to see whether there were any common themes of careers that participants had

either considered as strong alternates to Engineering, or whether they had explicitly discounted or avoided any particular career paths. Teaching was mentioned by most of the participants, but those who discussed it were split between those with an active interest and those with an active disinterest[23]. Alex and Alice mentioned that they had kind of been interested in teaching in the abstract sense, but were turned off by the realities of working with kids; Zahra had been interested in teaching but turned to Engineering when it was identified as a possible good fit, and is currently pursuing teaching at the postsecondary level as one aspect of her future career. Like her, James enjoys the teaching aspects of the academic track. Anne mentioned teaching as a possible future direction if her current plans didn't work out or if she wanted to shift gears.

Several described different careers that they felt they either would or wouldn't be suited for based on personal characteristics – James mentioned that he couldn't become a politician due to moral constraints, while Anne said that she couldn't see herself as a lawyer because of the moral conflicts that may arise and all the talking. In contrast, Marissa said that she could see herself as a lawyer because she thought it was something she could do well. Anne and James continued their similar disinterests by identifying healthcare fields as areas they wouldn't want to work in – the emotionally draining nature of nursing, the lifestyle and debt required for medical school, and the sheer volumes of memorization required in biology courses were all mentioned as reasons to avoid those fields. Alex and James mentioned that they have had the opportunity to turn their acting hobbies into careers, but both described the instability as being a major factor in sticking with Engineering.

Structural issues were also mentioned in different contexts for benefits or detriments to other possible careers. James noted that he found the idea of entrepreneurship unsettling – too much stress and too little internal drive. Zahra noted that she found during co-op that she didn't like working in a corporate management situation, but really enjoyed the research environment of a university. Marissa also mentioned co-op as being foundational in her career path: "the good thing about co-op is that I always did well at my jobs, so I knew I could do well in practice in Engineering if not in academics."

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[23] As the career most visible to all primary and secondary students, it is not surprising that everyone has an opinion on whether or not it would be a suitable career for themselves.

Most of the participants either have or will be pursuing licensure. For the aspiring professors, it's a requirement to teach Engineering in Canada, but neither has begun the process yet. The other three women have recently completed the licensing process. It wasn't required for any of their jobs, but Alice noted that there was a "bit of the 'you can't call yourself one' factor" – referring to the fact that an Engineering degree doesn't entitle you to use the title 'Engineer' in Canada, and that for her, the ability to use the title was important after all the hard work she's put in. The men interviewed tended to be a bit farther back in the process. Dan had just sent out his forms to the referees, so he was a few months out from assessment by the licensing body. The one non-white man interviewed (Alex) has stopped pursuing a license. He had been tracking his experience, but his work history of a long string of short contract jobs (typically less than one year) made it difficult to gain the appropriate types of experience and referees necessary for licensure. Furthermore, he has left the field of mechanical work for the software industry, in which the P.Eng designation has little value.

Many of the participants have experienced a shift in their long term goals now that they`re well established in their career paths. While those who originally wanted to be astronauts would still love to do so, their aspirations have come to earth after recognizing the incredible difficulty in being selected for the space program. At the time of the interview, Alice had just begun a new job, and had not yet developed an idea of where she wanted to take her career long-term. Marissa, who works at the same company as Alice, loves the nuclear Engineering field, but expects to shift away from the technical side in the next few years as she advances in seniority – she intends to eventually reach the VP level, though not in a technical role (interestingly, she is the participant who defined herself as "a mom"). The third aspiring astronaut, James, is still actively pursuing the goal of traveling to space, but he has an alternate goal of becoming a professor of Engineering. He is equally passionate about teaching and research, and is now employed as a postdoctoral researcher at a US university. Zahra is also pursuing professorship in Mechanical Engineering, and like James, she is passionate about both teaching and research – her original career goal had been to become a teacher, and she has simply changed the level of whom she will be teaching. She is currently working in a postdoctoral program in Europe, and has not yet decided if she will return to Canada – as a "citizen of the world" she is quite enjoying the opportunities to explore other cultures in her time abroad. Both aspiring professors consider both the work content (teaching and research) and the professorial lifestyle to be major factors in

setting their aspirations, especially compared to industrial work they had done as co-op students. Two of the participants' goals lie on more stereotypical grounds: Anne, whose interest in Engineering was inspired late in high school, doesn't foresee staying in a technical position long-term, but hasn't decided what her best alternative may be; she is particularly interested in a position "Where I can help." Dan, on the other hand, wishes to remain as a technical specialist, though he wouldn't object to supervising other engineers. Alex, whose career has veered away from traditional mechanical roles, also believes that he may have some aptitude for technical management in the longer term.

Engineers in manufacturing are often criticized for their focus on products, processes, and costs rather than keeping workers foremost in their minds – a position that has definite sexist, classist, and racist implications. It is interesting, then, that none of the participants in this study work in 'management' roles in manufacturing. This aspect of employment wasn't noted in any of the participants' discussions on why they are in their current industries, and the theme was only discovered on compilation of the interview notes for analysis. Of the non-academic women, each works in different highly technical roles in the energy industry. This was entirely coincidental. All participants do have experience in different fields of industry through their university co-operative education program, and many noted that it was highly influential in their career decision to work in this industry. Anne, for example, noted that she appreciates "the job protection/security, work/life balance, and reasonable pay (compared to the auto industry)." James, an academic, noted that his industrial jobs were largely rote, with little high level thought required[24]. Several of the participants specifically mentioned balancing work and family in describing their current goals.

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[24] It is interesting that some of the criticism of engineers/management in manufacturing environments criticize a withholding of certain high-level tasks from the floor workers, whereas the engineers themselves may see these tasks as tedious. There are some interesting explorations that could be done on this topic, but this is not the time or the place to do it.

Table 1
Demographic Background

Participant	Gender identity	Race/Ethnic identity	Immigration – Time and Origins		Language	Family Financial Situation	Family Configuration
			Maternal	Paternal			
Alice	Female	Caucasian (British roots)	Mom, age 11	Several generations back	English	Pretty comfortable	Both parents, 3 older siblings
Dan	Male	Caucasian	Grandparents, 1930s from Cuba	Dad, 1969, from England	English	Pretty comfortable, above average	Both parents, 1 grandparent, 1 younger sister
Marissa	Female	White – don't have one	Great grandparents, early 1900s		English	Depended on the year	Both parents, 1 grandparent, older siblings, others (unrelated)
James	Male	Caucasian ("European mutt")	Grandparents at least		English	Pretty comfortable, middle class	Both parents, 2 older siblings
Anne	Female*	Chinese – first generation	Immediate family, when Anne was 12 or 13, from China		Chinese (local dialect) with parents, English in own home	Doing okay, just getting by	Both parents, 2 grandparents, 2 siblings, 1 cousin
Alex	Male	Black/West Indian	Parents, early-mid 1970s, from Trinidad & St. Lucia		English	Doing okay, better over time	Both parents, siblings, 1 cousin
Zahra	Female*	Arab	Immediate family, early 1990s (1st gulf war) from Middle East		Arabic	Doing quite well	Both parents, 3 older siblings, 1 younger sibling

Table 2
Parental Backgrounds

	Parental Education		Parental Occupation		
Participant	Maternal	Paternal	Maternal	Paternal	Family Expectations
Alice	Bachelor's	Bachelor's	Teacher / Stay home parent / Writer	Engineer (Electrical)	University (partly self-imposed)
Dan	Bachelor's	Bachelor's	Teacher / Librarian	Engineer (Aerospace)	Any post-secondary plan
Marissa	High School*	Some High School	Stay home parent / Airline worker	Farmer	University
James	Bachelor's*	Bachelor's	Stay home parent, occasional work	Business systems analyst	Supportive of any plan
Anne	High School	High School	Housewife	General labourer / contractor	University
Alex	College*	Master's	Nurse	Engineer	University
Zahra	Bachelor's	Bachelor's	Teacher (Chemistry)	Accountant	(not asked)

Table 3
Self-Descriptions and Self-Definitions

Participant	Self-Description Demographic	Personality	Life Roles	Self-Definition
Alice		Outgoing, self-starter, not super-technical	Mechanical engineer (nuclear field)	(Rejected premise of question)
Dan		Quiet, friendly, "less shy than I used to be," "get along with most people"		"I used to be very focused on family and friends, now I'm focused on family"
Marissa		Outgoing, "somewhat bossy," "Type A personality"		As a mom
James	Caucasian male, upper middle class background, multi-generational Canadian	Well rounded	Engineer by training, PhD student, mechanical engineer, married, "James"	"As a human, who tries to think about everything and tries to make the best decisions and do the right thing in whatever situation; As a scientist."
Anne			Engineer, parent to a 2-year-old, married to an engineer	"A good person, wanting to learn as much as possible and enjoy life"
Alex	Black, male		Engineer, actor, martial artist	"I do define myself by my activities, I'm relatively easy going, a jack of all trades."
Zahra		Stubborn		"A citizen of the world – I belong to everywhere. I've lived in 4 countries, am a citizen of 2, and speak several languages."

Table 4
Extracurricular Activities

Participant	Past Extracurricular Activities		Present Extracurricular Activities	
	Physical	Other	Physical	Other
Alice	Figure Skating, Rugby, Badminton	Piano, Science Fiction	Running	Traveling
Dan	Sports (team)	Flying (not air cadets), Cubs/Scouts, hanging out		Socializing at home
Marissa	Competitive gymnastics, field hockey, basketball	Residence don, "drinking at the Bomber"	Exercise "when I had free time"	Socializing, dinners out
James	Kung Fu	Acting, RPGs, music	Weight training, running, cycling, circus school	Poi, reading, music, science experiments, gardening
Anne		Camp Discovery		Reading, mostly non-fiction
Alex	Martial arts, tennis, swimming lessons	Music, worked in library	Martial arts	Theatre, music
Zahra	Running, yoga		Running, yoga	Travel, pottery, cooking

Table 5
Past and Alternate Career Goals

Participant	Childhood Career Goal	Desirable Alternate Careers (past or future goals)	Undesirable Alternate Careers
Alice	Astronaut	Technical sales	Teacher
Dan	Garbage man, pilot, firefighter, tool & die maker, something hands-on	(nothing mentioned)	Business/finance
Marissa	Astronaut	Lawyer	
James	Food scientist, archaeologist, astronaut, engineer/robotics	Other areas of science & Engineering, Teacher	Nurse or support worker, doctor, CAD monkey/code monkey, actor/singer, politics, entrepreneur, upper management (C-suite)
Anne	Businesswoman	Something with math or physics, teacher	Lawyer, medicine, historian
Alex	Train engineer, teacher (ambivalent)	Stay within Engineering	Teacher
Zahra	Teacher (general)	Doctor	Consultant, anything in "industry"

Table 6
Current Personal and Professional Situation

Participant	Current family status	Current occupation	Industry	Licensure Status	Long-term career goal
Alice	Married, no children	Engineer	Energy (Nuclear)	Licensed	Not sure
Dan	Married, parent	Engineer	Aerospace	In process	Technical manager
Marissa	Married, parent	Engineer	Energy (Nuclear)	Licensed	VP, non-technical
James	Married	Post-doctoral researcher (Engineering)	Academia	Unlicensed, will pursue	Professor (teaching and research)
Anne	Married, parent	Engineer	Energy (Nuclear)	Licensed	Not sure
Alex	Unmarried, no children	Software designer	Software	Unlicensed, will not pursue	Technical manager
Zahra	Unmarried, no children	Post-doctoral researcher (Engineer)	Academia	Unlicensed, may pursue	Professor (teaching and research)

4 Discussion

Reviewing the compiled results of the interviews, three themes of strong influences on the participants' career paths arise: human influences (Chapter 4.1), educational and other activities (Chapter 4.2), and personal interests and aptitudes (Chapter 4.3). I examine each of these themes of influences through the lens of intersectionality in the discussion that follows. Although I as a researcher may view the participants' experiences through this lens, it is necessary to reiterate that the participants themselves largely do not perceive their experiences in light of their identities, and that the application of intersectionality theory to their experiences is an external treatment. Engineers as a group often minimize or dismiss the effects of sexism and racism (especially subtle forms), preferring instead to blame other factors (inexperience, for example) for negative influences on their careers. It is also notable that the participants interviewed are all satisfied in their current careers, which may have influenced their ability to reflect on the paths that have taken them to where they are; those with negative experiences may be more likely to reflect on structures of power that have hindered their progress.

4.1 Human Influences

The theme of human encouragement covers several types of influences, in increasing order of strength: information sources, role models (both general and specific), and mentors. Each participant credited human influences as being significant to their decision to pursue Engineering as a career. Research has shown that awareness of Engineering as a career path (and particularly discovery of the realities of Engineering rather than commonly held stereotypes) is a significant factor in attracting members of underrepresented groups to the field (Tomas & O'Grady, 2009), so it is to be expected that this is a common theme amongst the participants. Not all human influences were positive, however the positive influences have significantly outweighed the negative for the participants in this study.

The first type of encouragement within the human influences theme, information sources, is the most straightforward, and includes people who provided basic information or awareness that Engineering is a feasible career option (outside of outreach programs, which are discussed in

Chapter 4.2 Educational and Activity Influences, below). Zahra was first introduced to Engineering as a viable career path through human suggestion. She visited a high school guidance counsellor for career advice when she was considering university applications. When the counsellor asked what she was good at, Zahra's response of "Math and Physics" led the counsellor to recommend Engineering, "So I applied, and since I got in, that's what I did."

The second category within human influences, role models, is the broadest and was defined by all participants as being important. Role models acted in multiple ways: from general encouragement of the development of skills, to family members providing an example of an engineer (or other scientist) and showing the viability of the career path, to a famous person stating that Engineering was an excellent means to follow in her footsteps.

The most general of role model influences, that of encouragement and support, is most notable in a common theme among the students from underrepresented groups: a family expectation (whether explicit or perceived) of attending university. Alice and Marissa, as the youngest in large families, both noted that since all of their siblings attended university, there was never a consideration or thought that they wouldn't follow the same educational path. Both also noted significant self-pressure to live up to either what others had already done or to their own lofty career goals. In other cases it was a more general expectation (with parental buy-in to the *You Must Go to University* principle). Anne described how her mother did not have any higher education and felt limited by her lack of education, which translated into ambition for her children and a focus on the importance of their pursuing higher education (though Anne's brother has not pursued post-secondary education, instead starting his own business). One interesting observation from two of the participants (Anne and Alex) who were expected by their parents to pursue university educations was that they attended high schools in areas that didn't tend to send a lot of students on to universities, particularly for Engineering. Of these two, Alex recognized his socioeconomic status as being more salient than his race in terms of beginning his career path: "I grew up in [a large suburb with high immigration rates]. It was pretty racially mixed, but by the time I got to OAC, the other black men had basically vanished… Since both of my parents had post-secondary education, there was an assumption that I would as well." In contrast, the two white men (Dan and James) both identified that their parents would have been supportive of any post-secondary plan (be it university, college, trades, or work), though there was a difference in degree of support. Dan's family was more emphatic that there must be some

kind of actual plan in place (that would lead to a career), while James' family would have supported his taking time out to develop a plan or otherwise find himself.

The second form of role models, accessible direct examples of engineers, was shared by a majority of the participants. Three participants had engineers in their immediate family: Alice, Dan, and Alex's fathers were all engineers. For Alex, this influence was particularly strong: all the men in his family were engineers[25], and his father had undergraduate degrees in both Physics and Engineering as well as his Master's in Engineering. Alice similarly had "tons of engineers" in her family, and shared hobbies with her father further deepened his influences. Similarly, Dan shared a passion for flying with his father, though the closeness of his career path to his father's was largely coincidental. Zahra, while she did not have an engineer in her family, did have positive scientific role models in her mother (a Chemistry teacher) and her older sister (an endocrinologist), both of whom were influential in her development of skills in maths and sciences. Alice had a further role model providing encouragement towards Engineering. When she had an unusual opportunity to meet Roberta Bondar (Canada's first female astronaut, and an idol to many young women aspiring to become astronauts, including Alice), the astronaut recommended Mechanical Engineering as a good first step towards pursuing a career in space.

Mentorship for the participants in this study took on different forms, and may not be explicitly described as such by the participants. For this discussion, I define mentorship as a strong, direct and personal, encouraging influence towards success. Several participants described mentoring experiences that follow these guidelines. Anne was inspired by her high school calculus teacher's pride in her daughter, who attended the University of Waterloo for electrical Engineering. For her, attending UW was more important than her first choice of program. She couldn't explain why, exactly, but she chose to attend UW for her fourth choice program (with no financial offers beyond the co-op program) rather than any of the other schools she had applied to, even though all the others offered her electrical Engineering and scholarships.

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[25] While this may seem unusual, when considering that awareness of the field of Engineering is a critical factor in pursuing the field, it follows that presence of one engineer in a family will significantly increase the likelihood of more members of the family pursuing the same path, simply by creating awareness of the viability of the field. A joke was made at my wedding, for example, that there are now enough engineers in my in-laws' family to field a basketball team.

Some negative human influences were noted by some participants as well. After learning about their current roles and future goals, I thought to ask some of the participants[26] how identity or externally assigned demographic characteristics may have affected their experiences in the workplace, expecting to hear some differences between overrepresented and underrepresented groups. Each of the participants who were asked the question identified that explicit discrimination on the base of gender or race was not necessarily common but was nonetheless present. Anne noted that she has had some negative experiences with "folks who believe that gender got us ladies into those job positions rather than credentials and hard work." On the other hand, sometimes that is the case: from my own experience, an interviewer once told me "it's about time we hired a female student." While I was as qualified for the job as any other applicant, it was my gender that was the differentiating factor that landed me the offer. Zahra noted that she has spoken to Muslim women in Germany who have been told explicitly that they will not be hired due to their wearing of the Hijab. She also discussed how being female in Engineering can help "it draws attention to you – but it can only take you so far." James noted that while he has occasionally noted his ineligibility for awards due to his white-male status, he was also aware that none of the scholarships were of particularly large value, making it a pretty insignificant issue in practical terms[27]. Unusually for an engineer, he is highly conscious of his positions of privilege in many dimensions of identity and personal history, relating a number of stories of observed discrimination against friends and colleagues.

4.2 Educational and Activity Influences

A second common major theme for the participants' decisions to become engineers was organized activities, including educational programs and other organized activities such as outreach programs. This theme does not include organized programs for interests and hobbies; these are discussed below in Chapter 4.3 below. This theme was not universal for the participants, but was discussed by a majority.

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[26] I unfortunately didn't think to ask this in all of the interviews.

[27] It has been noted elsewhere that awards that are not explicitly targeted towards underrepresented groups tend to be larger and are disproportionately awarded to white men.

Marissa described a key influence in her career process as a "by dumb luck" opportunity to go to a NASA space academy during high school[28], and she learned about possible routes to careers in space from there. She also "lucked into" a spot at Pearson United World College, an elite pre-university international boarding school. Her ambition and drive combined with her identity as "the smartest kid in school" and her technical orientation differentiated her from her peer group, leading a school administrator to recommend that she apply to the Pearson program. She described herself as being "overwhelmed with [career] information" there. Both of these experiences came about through unexpected opportunities initiated by other parties, both of which Marissa was keen to seize when they arose. Her physical location during her childhood (a small province) was instrumental in the presentation of both of these options, however it was her ambition and drive that allowed her to pursue the opportunities.

Two participants mentioned school-based outreach programs as having been highly influential in their final decisions. Once she had been made aware of Engineering as a viable path (via her mentor, her Calculus teacher) Anne had the opportunity to participate in "Camp Discovery", a program for high school women interested in Engineering, which solidified her interest. James attended a middle-school demonstration on robotics led by a Mechanical Engineering professor, which directed him straight toward Mechanical Engineering as his path.

Beyond the early outreach programs, several participants discussed the co-op format of UW's Engineering program as being instrumental in their current paths. Marissa described co-op as being foundational in her career path: "the good thing about co-op is that I always did well at my jobs, so I knew I could do well in practice in Engineering if not in academics." Alex saw his experiences in co-op in more practical terms – the alternation between school and work terms and the financial boost provided by co-op were appreciated, and the introduction to workplace culture made the transition to full-time employment less of a major shift. For Zahra, the influence of co-op came largely in the form of finding a preferred organization type and work structure, "Through co-op, I decided I don't want to work for someone. I did a research term on my last term and loved it." This revelation reflects her self-description of "stubborn." Like

[28]To clarify, while the opportunity did initially arise through random happenstance, it was her follow-through that allowed her to pursue the program

Zahra, James found that research work suited him better than industrial jobs, and his term teaching reinforced academia as the best long-term path.

James also discussed another unusual element to his childhood education – he noted that his mother was not particularly impressed with the teachers or principal at his school, and as such took any opportunity to withdraw him from classes for more broadly educational experiences, from sausage-making with his grandmother to going to the zoo or a museum. "As one of the smart kids," he explained, "I didn't have any trouble keeping up with the schoolwork, but I didn't realize until I was older how she'd felt about my education." This privilege of having the opportunity to opt out of 'regular' schooling in favour of enrichment activities was unique among the participants, and reflects the cultural capital available in his upbringing.

4.3 Interests and Aptitudes as Influences

The first two themes discussed, human influences and education/activity influences, primarily discuss external forces that the participants perceived as helping to guide them towards Engineering as a career path. The third theme is more personal, and discusses interests and aptitudes that the participants either identified as being influential towards their careers, or may be perceived as influential by an outside observer. This theme includes organized activities that are not related to the education system or outreach programs, unorganized activities or hobbies, and innate characteristics or aspects of identity that the participants recognized as being important.

Most of the women had participated in competitive athletics of one sort or another, both team- and individual-based, including gymnastics and various team sports. This is notable, since physical activity (especially at high speeds) can be influential on developing spatial skills, which are essential in Mechanical Engineering (and are highly correlated to test scores in mathematics, which is a necessary precursor for Engineering). Alice also spent a lot of time in small planes with her father, which provided a degree of familiarity with technologies that others might find daunting. Dan developed a passion for flying as well, and attained his pilot's license in high school, though dreams of a career using those skills were shot down by a minor medical consideration. This hobby was also linked to his highly practical and hands-on nature.

Media consumption was mentioned by two of the participants. Alice and James both discussed a love of science fiction as being important to their development of interests in science in general, and in space specifically. James was also fascinated by 'science reality,' identifying the "amazingness of the shuttle launch" as reinforcing his drive to become an astronaut.

The participants' self-descriptions and self-definitions also provide some insight into their pursuance of Engineering. The women who included personality traits in their self-descriptions (Alice, Marissa, and Zahra) all used very strong adjectives: bossy, outgoing, and stubborn; all of these are terms that are often applied to women in positions of power, particularly in male-dominated industries. Anne's self-definition varied from this trend: she defined herself in more subtle terms, as "a good person, wanting to enjoy life." She is also the least professionally ambitious of the women interviewed for the study. Alex's self-definition as "a jack of all trades" has served him with a significant level of flexibility that has been necessary in his challenge-filled career, and allowed him to transition easily from mechanical design to software design. For him, Engineering wasn't a passion in his youth; instead, he saw the field as a reliable and open-ended means to get a decent job in the absence of a career he actively wanted to pursue.

5 Conclusions

5.1 Summary

Ursula Franklin writes "One must not think about these [racial-, class-, and gender-based] biases [in the design of technology] solely in terms of being hurtful to women, however. The exclusion of women as formative practitioners of technology is even more harmful to society" (Franklin, 2004, p. 103). In looking at ways to support the breaking down of these historical exclusions, I set out in this thesis to learn how people came to pursue a discipline in which they would be underrepresented. I expected that there would be themes or experiences that were either common or unique between members of underrepresented and overrepresented groups, and wanted to see how personal identity shaped the participants' experiences and influences. In a small study such as this one, broad conclusions applicable to the population at large are impossible, but the value of the study lies in the importance of personal stories and narratives. In this particular study, using open-ended questions in a dialogue format allowed the participants to reflect on details that would likely have remained hidden in other formats, which allowed a deeper level of insight to the paths that brought the participants to their current careers.

Three main themes were found in the influences that brought the participants to Engineering: Human Influences, Educational/Activity Influences, and Interests and Aptitudes as Influences. All of the engineers interviewed had strong family support, but only the white male students were given the impression that non-university educations or career paths would be acceptable to their parents. Many (but not all) of the participants had prior exposure to Engineering through family members or outreach programs, with no difference between overrepresented and underrepresented categories, and all received active encouragement and support for their choices. Several had specific fields or careers they wanted to pursue (robotics, astronaut), but several did not (for them, general ideas of success or aptitude were more significant guiding factors). Educational experiences and outreach programs were important to several of the participants, either for creating awareness of the possibilities within Engineering or for encouragement to follow the path once it had been revealed. Childhood interests played varying types of roles for the participants, but for most of the participants their childhood interests were logical precursors

to Engineering, using similar skill sets to those required in the profession (such as spatial sense or use of technology). The engineers interviewed for the most part didn't feel strongly that their demographic identities played a strong part in their career paths (considering their personalities and skills to be of greater importance), and had varying degrees of recognition of the barriers that can face underrepresented groups (including different levels of recognition of barriers they themselves may have faced in comparison to their peers). Since the participants are all happy and successful with their current lives, it is understandable that they may be less cognizant of barriers that may be more apparent to people who have had more negative experiences to reflect on. This study also focused on positive influences rather than barriers, and as such, the participants may not have actively considered experiences or influences that they had to overcome to pursue their current paths.

The stories shared by the participants illustrate the importance of maintaining many open paths to Engineering rather than focusing on particular outreach activities. The most important of these is awareness – existence of family members who are engineers, media exposure (particularly, for the participants in this study, of the space program), recommendations by mentors (such as teachers), and information provided by guidance counsellors were all useful 'initial exposures,' while outreach programs served well to reinforce interests in Engineering for those who participated in them. It may seem obvious to identify that a lack of discouragement may be influential alongside any positive encouragement. Environments and family influences supportive of science and mathematics achievement in general further reinforced (or prevented discouragement from) goals in Engineering. It is notable that none of the participants discussed any significant impediments to their careers, though several mentioned barriers they've observed for others. Since this study was focused primarily on positive influences rather than negative ones, the lack of discussion of barriers is not unexpected.

5.2 Challenges

A major challenge in this research is my limited ability to seize the moment and immediately recognize statements of importance. As a hard-core introvert, I find social interactions such as interviews to be highly demanding on my faculties, and as such noticed many times during my reviews of the interview transcripts that I ***should*** have followed up on a particular statement, but missed it at the time. In some cases, I was able to follow up with the participants to ask

additional questions when I did realize the opportunities, but this was not always so. Furthermore, I think better visually and on paper than through verbal communications, which is not a beneficial orientation for interviewing. On reflection, live interviewing is probably not a great method for me personally to perform, though it may be a good element to include if more skilled interviewers are available to participate on the research team.

Another challenge came from my highly positivistic training as an engineer: I like statistics, I like data, and learning to use stories as a valid form of research was a difficult paradigm shift for me to make. Learning to write as a social scientist (and for social scientists) rather than engineers has been similarly difficult. Accepting that with some notable exceptions, most of my (Engineering) classmates and work colleagues will not recognize the value of this kind of research (let alone this specific paper) without years of re-education is hard, but learning to value these methods and ideas myself has been an area of growth for me and I hope that this study will aid me in helping others to learn the value of this kind of work.

Though these challenges must be acknowledged, they do not detract from the work that has been accomplished, and should be seen instead as opportunities for improvement for future work.

5.3 Future Work

There are many possible extensions of this research, along lines of methodology, themes, and scope:

- Including participants who could have pursued Engineering (by interest and/or aptitude), but chose other paths
- Adding explicit consideration of potential barriers to entry, whether they were experienced by the participants, and how they were overcome
- Expanding the scope to look at underrepresented groups in other fields to see if themes are unique to Engineering or are more widespread
- Asking similar questions of students prospectively rather than just retrospectively (i.e. changing the position in the pipeline at which the interview is performed)

- Performing the study longitudinally, to examine changing influences and senses of identity at different stages of the pipeline
- Increasing the numbers of participants (in the population for this study or in any of the expanded groups listed above) to allow the types of analysis that positivistically oriented academic and industrial leaders are more apt to find convincing, with the goal of making recommendations more likely to be acted upon

While I have no specific plans to pursue this work further personally or immediately, I do strongly believe that the extensions hold significant value for policy and program development relating to improving diversity in fields with significantly disproportionate populations, as well as for improving opportunities for members of underrepresented groups in those fields or people who may be excluded from the disproportionate fields.

5.4 Recommendations

This exploratory project was intended to learn about the influences that bring people, especially those from underrepresented groups, to Engineering. I was particularly interested in whether some influences were common between underrepresented and overrepresented groups, and which ones were unique. Through listening to these stories, I found four elements that should be considered when developing programs to better engage underserved populations:

1. Outreach programs to explain what Engineering is and what engineers do are essential to helping students perceive Engineering as a valid career path.

2. Emphasis on the realities of Engineering work is essential to developing a diverse population in the field - most Engineering jobs do not, contrary to popular opinion, consist of sitting alone in a cubicle staring at a computer; teamwork and social impacts are particularly important aspects to present more prominently.

3. For Engineering educational programs, identification of indirect-Engineering careers (such as astronaut or project manager) or non-Engineering careers (such as doctor or lawyer) that an Engineering background can support would broaden the potential applicant pool. The related strategy of emphasis on skills developed in a program has

historically worked to some extent for Liberal Arts courses, which lack obvious vocational paths as outcomes from educational programs.

4. Parental support is essential to developing students' interests and aptitudes in Engineering-related activities. Outreach programs towards parents and the general public (particularly in underrepresented communities) should be developed to complement the programs that already exist for students.

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