Understanding Career Persistence of Women in Engineering in Manitoba: A Phenomenological Study of Former Practicing Members and Graduates Never Registered

by

Kathryn Atamanchuk

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

MASTER OF SCIENCE

Department of Biosystems Engineering

University of Manitoba

Winnipeg

Abstract

Women are underrepresented in the Canadian engineering profession at a rate of nearly 10:1 when compared to their male counterparts. This poses a problem for a profession whose goal is to provide innovative and inclusive solutions for all people. In Manitoba, while women are underrepresented in engineering at the same rate as the national average, there is also evidence that some either never enter the profession after graduation or leave at various stages in their career. This qualitative research study examined the experiences of two groups of women in Manitoba, Former Practicing Members and Graduates Never Registered, to understand the factors that both enable and deter their persistence in the engineering profession. Focus group sessions and one-on-one interviews provided an in-depth perspective of factors contributing to women's career decisions. The findings generally align with the literature-based conceptual framework and indicate that this is a multi-dimensional problem that includes factors such as a need for improved work-life balance, workplace cultural shifts, and confidence building. Implications of these finding include a need to support both new graduates in the licensure process and former members who wish to return to practice.

Acknowledgements

I wish to express sincere thanks and gratitude to the women who shared their stories with me in support of this research and in support of making engineering a welcoming place for all. I would like to acknowledge Engineers Geoscientists Manitoba for supporting this research.

I am sincerely grateful to have had Dr. Marcia Friesen as my advisor for this research. Her insight, support, and encouraging feedback made this an invaluable learning experience for me. Thanks also go out to my thesis committee members, Dr. James Blatz and Dr. Stefan Cenkowski, for their feedback and support of this research.

A huge thank-you goes out to my friends and family. Thanks to my life-long friends Marie, Shanda, and Jen for their encouragement and especially for their ability to recognize when I needed a night out. I am lucky to have parents and in-laws who provide me with love, unwavering support, and free childcare. Finally, much love to my husband Gord, and kids Jane, Will, and Greta, for their sacrifices, understanding, patience, and love during the long evenings and weekends that went into this work.

Table of Contents

Table of Figures

Chapter 1: Introduction

The Need for Gender Diversity in Engineering

Women are underrepresented in the Canadian engineering profession at a rate of nearly 10:1 when compared to their male counterparts. As of the end of 2017, only 13.1% of the 295,926 professional engineers registered in Canada were women (Engineers Canada, 2018), while in Manitoba, the average was only 9.6% as of June 30, 2017 (Engineers Geoscientists Manitoba, 2017). But is it a problem that women only make up a small portion of our engineering workforce? Yes it is. There is research that demonstrates that a diverse team (including gender diversity) leads to more innovative solutions. Hewlett, Marshall, & Sherbin (2013) argue that organizations who have "leaders who give diverse voices equal airtime are nearly twice as likely as others to unleash value-driving insights", while Woolley et al. (2010) found that teams that include more women tend to have more equitable team communication and increased participation by all team members. However, Smith Doer, Alegria, and Sacco (2017) contend that 'representational diversity' (i.e. diversity that represents society) alone does not provide the full intended outcomes. They argue that 'integrated diversity', or the integration of a diverse workforce (including women and visible minorities) that removes power imbalances and allows for open exchange of ideas and information is what is required if an organization wants to achieve the full innovative potential that diversity can bring (Smith Doerr, Alegria, & Sacco, 2017). As a profession that has its hand in almost everything designed, created, built, and used in our world, it is critical that engineering not only reflects the diversity of society but also supports work environments where diversity is integrated to maximize the potential to create innovative and inclusive solutions that protect the safety and well-being of all people.

While the justification for increasing gender diversity in engineering is clear, actually achieving it has proven to be difficult. As seen in Figure 1, over the 20-year period from 1999 to

2018, enrollment of female engineering students at the University of Manitoba showed no marked increase, and in fact, dropped from 21.0% in 1999 to 13.8% in 2008 before increasing to 22.5% in 2018. The female enrollment numbers for the Faculties of Law, Medicine, and Science are more than twice the rate of that in engineering, and did not see the decline in numbers in the mid-2000's that was seen in engineering. Clearly, engineering still has a long road ahead to achieve the gender diversity seen in other career paths such as law, medicine, and science. The next section will provide context for the regulation of the engineering profession in Canada and define efforts underway at both the national and provincial levels towards gender diversity in engineering.

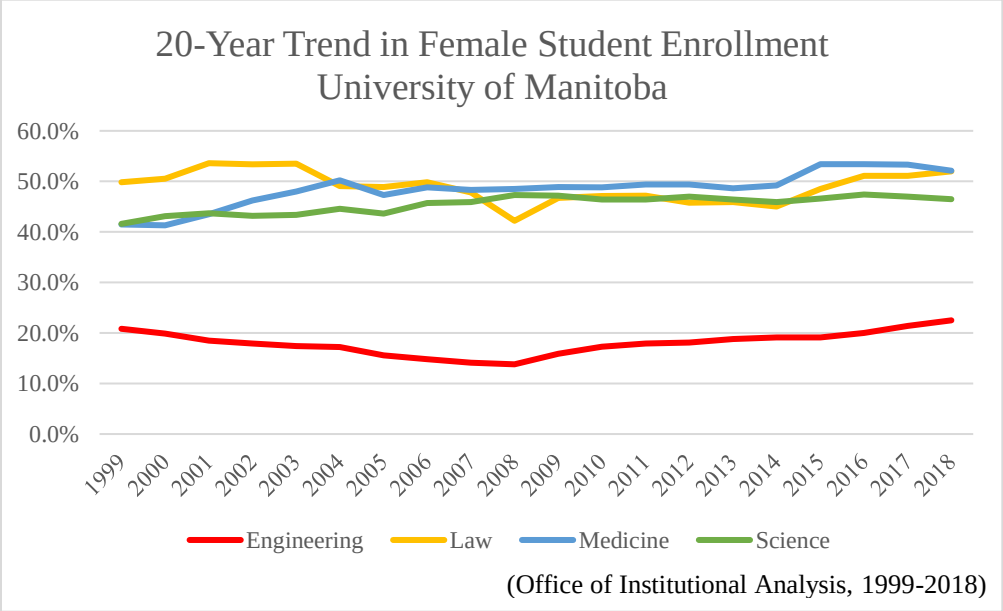


Figure 1: 20- year enrollment trend of female students in engineering, law, medicine, and science at the University of Manitoba

Engineers Canada: The 30 by 30 Goal

In Canada, professional engineering is regulated by 12 provincial/territorial associations. Each of these associations is responsible for the self-regulation of the engineering (and

sometimes geoscience) profession in their respective jurisdiction. A national organization called Engineers Canada helps facilitate relationships between the associations, oversees accreditation of undergraduate engineering programs across Canada, and acts to promote "diversity and inclusivity in the profession that reflects Canadian society" (Engineers Canada, 2019). In 2014, in an effort to support diversity and inclusivity in the engineering profession, Engineers Canada established the "30 by 30" goal. The 30 by 30 goal is Engineers Canada's commitment to raise the percentage of newly licensed engineers who are women to 30% by the year 2030 (Engineers Canada, 2017) . This national goal has been endorsed by all 12 Canadian engineering regulatory bodies, and many engineering schools across Canada. While 30% doesn't represent parity, it is seen as an interim goal wherein measurable results can be seen in a relatively short timeframe (as the time from entry into engineering school to professional licensure is a generally an 8-11 year process). Additionally, the 30% figure has been shown to represent a 'tipping point for sustainable change', meaning that once a population reaches 30%, additional increases should be self-perpetuating (Engineers Canada, 2017).

Since establishment of the 30 by 30 goal in 2014, Engineers Canada has been gathering data on the progress towards the goal from each provincial regulator. Figure 2 shows the 30 by 30 data across Canada as of December 31, 2017.

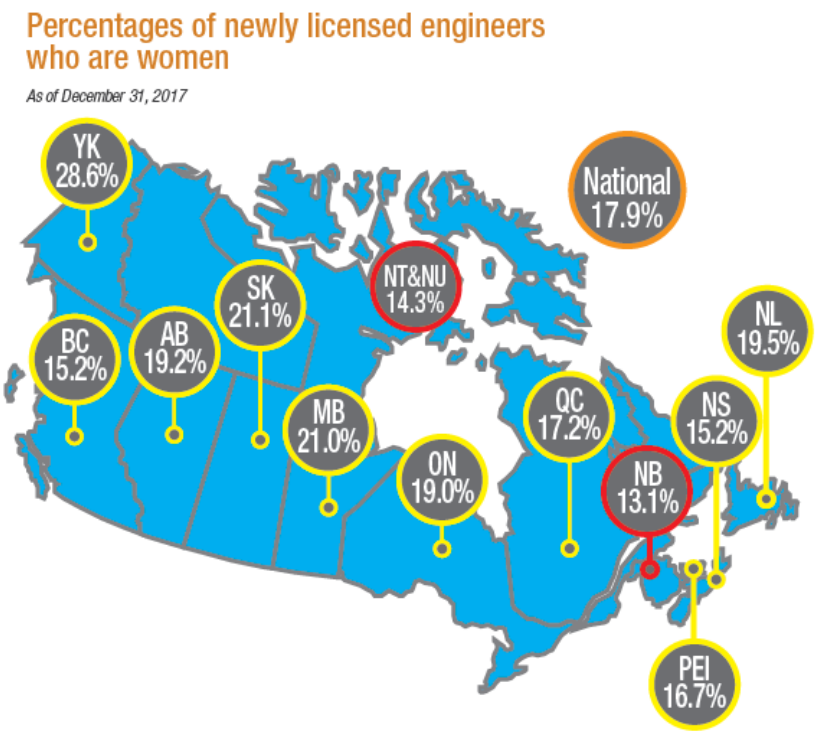


Figure 2: Percentages of newly licensed engineers who are women, Dec. 31, 2017 (Engineers Canada, 2019)

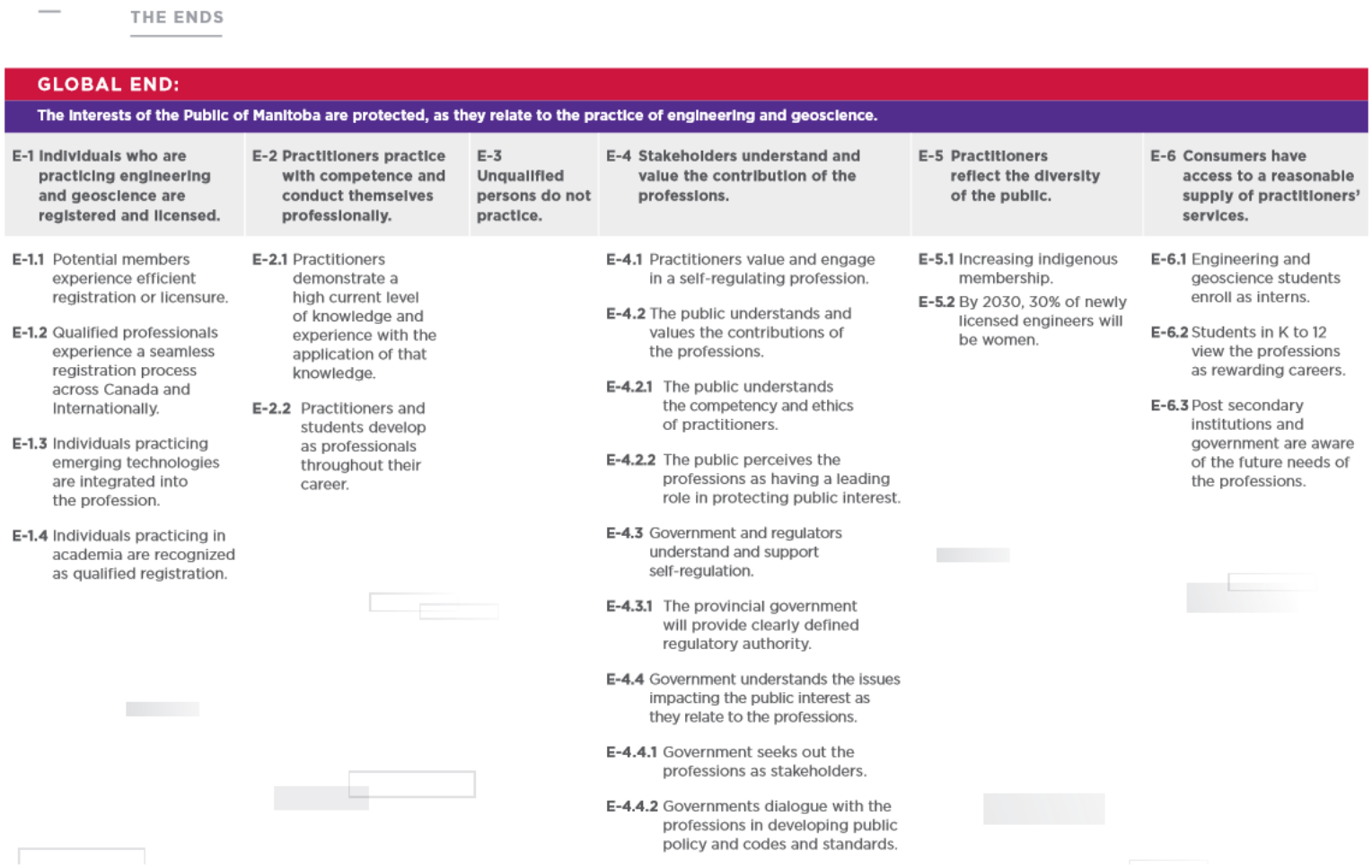
As seen in Figure 2, the 2017 Engineers Canada report indicated that the national average of newly licensed female engineers in Canada was 17.9%, with Manitoba reporting 21.0%. When examined in this context it would appear that Manitoba is ahead of all but Yukon in their work towards achieving the 30 by 30 goal, however, due to the small pool of women in engineering and the fact that time to licensure can take longer than four years, these numbers tend to fluctuate annually.

A main criticism of the 30 by 30 goal is that it is focused only on increasing the percentage of *newly licensed* female engineers. There is (currently) little focus on monitoring and/or increasing the retention of these women once they have become licensed. Anecdotally, there are stories of women leaving engineering at various stages in their career, a phenomenon

often referred to as the ‘leaky pipeline’. The concern is that even if engineering schools reach 30% female enrollment, or if the newly licensed engineers reach 30% female, attrition caused by ‘leaks’ in the pipeline during various stages of career progression will prevent the profession from reaching 30% female representation over the long run. If recruitment is an essential part of increasing gender diversity in engineering, so too is retention. The following sections will provide an overview of the engineering profession in Manitoba including an overview and discussion on the ‘leaky pipeline’.

Diversity in Engineering in Manitoba

In Manitoba, the profession of engineering (and geoscience) is self-regulated through Engineers Geoscientists Manitoba (EngGeoMB). EngGeoMB has long recognized the gender disparity in the profession and, for over 20 years, has supported an operating committee called the Committee for Increasing the Participation of Women in Engineering (CIPWIE). CIPWIE, which was run by volunteers, focused efforts to support women in engineering in four key areas: Awareness (through communications); Equity (through research); Recruitment (through outreach); and Retention (through community and networking). In its 2017-2022 Strategic Plan, EngGeoMB introduced new association-level ‘Ends’ and an initiative called Engineering Changes Lives. ‘Ends’ “describe the strategic targets for the professions and provide direction for the CEO” and “are written as statements about where Engineers Geoscientists Manitoba wants to end up” (Engineers Geoscientists Manitoba, 2017). The Ends are shown in Figure 3 on the following page.



THE ENDS

GLOBAL END:

The interests of the Public of Manitoba are protected, as they relate to the practice of engineering and geoscience.

E-1 Individuals who are practicing engineering and geoscience are registered and licensed.	**E-2 Practitioners practice with competence and conduct themselves professionally.**	**E-3 Unqualified persons do not practice.**	**E-4 Stakeholders understand and value the contribution of the professions.**	**E-5 Practitioners reflect the diversity of the public.**	**E-6 Consumers have access to a reasonable supply of practitioners' services.**
E-1.1 Potential members experience efficient registration or licensure.	**E-2.1** Practitioners demonstrate a high current level of knowledge and experience with the application of that knowledge.		**E-4.1** Practitioners value and engage in a self-regulating profession.	**E-5.1** Increasing indigenous membership.	**E-6.1** Engineering and geoscience students enroll as interns.
E-1.2 Qualified professionals experience a seamless registration process across Canada and internationally.	**E-2.2** Practitioners and students develop as professionals throughout their career.		**E-4.2** The public understands and values the contributions of the professions.	**E-5.2** By 2030, 30% of newly licensed engineers will be women.	**E-6.2** Students in K to 12 view the professions as rewarding careers.
E-1.3 Individuals practicing emerging technologies are integrated into the profession.			**E-4.2.1** The public understands the competency and ethics of practitioners.		**E-6.3** Post secondary institutions and government are aware of the future needs of the professions.
E-1.4 Individuals practicing in academia are recognized as qualified registration.			**E-4.2.2** The public perceives the professions as having a leading role in protecting public interest.		
			E-4.3 Government and regulators understand and support self-regulation.		
			E-4.3.1 The provincial government will provide clearly defined regulatory authority.		
			E-4.4 Government understands the issues impacting the public interest as they relate to the professions.		
			E-4.4.1 Government seeks out the professions as stakeholders.		
			E-4.4.2 Governments dialogue with the professions in developing public policy and codes and standards.		

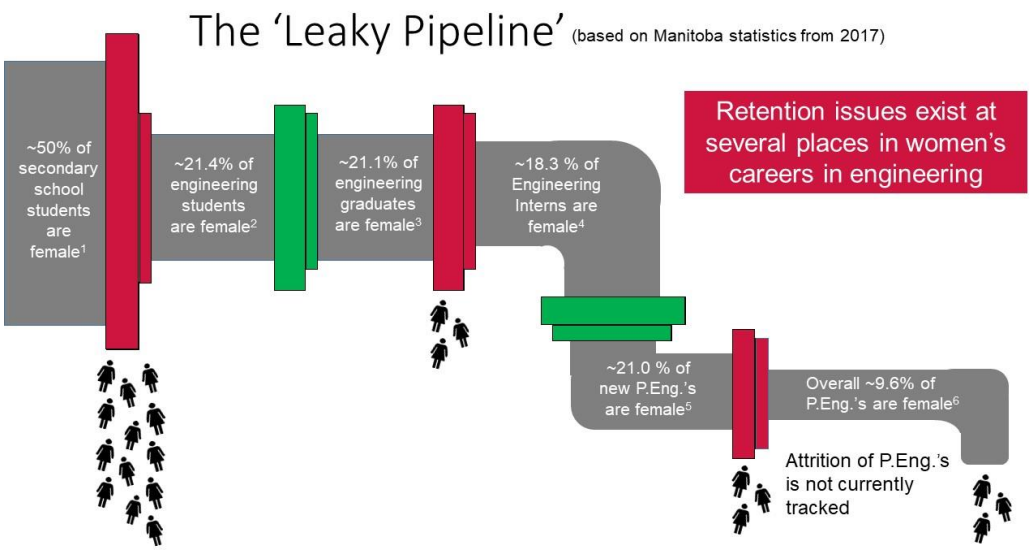
Figure 3: Engineers Geoscientists Manitoba 'Ends': strategic targets for the association (Engineers Geoscientists Manitoba, 2017)

The ends that relate most to this study are *End E-5: Practitioners reflect the diversity of the public* and sub-*End E5.2: By 2030, 30% of newly licensed engineers will be women*, which shows support for the Engineers Canada 30 by 30 goal. The other key strategic priority introduced in the 2017-2022 Strategic Plan is the Engineering Change Lives initiative which aims to support diversity in the profession. Per the strategic plan, "in order to make rapid progress, Engineers Geoscientists Manitoba must broadcast an urgent message of social change within the profession. The message must be inclusive of all forms of diversity and must clearly state the message that engineering changes lives." (Engineers Geoscientists Manitoba, 2017).

As of May 2019, the EngGeoMB council voted to operationalize the Engineering Changes Lives initiative and the CIPWIE committee under the newly formed Diversity Outreach department. Efforts to support End 5.2 are now part of the EngGeoMB organization, and will no longer run solely on the support of volunteers. This signals the association's continued commitment to diversity and inclusion in the engineering (and geoscience) profession in Manitoba. However, to be able to support diversity and inclusion in engineering, one must first understand the pipeline of women at various points in their careers, and where are there are 'leaks' in this pipeline.

The Leaky Pipeline: A Manitoba Perspective

Data were gathered from several sources including the University of Manitoba (Office of Institutional Analysis), Engineers Geoscientists Manitoba, and Engineers Canada to develop a 'leaky pipeline' illustrating the attrition of women in engineering at various stages in their career. The leaky pipeline based on statistics from 2017 is shown in Figure 4 below.



Notes:
1 – For the purposes of this study, it was assumed that ~50% of secondary students in Manitoba are female
2 – Data from: University of Manitoba (University of Manitoba, 2017)
3 – Data from: University of Manitoba (University of Manitoba, 2018)
4 – Data from: Engineers Geoscientists Manitoba (Engineers Geoscientists Manitoba, 2017)
5 – Data from: Engineers Canada (Engineers Canada, 2019)
6 – Data from: Engineers Geoscientists Manitoba (Engineers Geoscientists Manitoba, 2017)

Figure 4: The 'leaky pipeline' depicting points of attrition in women's careers in engineering in Manitoba in 2017

Prior to a discussion on the 'leaky pipeline' depicted in Figure 4, it is important to highlight some key assumptions made in its preparation. First, the percentages depicted in each section of the pipeline are the percentage of women in that population. However, the total number, N, in each section is different. For example, there were N=2285 students enrolled in the Faculty of Engineering at the University of Manitoba in the Fall 2017 with 490 (21.4%) being women. In the same year, there were N=441 engineering degrees awarded at all levels, with 93 being awarded to women (21.1%).

A second important note about the pipeline is that it is a snapshot in time. It contains data for 2017 only and does not track a cohort over time as the number of years to degree and/or

licensure can vary from 4-6 years on average. However, this snapshot approach still provides useful information that can determine where retention issues exist in the pipeline of women in engineering. Where retention issues exist in the pipeline, they are highlighted by red coloured connectors and visual cues of women dropping out.

Finally, the leaky pipeline for engineering in Manitoba presented herein includes only data related to women in engineering. While it may be of interest to investigate whether there is also a leaky pipeline of men who drop out of the engineering profession at various points, it is out of the scope of this research to investigate this, as there is no indication that men are experiencing disadvantage in the profession on the basis of their gender. From the perspective of EngGeoMB, this is important membership information that should be understood, but the focus of this research is to understand career persistence of women in engineering – a population that is already markedly underrepresented.

Beginning at the left-hand side of the pipeline, it was assumed that approximately 50% of secondary students in Manitoba in 2017 were female (note that accurate data were not readily available from the Manitoba Department of Education, but was not deemed necessary for the purposes of this study). From the Office of Institutional Analysis at the University of Manitoba, 21.1% of engineering students enrolled in the Fall 2017 term were women, a sharp drop-off from the pool of ~50% female secondary students. Clearly, this is a large leak in the pipeline and indicates that there are issues attracting women to post-secondary engineering education. This is also evidenced nationally in the significant number of programs that aim to recruit girls and young women to post-secondary STEM (Science, Technology, Engineering, and Math) studies, including WISE KidNetic at the University of Manitoba. This section of the pipeline represents a large opportunity in the effort to reach the 30 by 30 goal. When looking at the percentage of

women who enrolled in an engineering program at the University of Manitoba versus the percentage of women who graduated, we see very little, if any attrition. This signals that women who elect to study engineering tend to persist through to graduation at very high rates. This is corroborated by a study published by Statistics Canada entitled "Persistence and representation of women in STEM programs", which found that 87% of female engineering students (and 82% of male engineering students) persisted in their engineering studies based on longitudinal data from 2010-2015 (Wall, 2019).

A comparison of the percentage of female engineering graduates (21.1%) to the percentage of women registered as Interns with Engineers Geoscientists Manitoba (18.3%) indicates another leak in the pipeline. Although engineering is a regulated profession, there is no requirement for engineering graduates to become registered with their provincial association. According to the Engineers Canada 2018 National Membership Information Report, approximately 47.7% of the 2013 cohort of engineering graduates became licensed in 2017. Clearly, since individuals must register to practice engineering in Canada, encouraging more engineering graduates of all genders to pursue licensure should be something that all associations focus on, and could be a tactic that supports the 30 by 30 goal.

Further down the pipe, the numbers for 2017 indicate that 21.0% of newly licensed engineers in Manitoba were female, which indicates that women who register as Interns are successful in obtaining their professional license. However, since the number of women in the Intern and newly registered categories are small, and the length of time it takes to become licensed can vary from 3-6 years depending on one's previous experience, current job, and diligence in Intern experience reporting, these percentages may vary significantly year over year

in Manitoba and thus it is hard to draw a strong conclusion regarding retention during the Intern phase of a woman's engineering career.

Once women become licensed, they fall into a much larger pool of overall membership, the majority of which is male, so the percentage overall drops to 9.6% based on EngGeoMB membership data as of June 30, 2017. Leaks in the pipeline, however, don't stop after licensure. There are anecdotal stories of women leaving the profession at various points after becoming registered – another source of attrition. However, until 2018, data regarding the number of women letting their professional engineering license lapse in Manitoba had not been tracked.

The values shown in the leaky pipeline in Figure 4 demonstrate that while there is still work to do to increase the recruitment of women into engineering education programs, there is also a strong need to retain women who have already chosen the engineering profession, or in other words, to focus both on recruitment to as well as persistence in the engineering profession. This study is focused on the latter. The following section provides insight in to the research context and questions to be addressed in this study.

Research Context and Questions

Based on the leaky pipeline of women in engineering in Manitoba presented in Figure 4, one can conclude that there are both recruitment and retention issues that exist. To date, under the Engineering Changes Lives initiative within EngGeoMB, much work has been focused on awareness, or educating and advising young women on the profession of engineering with the aim of increasing recruitment in order to achieve the 30 by 30 goal. However, focus must also be placed on understanding factors that lead to retention, or persistence, of women that have already chosen engineering in order to achieve long-term, sustainable growth in gender diversity in the profession. In support of this, two sections of the pipeline will be studied: 1) the transition

between engineering school and initial registration as an Intern with EngGeoMB; and 2) the timeframe after full P.Eng. licensure.

While previous studies (which will be described in Chapter 2) have explored reasons why some women stay in engineering and some women leave, the vast majority of these studies were conducted in engineering environments where there is a much different approach to, and imperatives for, engineering licensure than there is in Canada. Further to this, most studies were based on a quantitative survey-based methodology. A qualitative approach can uncover complementary and new insights by allowing women to tell their stories about their experiences in engineering school and the engineering workplace.

Therefore, the objective of this study was to begin to understand woman's career persistence in engineering in Manitoba by exploring factors that lead some women away from the profession. Data were collected by interviewing women who graduated with an engineering degree from the University of Manitoba, but did not pursue professional licensure, and women who let their registration with Engineers Geoscientists Manitoba lapse, to gain insight into their stories.

The following research question guided the design of the study: *What are the elements of women's experiences in the engineering profession that both enable and deter their persistence in the profession, and how do these elements or factors interact with one another over time & space?* More specifically, the initial study design explored factors that contributed to choices to pursue engineering as a career initially, choices not to pursue licensure, choices to leave the profession, perceptions of the profession and the value of professional licensure.

Chapter 2: Literature Review

The objective of this literature review is to understand and identify gaps in the existing research on the topics of attrition and retention of women in engineering practice in order to support the overall research objective of understanding women's career persistence in engineering in Manitoba. The literature review includes research on *attrition* as well as *retention* of women in engineering as the ultimate goal is to identify opportunities to implement practices in Manitoba that will encourage more women to remain (or *persist*) in the profession.

When examining work that has already be carried out with respect to understanding career persistence of women in engineering, it is important that this review is conducted through a global lens and within the context of the regulation and licensure practices that govern the profession of engineering in those global regions, in order to provide a thorough basis of understanding upon which a conceptual framework for this study can be built. This chapter includes reviews conducted with respect to regulatory frameworks and previous research conducted in four global regions, including; Canada, the United States, Australia, and the United Kingdom. In each of these areas and regions, literature is reviewed and critiqued. This comprehensive review is then synthesized to create an overall understanding or conceptual framework that is applied to this study (see Figure 5).

Regulation and Licensure in Engineering

A profession can be defined by a number of factors, including; requirements for extensive study, practical training, and provision of a service. Professions are further defined by requirements for membership within a regulated environment where all members are bound by a code of ethics. As such, members of a profession have a fiduciary responsibility to those outside of the profession (Andrews, 2014). Engineering meets all of these criteria and, therefore, can be

considered to be a profession. In Canada, the engineering profession is self-regulated wherein each province and territory have enacted legislation with the aim of protecting the welfare, safety, and health of the public and the environment. In addition, legislation also governs who can practice engineering (right-to-practice) and who can call themselves an 'engineer' (right-to-title). In the context of this study, it is important to understand the regulatory environment not only in Canada, but in other jurisdictions as well, to assess whether the stringency and rigor (or by contrast, the ease) of licensing requirements has connections with the licensure rates and persistence of women in the engineering profession. To that end, the following sections explore the regulatory environments in Canada, the United States, Australia, and the United Kingdom.

Engineering Regulation and Licensure in Canada

In Canada, the practice of engineering has been 'self-regulated' since as early as 1920, with regulations administered at the provincial and territorial level by 12 engineering associations. In Manitoba, engineering is regulated by Engineers Geoscientists Manitoba. Each provincial/territorial engineering association provides oversight, regulation, and licensing of engineers through Acts passed as provincial legislation and issues licenses to those meeting certain qualifications (Engineers Canada, 2019). While there are some minor differences across Canada, the process for professional licensure generally requires:

- Graduation from an engineering (or applied science) program accredited by the Canadian Engineering Accreditation Board (CEAB);
- Completion of a four-year Intern program, working under the direct supervision of a professional engineer (in Quebec, the Internship program is only two years);
- Submission of Intern work review reports and acceptance by the applicable provincial association; and

- Successful completion of a National Professional Practice Exam (NPPE) which tests candidates on ethics and legal related material (and varies slightly by province).

Once the preceding steps are completed, a professional license is issued. Ongoing professional development is becoming a requirement for most Canadian regulators to ensure continuing competency of its members. While licenses to practice engineering are assigned by province/territory, mobility agreements are in place to facilitate relocation or registration in more than one region. In Canada, the term 'Professional Engineer' or 'P.Eng.' is protected and only those with the designation have the right-to-title as well as the right-to-practice (aside from some exemptions such as 'locomotive engineers' and 'power engineers'). Those who have completed engineering degrees but have not obtained licensure with the regulatory engineering body (or are not registered as an engineering Intern) cannot represent themselves as 'engineers' and cannot use the word 'engineer' in their job title. Thus the regulatory environment in Canada provides a clear position that one's freedom to call themselves an engineer, and, ultimately, their identity as an engineer, is tied to licensure. Despite this, data from Engineers Canada, the organization that supports provincial/territorial regulators, estimates that only 48.3% of graduated engineers from the 2012 national cohort became Professional Engineers by 2016 (the average time it takes to obtain licensure) (Engineers Canada, 2018). This 'graduation to licensure conversion rate' indicates that more than half of those graduating with an engineering degree do not go on to pursue professional licensure, however, it should be noted that many graduates may not have employment that is conducive to the pre-registration work experience requirements and may take longer than four years to obtain their license. Perhaps a comparison of the 2012 cohort to the 2017/2018 cohort would reveal a higher conversion rate. While these data are not separated by gender, it still illustrates that a significant number of engineers, some of which will be women,

choose not to pursue licensure. The reasons *why* this is the case is still not clearly understood and is the focus of this research study.

Engineering Regulation and Licensure in the United States

Similar to Canada, engineering licensure in the United States is governed by each state, and registration is only valid in the state in which it is obtained. Mobility agreements, called 'comity,' allow licensed engineers to easily transfer licenses between states or retain licenses in multiple states. The process for licensure follows a similar path to that of Canada with a few notable differences. The requirements for licensure in the United States generally consist of:

- Graduation from a four-year college or university engineering program (or, in some states, a four-year engineering technology program) which is accredited by the Accreditation Board for Engineering and Technology (ABET);
- Completion of a common Fundamentals of Engineering (FE) exam, which tests graduated engineers on a breadth of technical understanding of engineering principles and qualifies a graduated engineer to become an Engineering Intern (EI) or an Engineer-in-Training (EIT);
- Completion of up to four-years of engineering experience;
- Successful completion of a Principles and Practice in Engineering (PE), which tests candidate's technical knowledge in their chosen discipline (i.e. civil, electrical, mechanical, etc.) and on engineering ethics (National Society of Professional Engineers, 2019).

While the FE and PE exams are administered nationally by the National Council of Examiners for Engineering and Surveying (NCEES), each state's engineering association sets the

exam requirements and the minimum passing score. Persons in the U.S. that hold an engineering license are known as 'Professional Engineers' or 'PE's' and are therefore licensed to offer services to the public (National Society of Professional Engineers, 2019).

There are three key differences in the regulatory structure between the U.S and Canada. First, both the FE and PE exams administered in the U.S. as part of the licensure process are much more technically comprehensive in nature than the NPPE exam required in Canada and test candidates on specific engineering principles and knowledge. Second, in the U.S., an 'industrial exemption' applies that allows areas of engineering involved in 'interstate commerce' to be exempt from licensure. This exemption applies to any engineers working in companies whose products are sold out of state. As a result, many engineers working in the mechanical, aerospace, and chemical engineering sectors do not require PE designations. While there is no strict requirement for licensure in Canada and many graduated engineers do not register and do not require registration for their jobs, there is no formal 'industrial exemption' that applies. Finally, while the U.S. makes a distinction between the terms 'graduate engineer' and 'professional engineer' (with the term 'professional engineer' being protected), the word 'engineer' itself is not regulated. Unlike Canada, graduated engineers in the U.S. can use the term 'engineer' to describe their vocation or in their job titles, they are just not authorized to use the term 'professional engineer' without licensure. Indeed, in the U.S. it is not uncommon for private companies to employ people who have not graduated from an accredited engineering program in technical roles with titles such as 'test engineer' or 'field engineer'.

Despite these differences, which may be seen as disincentives to registration in the U.S., the graduate to licensure conversion rate is very similar to Canada. According to the NCEES, in 2014-2015 there were 820,000 PE's in the United States compared to 1.6 Million engineering

graduates. Thus, the conversion rate to licensure is approximately 51% (Bureau of Labor Statistics, 2019; NCEES, 2019).

Engineering Regulation and Licensure in Australia

Engineering regulation in Australia is substantially different than that in Canada or the U.S. There are two main organizations that govern engineering in Australia; Professionals Australia and Engineers Australia. The Association of Professional Engineers Australia (APEA) and the Local Government Engineering Association (LGEA) are divisions of Professionals Australia that offer three main engineering credentials; the Professional Engineer (PEng), the Registered Professional Engineer of Professionals Australia (RPEng), and the Registered Professional Engineer of Queensland (RPEQ) (Association of Professional Engineers Australia, 2019). The Chartered Professional Engineer (CPEng) designation, is available through Engineers Australia (Engineers Australia, 2019). Both the RPEng/RPEQ and CPEng are touted by their respective organizations as trusted designations and it is not clear if industry, government, or engineers themselves value one over the others. What is clear is that the PEng designation in Australia differs significantly from the P.Eng. designation in Canada or the PE in the U.S. The following points summarize the requirements that must be met in order to obtain a Professional Engineer (PEng) designation;

- Membership with Professionals Australia
- Completion of an approved four-year degree in engineering
- Agreement to abide by the Professionals Australia Professional Engineering Code of Ethics

It is clear from these requirements that the designation of PEng in Australia is significantly less rigorous than the P.Eng. or PE designations in Canada and the U.S. (respectively) as there is no requirement for professional experience or examinations to obtain the designation. However, the RPEng designation, available through Professionals Australia's APEA or LGEA divisions requires additional steps as outlined below.

- Completion of a four-year accredited degree;
- Completion of five years of relevant engineering experience in the last 5-7 years, which is provided in the curriculum vitae; and
- Submission of references from three Professional referees (RPEng's themselves), who are familiar with the candidate's work and can attest to their Australian experience.

While there are no examination requirements, the process to obtain a RPEng is otherwise quite similar to the requirements for a P.Eng. in Canada or a PE in the U.S. The RPEQ designation, which applies specifically to the state of Queensland, follows a similar qualification process as for obtaining the RPEng.

A Chartered Professional Engineer (CPEng) designation, obtained through Engineers Australia, and follows a six-step process, assuming that the candidate has already obtained an engineering degree from an approved institution:

- Completion of a self-assessment of engineering and leadership related skills;
- Completion of an industry review by peers;
- Enrolment in the Chartered Engineer program;

- Submission of ‘chartered evidence’ which includes samples of engineering work, curriculum vitae, and a Continuing Professional Development (CPD) log;
- Completion of a professional interview administered by Engineers Australia; and finally,
- Registration as a Chartered Professional Engineering (CPEng)

A key difference between the regulatory landscape in Australia and that in the U.S. or Canada is related to title protection. According to Engineers Australia (2019), “the title “engineer” is not protected in Australia; therefore anyone can claim to be an engineer and practice without the necessary competencies, understanding of standards, or in compliance with a code of ethics”. The designations of PEng, RPEng, RPEQ, and CPEng have been developed as a method to provide assurance to the public about the credentials and qualifications of engineers. Engineers Australia reports that there were over 16,000 members registered in the National Engineering Register (NER) in Australia in 2017, although these data do not indicate the respective numbers by designation or by gender (Engineers Australia, 2019). As well, registration on the NER is voluntary, so it is possible that some licensed engineers are not included in these numbers. The 2016 Australian Census data indicates that there were 329,957 people in Australia with engineering degrees (13.6% of these are women), with 185,916 (about 56%) working in the engineering field (with 11.2% being women) (Engineers Australia, 2019). Therefore, based on the numbers, less than 9% of engineers working in an engineering field in Australia are listed in the NER.

Engineering Regulation and Licensure in the United Kingdom

In the United Kingdom, an organization called the Engineering Council acts as the regulatory body for the engineering profession. The Engineering Council grants licenses to

professional engineering institutions throughout the UK that gives these institutions authority to assess and issue engineering licenses on behalf of the Council. As of September 2019, there were 35 authorized professional engineering institutions in the UK, primarily organized by industry sector (e.g. The Institution of Agricultural Engineers, The Institute of Highway Engineers, and the Royal Aeronautical Society). The two engineering licenses available in the UK are the Incorporated Engineering (IEng), and the Chartered Engineer (CEng) (Engineering Council, 2019). The requirements for obtaining an IEng or CEng designation are laid out in the UK Standard for Professional Engineering Competence (or UK-SPEC). For an IEng, the requirements include;

- Completion of a four-year bachelor's degree in engineering or engineering technology from an institution accredited by the Engineering Council; and
- Completion of an 'assessment of competence and commitment'. There is no specified time requirement for obtaining the necessary competence and commitment required for the IEng designation – it is dependent on the person and their work experience. A formal interview with assessors from the applicable professional institution authorized by the Council is conducted to determine whether sufficient professional development has been achieved (Engineering Council, 2019).

Once an IEng designation is obtained through the appropriate education, competence, and commitment assessment, the license holder is required to maintain CPD reporting records to demonstrated continued competency in their area of engineering work (Engineering Council, 2019). The Chartered Engineer, or CEng designation requires a different and more stringent set of requirements as outline below.

- Completion of a four-year bachelor's degree in engineering or engineering technology from an institution accredited by the Engineering Council plus an applicable graduate degree at the masters or PhD level, or equivalent demonstration of advanced skills; and
- Completion of an 'assessment of competence and commitment', including an interview with assessors from an authorized professional institution. Like the IEng, there is no specified time requirement for obtaining the necessary competence and commitment required for the CEng designation – it is dependent on the person and their work experience (Engineering Council, 2019).

According to the Engineering Council (2019);

> use of the word 'engineer' in our language has evolved over many centuries. Hence anyone in the UK may describe themselves as an engineer. Seeking to regulate or legislate on the use of a now common term is recognised by the Engineering Council as totally impractical.

The IEng and CEng titles are protected and can only be used by people who hold the associated designation in order to provide transparency to the general public and to combat misrepresentation by those without the proper qualifications,. Despite limited requirements for licensure, the Engineering Council reports there are over 220,000 people registered in the UK, however this number includes not only IEng and CEng designations, but EngTech and ICTTech designations for engineering and information and communication technologists as well (Engineering Council, 2019).

Summary

From the four global regions explored, it is clear that while there are some similarities, there are differences in how engineering is regulated, and particularly, with regards to the protection of the word 'engineer'. For those jurisdictions where 'engineer' is protected (Canada and the U.S.), there could be a spectrum of opinions and perceptions about this title protection by engineering graduates, bounded by two dichotomous viewpoints. On the one hand, graduated engineers may feel compelled to register to gain the right to practice, while on the other hand, they may feel turned off by this institutional and legal requirement and, therefore, may choose not to register. In between, there are likely various scenarios that lead those who have graduated from engineering programs either towards or away from licensure, such as registration (or non-registration) due to job (or lack of job) requirements, the relative rigor (or ease) of the licensure process itself, a lack of financial incentive to pursue licensure, time constraints, a decision to pursue work outside of engineering and so on. Since understanding views and perceptions of engineering licensure is one of the key research areas in this study, it is useful to have knowledge of the regulatory system used in Canada as well as in other parts of the world for comparison.

The following section will explore research and studies previously undertaken related to understanding factors that lead women towards or away from pursuit and persistence in licensed engineering environments.

Previous Research Related to Career Persistence of Women in Engineering

While conducting a search for previous studies related to persistence of women in engineering practice, it was clear that a large number of studies have been completed in the area of retention, attrition, and persistence of women earlier in the pipeline, namely in the areas of K-12 and postsecondary engineering education (Baram-Tsabari & Yarden, 2008; Abri, 2006; Geisinger & Raman, 2013; O'Callaghan & Enright Jerger, 2006). Much less academic research

has been conducted in the area of career persistence of women in the engineering workplace, and in particular, understanding why women leave engineering using a qualitative research approach. The studies that do exist are often conducted outside of academic settings by sector groups and industry organizations. The following sections outline both the academic and advocacy related research carried out in four key global areas (which align with the regulatory environments explored earlier in this chapter); Canada, the United States, Australia, and the United Kingdom. Due to the varying imperatives for licensure in different jurisdictions, the geographic regions are reviewed separately.

Studies in Canada

As mentioned earlier in this chapter, the Canadian engineering environment is unique in its professional regulation in that the title of 'engineer' is protected and thus licensure is tied to the identity of oneself as an 'engineer'. As such, it is important to understand if any studies related to the attrition or retention of women in engineering in Canada have been conducted. Upon review, it appears that there has been limited academic research conducted from a Canadian perspective. A study conducted by Gillian Ranson (2003) examined the career paths of 164 women and 153 men who graduated from a Western Canadian engineering school between the years of 1980 and 1990 – notably a turbulent time for the oil and gas industry. While the focus of the study was to examine if the experiences of women working in engineering differed substantially from their male counterparts, the study did reveal that 8.5% of the 164 women surveyed were no longer working in an engineering occupation and an additional 10.4% were not in paid employment at all. This hints to a persistent problem in retaining women in the profession in Canada, even though this study examined a very specific cohort of female engineers. One of the key findings of this study related to differences in men's and women's

views of ‘autonomy’ in the workplace. Men viewed autonomy at work as a control function that allowed them to be ‘in charge’ of the work they were doing. When women were asked to define autonomy at work, they defined it as control that allowed them to be ‘flexible’ with their work in terms of setting in-office hours, allowances to make-up time to attend non-work related appointments, and the freedom to prioritize their daily tasks (Ranson, 2003). The importance of flexibility in the workplace is a theme that is reiterated among many studies related to women’s experiences in engineering.

Closer to home, two notable studies related to women’s experiences in engineering specifically in Manitoba have been conducted. Both of these studies arose from a larger mixed-methods study carried out in 2005 that examined career attitudes of engineers working in Manitoba through a two-phase process involving surveys and interviews. The first sub-study, conducted by Ingram and Mikawoz in 2006 examined the stories of three women engineers under the age of 30 who were currently working in engineering and had been part of the cooperative education programs available to them in the Faculty of Engineering at the University of Manitoba that provided them with two or three work terms in industry ranging in length from 4-16 months each throughout their degree. The authors found that the opportunities for networking and mentorship afforded to them through their work experience placements as students put them in a positive position for full-time job advancement in their early careers. Despite this positive career outlook, Ingram and Mikawoz noted that all three participants were already expressing concerns about the future and how children and a need for increased work-life balance could affect their career trajectory (Ingram & Mikawoz, 2006). These comments could be viewed as a sign of an impending leak in the pipeline. The data presented in this study also provide evidence that, in 2006, the primary role of family-care still appears to fall on women, a

responsibility that may result in a need or desire to shift career focus. This finding is something that likely still holds true in many households today.

In a second study using a 2005 dataset, interviews were conducted with 18 mid-career stage women who had been working in engineering for 20+ years (Ingram, 2007). This group of women represents a unique dataset in that they were among the first engineering graduates to begin working at a pivotal point in the Canadian societal and political climate with respect to legislation aimed at increasing diversity in the workforce (sometimes referred to as 'quotas' or 'affirmative action policies'). These women were also among the first to see paternity leave and other family-related policies be established and implemented. While only highlights from three participants were included in her study, and all worked at the same utility company, there were notable observations from the data. First, the experiences of the three women, all of whom graduated around the same time and worked at the same organization, were all different, thus underpinning the belief that women's career paths in engineering are multi-dimensional and individual. Secondly, Ingram noted that it was large, government-owned organizations that led the way with implementation of family-friendly policies and were seen as more progressive, whereas policies in smaller, consulting organizations were now well understood, but were presumed to be less progressive. While this study is over a decade old, it is likely that disparity in equitable policy development still exists in some smaller organizations today. Finally, Ingram notes that while these women were "beneficiaries of societal and organizational progress" they did not have the opportunities of mentorship and cooperative education programs afforded to them that are available to young women today, yet these women still persisted (Ingram, 2007).

While the literature review did not uncover any additional academic based studies conducted in a Canadian context that directly relate to this research, there have been a number of

advocacy-based initiatives in this area. In 2017, the Ontario Society of Professional Engineers (OSPE) was awarded a grant from Status of Women Canada, a department of the Federal Government. With this funding, OSPE initiated a campaign called 'Breaking Barriers for Women in STEM' to better understand barriers that women face in these sectors. In May 2018, OSPE released a report entitled 'Calling all STEM Employers: Why Workplace Culture Must Shift to Change the Gender Landscape'. This report is based on data collected through responses to 2956 surveys across Canada, as well as data from focus groups and interviews held with 81 participants from across Ontario (OSPE, 2018). The results of this study indicate that women across all areas of STEM face similar challenges and barriers which include; feeling undervalued for their contributions, lacking role models or mentors, gender pay gaps, work-life balance issues, and lack of a professional network. These barriers tend to decrease in areas and organizations where there is higher female representation, except for the barrier of a lack of work-life balance – this issue persists despite increased gender diversity in the workplace. While the results of this study are insightful and reflect other research findings, it is important to note two weaknesses with regards to the approach used. First, while focus group sessions and interviews were used (granted they were limited to participants from Ontario), the study gathered the majority of its findings through the use of surveys with predetermined list of response options for selection by participants. This approach minimizes not only the researchers' opportunity to 'dig deeper' on certain topics as might be found in a qualitative study, but it may also compromise the data as participants may feel compelled to select responses that may not represent their true feelings and perceptions but may seem more culturally acceptable, or their true response is not available in the set of available responses. Secondly, while there were extensive amounts of data collected through the surveys, focus group sessions, and interviews,

the epistemological approach and theoretical framework was not articulated, nor was a conceptual framework for comparison developed.

Studies in the U.S.

One of the largest and most well-known studies related to attrition and retention of women in engineering in the U.S. is the Project on Women Engineer's Retention (POWER) that was carried out from 2009-2012. The project is summarized in the report entitled 'Stemming the Tide: Why Women Leave Engineering' (Fouad, Singh, Fitzpatrick, & Liu, 2012). The study surveyed 5,562 female alumni from over 300 American universities who graduated with an undergraduate degree in engineering. Based on survey responses, the women were placed into one of four categories; those with an engineering degree who never worked in the engineering profession, those who left the profession less than five years ago, those who left the profession more than five years ago, and those who remained in the profession. The study found that 10% of women with engineering degrees never actually worked as an engineer, and an additional 27% had left the profession (Fouad, Singh, Fitzpatrick, & Liu, 2012). Beyond capturing statistics, this study also explored *why* some women left (or never entered) engineering and why some women stayed in engineering. The top five reasons cited by the women who did not enter the profession after graduation include; a lack of continued interest in engineering, a dislike for the engineering culture, a long-held intention to pursue another profession, concern over inflexibility in the workplace, and a desire to start their own business (Fouad, Singh, Fitzpatrick, & Liu, 2012). Of the women that left the profession, the main reasons cited included; poor working conditions, too much travel, lack of opportunities for career advancement, low salary, undesirable workplace culture (including management), and desire to spend more time with family (Fouad, Singh, Fitzpatrick, & Liu, 2012). While this study provides some important insight into why women

leave engineering, it is important to note that this study was conducted under the auspices of advocacy as opposed to academic research. As such, theoretical frameworks and research methods are not clearly articulated.

Nevertheless, some of the reasons cited by Fouad et al. align with the academic research carried out in another large American study conducted by Hunt (2016), and include similarities such as dissatisfaction over salary and opportunities for advancement, and changes in career interests. However, a significant difference is that Hunt's research finds that family-related issues were not a major contributing factor to women leaving the engineering profession (Hunt, 2016). As more and more Millennials enter the workforce looking for increased work-life balance (Main, 2017) it will be interesting to see if Hunt's conclusions hold true as her research, though published in 2016, is based on data from the 2003 and 2010 National Survey of College Graduates, which is now more than a decade old. Her study included a sample of 5,532 female engineering graduates. In addition to her findings on why women leave the profession, her study also found that 15.5% of women with engineering degrees were working in a field other than engineering, while an additional 28.4% were working in fields that were only 'somewhat related' to engineering (Hunt, 2016). These numbers are in fairly close alignment to those found by Fouad et al. (2012).

Similar to the OSPE Breaking Barriers study, a study by Yonemura and Wilson (2016) aimed to understand barriers that exist in the engineering workplace. They, however, took a qualitative approach and examined these barriers by interviewing 45 people (64% of whom were women) who graduated from engineering or computer science programs between 1998 and 2015 at various universities across the U.S. The research focused specifically on gathering data to understand the types of negative conditions women experienced in the engineering workplace

and compared that to the conditions that men experience. The study found that the women interviewed experienced negative working conditions that manifested as a hostile work environment, a sense of isolation, a lack of clarity in career paths, penalties for risk-averse individuals who are not comfortable making a 'Diving Catch'. In this context, a 'Diving Catch' refers to a situation in the workplace that requires extreme effort in a high pressure environment, much like a baseball fielder diving to catch a ball. Men, on the other hand didn't report 'Diving Catch' as a negative working condition (but rather saw it as something to be proud of having experienced), and their descriptions of 'hostile work environment' were less focused on gender-related issues (Yonemura & Wilson, 2016). The main limitation of the Yonemura and Wilson study is that all participants interviewed were still working in engineering, so while their perspectives are certainly important and valid, their experiences may not emulate those that have taken the next step and have exited the profession.

In 2017, Fouad, Chang, Wan, and Singh extended the work from the 2012 Stemming the Tide study into a qualitative study entitled 'Women's Reasons for Leaving the Engineering Field'. This study analyzed the data collected from the 1464 women engineers who had left the engineering profession as indicated in their 2012 survey responses (Fouad, Chang, Wan, & Singh, 2017). In this study, Fouad et al. used the person-environment fit theory called the Theory of Work Adjustment (TWA) as a tool for understanding why people leave their jobs and the factors that lead to these decisions (Dawis & Lofquist, 1984; Dawis, 2005). The results from this study indicate that women left the engineering profession due to; a work environment that was inconsistent with their expectations with respect to pay, working conditions, and flexibility; an inability for them to effectively use their technical skills; and insufficient recognition and opportunities for advancement. These findings align with the work done by Hunt (2016).

A 2019 study by Ettinger, Conroy, and Barr surveyed 251 late-career and retired women engineers who graduated from U.S. colleges in the 1970's, which is seen as the decade of the start of growth of women engineering schools. Through open-ended survey questions, their study explored the challenges faced by these women during their engineering careers, if they felt that these challenges had changed over time, and advice that they would have for young women considering a career in engineering today. With regards to challenges faced by these women, the findings echo those of Fouad et al. (2012) and Hunt (2016) in that participants indicated that they felt they didn't experience the same level of respect, recognition, or opportunities for advancement as their male counterparts. While mentorship programs, benefits, (such as parental leave and flextime) were more readily available at their organizations later in their careers, many women still identified a lack of cultural fit and a lack of work/family balance as critical issues they faced. While the authors report that there were some similarities in responses across engineering disciplines and industry sectors, certain industries, notably construction and manufacturing, were seen to be more challenging environments for women engineers to work in. When participants were asked if the challenges facing women engineers today are different than the ones they faced, the responses were varied. Some women reported slow progress in the areas of respect, recognition and cultural fit, while others said they felt that there was now gender acceptance in engineering. With regards to advice they would have for young women considering engineering as a career, again the responses varied from strong recommendations, to recommendations with reservations about ongoing gender discrimination to outright recommendations against pursuing engineering (Ettinger, Conroy, & Barr, 2019). These contradictory responses indicate that women's experiences are individual and often organization dependent.

With the exception of the Yonemura and Wilson study, the data from all other studies examined in the U.S context were collected solely based on surveys. While surveys are excellent tools to build a picture of *what* is happening, they have limited ability to explore the complexities of *why* and *how* it is happening. Additional insight into motivations to either stay in or leave engineering might be gleaned from a more personal interview or focus group approach as is proposed for this study.

Studies in Australia

A 2006 study by Mills et al. examined the engineering profession in Australia to identify areas of the engineering workplace that correlate to attrition rates of women and to develop recommendations for changes in the workplace based on the findings. The study included in-depth interviews conducted in 2002 with 51 Australian engineers (41 women, 10 men). Of the women interviewed, 26 were practicing, 4 had left the profession, 8 were contemplating departure, and 3 had taken time off and had returned to engineering. The study found that women's 'discomfort' in the engineering profession was tied to factors such as; workplace culture and a requirement to adapt to fit within the organization culture; lack of opportunities, and supports for work-life balance. These findings echo those of Fouad et al. and Hunt (Fouad, Chang, Wan, & Singh, 2017; Hunt, 2016). While the study was conducted as academic research, there was no information with respect to the epistemological approach or theoretical framework employed in the study.

As a counterbalance to examining why women leave engineering, it is also worthwhile to review studies that focus on what factors make women *persist* in engineering. A study conducted by Ayre, Mills and Gill (2013) examined a group of 76 female civil engineers that graduated from Australian Technical University (ATU) between 1974 and 2008. This cohort

was found to have a rate of persistence in engineering of over 70%. Interviews were conducted with 16 members of the cohort to further understand what led these women to stay in engineering. The study found that "a close match between an individual's expectation of personal fulfillment as an engineer and the reality of their workplace experience is strongly linked to remaining in the profession" (Ayre, Mills, & Gill, 2013). Ayre et al. suggest that companies wishing to retain female engineers need to; provide affirmation to their female employees of their competence as engineers, demonstrate a respectful and supportive workplace – especially from male managers and coworkers, and provide consistent leadership in the development and application of equality and diversity policies. The study concludes that women who feel a sense of community and belonging are those more likely to stay in the profession (Ayre, Mills, & Gill, 2013), which is corroborated by Hunt's finding that a lack of mentorship and networking opportunities are contributing factors for women leaving the profession (Hunt, 2016). Understanding if the recommendations provided by Ayre et al. hold for Manitoba's female engineers will be key to developing a path towards increased retention.

Studies in the United Kingdom

An advocacy-based study conducted by the Institution of Mechanical Engineers in the UK entitled 'Stay or Go: The Experience of Female Engineers in Early Career' found that nearly half of the women graduating from engineering programs in the UK will leave the profession within just a few years of graduation (compared to only one-third of men) and nearly two-thirds of women will not return to the profession after maternity leave. The research was broken into two parts. The first part was based on a qualitative sample of 26 STEM participants (12 being engineers) who were given topics to discuss (such as workplace culture or work-life balance) via an online forum. A researcher monitored the forum and examined comments for emerging

themes and trends. These qualitative assessments informed the development of a survey which was then administered as part of the second phase of the study. In the phase, 558 STEM participants (including 250 engineers from the UK and 104 engineers from Germany) were surveyed to determine if they had experienced certain factors such as discrimination in the work place or a requirement to 'fit in' to the corporate culture. The report cites differential treatment in the workplace as a culprit in why many women may choose to leave, but notes also that "the reasons why women choose to enter engineering employment and subsequently stay or leave, are as complex and diverse as the people who make up the profession" (Institution of Mechanical Engineers, 2017). While not academically grounded, this study does provide insight into experiences of women in the early phases of their career, which aligns well with this research study's focus on the Graduates Never Registered group.

Summary

Examination of the regulatory framework of the engineering profession in four distinct regions; Canada, the U.S., Australia, and the United Kingdom, revealed some similarities, but many differences as well. Of note, the Canadian regulatory environment appears to be the most rigorous with oversight and protection of both the right-to-practice and the right-to-title. In this environment, one's identity as an engineer may be perceived to be more aligned with regulation than in other jurisdictions examined.

While conducting the review of previous research studies on retention, attrition, and persistence of women in engineering, two key observations were made. First, while there is plenty of academic research that explores persistence of women during their engineering education, there is a paucity of academic research that aims to understand *why* women leave the engineering workforce at various points in their career. Further to this, the research that has been

conducted has been largely quantitative or survey-based, which limits the ability to gain a deep understanding of the phenomenon. However, there was substantial consistency observed in the studies that have been previously undertaken regarding the factors that contribute to women's decisions to persist or leave the profession. Women tend to persist in supportive work environments where they have a sense of belonging and career fulfillment, feel confident in their technical abilities and are supported by a respectful and equitable work environment. On the other side, the studies examined show that women leave when there is a lack of opportunity for advancement, if they lose interest in engineering or decide to pursue an alternate career path, but primarily they leave due to an unwelcoming culture and job inflexibility that leads to sacrifices with respect to work-life balance. The collective findings from the literature review are described further in the next section where they are developed into a conceptual framework for use in this study.

Conceptual Framework

A conceptual framework is described as "the researcher's synthesis of literature on how to explain a phenomenon" (Regoniel, 2015). Based on the literature review presented and summarized above, I have developed a conceptual framework that represents my understanding of the factors that enable and deter women's career persistence (or lack thereof) in engineering, based on the literature reviewed. This framework is presented in Figure 5 on the next page.

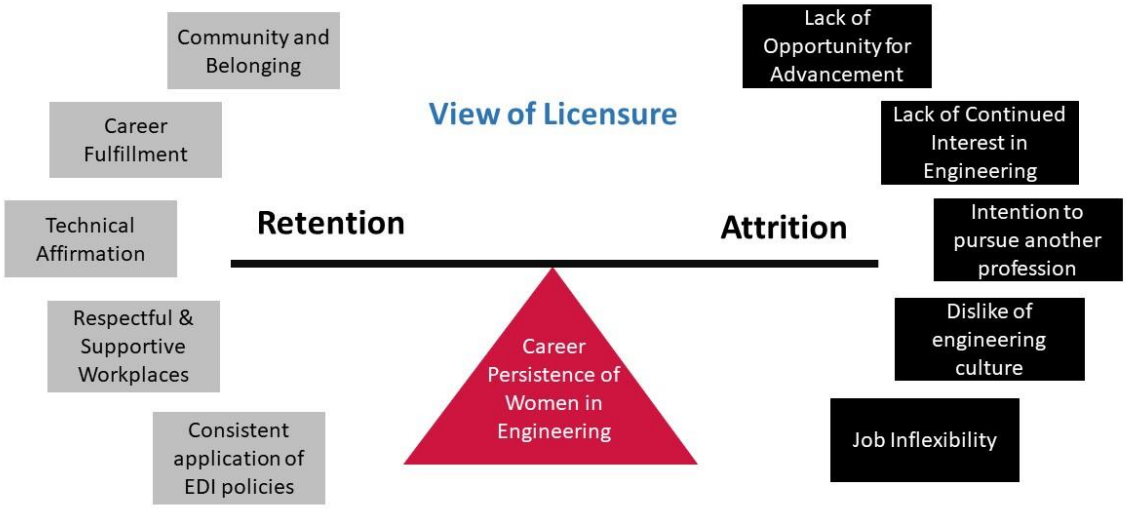


Figure 5: A conceptual framework for understanding career persistence of women in engineering

This conceptual framework illustrates the career persistence of women in engineering as a balance between retention and attrition. Throughout the previous research studies examined, women tended to stay in the engineering profession when they felt a sense of community and belonging, career fulfillment in the work they were doing, and received affirmation from colleagues and management about their technical abilities. Persistence in engineering also appears to be aligned with organizations that have respectful and supportive workplaces including the existence of equity, diversity and inclusion (EDI) policies, and where EDI policies are applied in a consistent and fair manner (meaning that policies such as parental leave and flex time are available and used by all employees, not just women).

On the other side, women tend to leave engineering when they are no longer interested in the field or when they decide to pursue another profession. However, the root cause for the lack

of continued interest in engineering by some women is not well understood but in some studies, can be tied to other retention issues such lack of opportunities for advancement, negative culture in the workplace or job inflexibility (Fouad, Singh, Fitzpatrick, & Liu, 2012; Fouad, Chang, Wan, & Singh, 2017; Hunt, 2016). In fact, these last three elements of attrition are dichotomous views to elements of retention shown in Figure 5, meaning, for example, that women experiencing a positive work environment are more likely to stay in engineering than those that don't. Therefore, the balance between retention and attrition of women in engineering is a fine one and is likely related to the conditions that women experience in their industry, workplace, and professional environment.

To explore this balance between retention and attrition from a Manitoba perspective, focus group sessions and one-on-one interviews were held with two groups of women; Former Practicing Members and Graduates Never Registered. The data were analyzed for common themes and patterns in order to facilitate a deeper understanding of why women leave the engineering profession in the context of a regulated environment. The data were examined relative to the conceptual framework in Figure 5 and were used to enrich the conceptual framework.

Chapter 3: Methodology

Introduction

As described in Chapter 1 (Introduction), the following research question guided the design of the study: *What are the elements of women's experiences in the engineering profession that both enable and deter their persistence in the profession, and how do these elements or factors interact with one another over time & space?* More specifically, the initial study design explored factors that contributed to choices to pursue engineering as a career initially, choices not to pursue licensure, choices to leave the profession, perceptions of the profession and the value of professional licensure.

The literature review contained in Chapter 2 illustrated that while there have been several large studies completed on understanding factors that cause women to either stay or leave engineering, these studies were primarily quantitative in their methodological design and were not conducted in the regulatory environment seen in Canada. This study attempted to address this chasm in our knowledge on understanding career persistence of women in engineering.

Due to the open-ended research questions considered for this study and to uncover insights that quantitative data and statistics cannot reveal, a qualitative research methodology was deemed most appropriate. This chapter outlines the justification for the qualitative research approach used, the epistemological lenses applied, the data collection and analysis methods employed, the data credibility, and the role of the researcher in this study. The second half of the chapter details the specific research environment, participant selection and recruitment procedures, protocols for data collection and analysis, the ethical considerations, and the limitations of the study.

Qualitative Research Approach

The research conducted as part of this study employed a qualitative research methodology. As the discipline of engineering is generally known to draw almost exclusively on quantitative research methods, this section briefly discusses these two common research paradigms and provides an overview of why qualitative research is a suitable methodology for use on this study on career persistence of women in engineering in Manitoba.

Quantitative research methods and qualitative research methods are the two most common paradigms or frameworks under which research is conducted (McMillan, 2012). In the quantitative framework, the assumption is that "the phenomena should be studied objectively with the goal of obtaining a single true reality, or at least a reality within known probabilities, with an emphasis on measurement, numerical data, control, and objectivity" (McMillan, 2012, pg. 11). Generally, the goals of quantitative research include proof of hypotheses, development of conclusions, and predictions of future events (McMillan, 2012). The sample size (i.e. the participant group) in quantitative studies tends to be large and randomized to aid to provide statistical significance and aid in study validity. While interviews may be used in quantitative research, they tend to use more structured, close-ended questions that allow for responses to be categorized and assessed numerically. Contact between the researcher and study participants tends to be short-term and impersonal, and data are analyzed in a deductive and statistical manner (McMillan, 2012). Inherent assumptions of quantitative methods include the existence of an objective, single, knowable reality, and the generalizability of the findings from the study sample to a larger population. Specific methods include descriptive statistical research, experimental research, and quasi-experimental research.

In contrast, qualitative research "stresses a phenomenological model in which multiple realities are rooted in the subjects' perceptions" (McMillan, 2012, pg.12). Rather than testing theories and proving relationships (as in quantitative research), qualitative research focuses on developing an understanding and description of multiple realities which are gathered from a small and select group of participants using data gathering techniques that commonly include open-ended interviews, embedded observations (ethnographic participation in the research setting), and narrative analysis of textual data. In many qualitative studies, the researcher intentionally becomes closer and more involved with the participants in order to build the trust required to gather the necessary data to support the study. Finally, data analysis in a qualitative study is generally textual, with structured techniques to provide insights, thematic development, and at times grounded theory. Thus, the data analysis in a qualitative study is interpretative, inductive, and often performed in parallel with data gathering (McMillan, 2012). The motivation of qualitative studies is to develop a deep understanding of a specific bounded context, in order to generate new theoretical insights into the phenomenon under study. Generalizability to a larger population may be serendipitous, but it is not a design goal of the methodology. Where quantitative research can often effectively answer questions of "who" and "what (is happening)", qualitative research can provide insights into "how" and "why" on the same phenomenon.

As discussed in Chapter 2, there have been numerous studies conducted on the issue of career persistence of women in engineering, but most have employed a quantitative approach using surveys and large, country-wide participant pools. The value that a qualitative approach brings is the ability to develop a rich narrative of stories, perceptions, and experiences of a smaller, more targeted study group. Thus, this study will utilize a qualitative research framework to examine two groups of women: 1) women who were registered with Engineers Geoscientists

Manitoba (as either an Intern or P.Eng.), but have subsequently let their registration/licensure lapse (this group will be referred to as Former Practicing Members), and 2) women who graduated from an engineering program at the University of Manitoba (at any level of degree), but did not pursue registration and/or licensure with Engineers Geoscientists Manitoba (this group will be referred to as Graduates Never Registered). Through the use of semi-structured one-on-one interviews and focus group sessions with each group of women (the process of which is discussed in more detail in the following sections of this chapter), I will be able to develop themes that related to women's career persistence in engineering in Manitoba which can then be examined in relation to the conceptual framework developed from the literature review in Chapter 2 (see Figure 5).

In the following sections, further details on the qualitative design used in this study are described. These sections describe the theoretical perspective employed, the data collection methods, data analysis and credibility, and the role of the researcher in this study.

Theoretical Perspective

According to Merriam-Webster, epistemology is "the study or a theory of the nature and grounds of knowledge especially with reference to its limits and validity" (Merriam-Webster, 2019). When undertaking any research, it is important to consider the epistemological paradigm by which the researcher is examining and interpreting the data. While there are a number of paradigms that can be used to describe one's belief system with respect to the nature of knowledge, there are two in particular that are relevant to this study and are discussed these below.

The first epistemological paradigm that this research follows is an interpretivist approach. Interpretivists aim to create open discussion between the researcher and the study participants in

order to gain a deeper understanding, or *interpretation*, of a phenomenon, experience, or situation. Interpretivism uses an inductive approach to research in that findings emerge as the research proceeds rather than gathering data to prove a hypothesis as is used in a positivist approach often associated with quantitative research (Cohen & Crabtree, The Interpretivist Paradigm, 2006). A key element of interpretivism is that understanding is obtained within a certain context, time, or place, thus participant-observer techniques such as interviews, observation, and analysis of participants' journals, diaries, or logs, are dominant data collection methods utilized in this paradigm. It is also true that an understanding gained through one researcher's interpretivist lens could differ than that gained by another researcher as "there can be multiple, valid claims to knowledge" (Cohen & Crabtree, The Interpretivist Paradigm, 2006). As such, researchers employing an interpretivist view are encouraged to consider the ethical and substantive validity of their work by reflecting on their own biases and seeking out alternative interpretations of the data (Cohen & Crabtree, The Interpretivist Paradigm, 2006). As this bias may be seen as a downfall of an interpretivist approach, it will be discussed further in the Limitations of Methodology section later in this chapter.

The second epistemological paradigm under which this study was conducted was that of feminist empiricism. Empiricism is an "epistemology that gives primary importance to knowledge based on experience" (Hundleby, 2011, pg. 28), which is certainly in line with the central purpose of this research study. Feminist empiricism, therefore, applies a feminist lens to the research in an attempt to explain how *women* experience a particular situation and environment, which may include social and institutional bias and inequity (Cohen & B, Assumptions of Feminist Paradigms, 2006). Again, as this is a study on understanding women's career persistence in engineering based on the views of women who were or are in this

profession, this epistemological approach is suitable. According to Olesen (1994) and Thompson (1992), feminist empiricists approach their research using standard qualitative and/or quantitative methods as they assume that any method can be a feminist method so long as women's views and perspectives are central to the research question(s) (Olesen, 1994).

In addition to understanding the study's theoretical approach from an epistemological perspective, it is critical to select the right *type* of qualitative study to carry out to ensure that the data can meaningfully address the research questions posed. For this study, a phenomenological methodology has been selected. Per McMillan, phenomenology seeks to "describe and interpret the experiences of participants in order to understand the "essence" of the experience *as perceived by the participants.*" (McMillan, 2012, p. 282). The concept of a phenomenological study was developed based on the work of philosopher Edmund Husserl in the 1900's and aims to understand "four aspects of a lived experience: lived spaced, lived body, lived time, and lived human relations" (Grand Canyon University - Center for Innovation in Research and Teaching, 2019). Phenomenological studies often focus on one central research question (in the case of this study, that research question is "*What are the elements of women's experiences in the engineering profession that both enable and deter their persistence in the profession, and how do these elements or factors interact with one another over time & space?*) and use a small participant group to gather individual perspectives which can then be correlated into themes surrounding a particular experience (Grand Canyon University - Center for Innovation in Research and Teaching, 2019).

Besides providing a deeper understanding of particular issue, phenomenology can also help expose misconceptions and can allow the researcher to examine an issue in the context of a larger environment. However, while a phenomenological approach has been selected for this

research, like all research methods, it is not without its unique challenges. These challenges will be discussed in the Limitations of Methodology section later in this chapter.

Data Collection Methods

Following a phenomenological, qualitative research methodology that aims to "describe and interpret the experiences of participants" (McMillan, 2012, p. 282), the most suitable data collection methods include focus group interviews and one-on-one interviews. Key features of these data collection methods are described below. Due to the human involvement in this study, Research Ethics Board (REB) approval was required. A copy of the REB approval form for this study can be found in Appendix A: Education/Nursing Research Ethics Board Approval Certificate.

The timing of the data collection events was as follows:

Participant Group	Data Collection Event	Date
Former Practicing Members	Initial Focus Group Session (5 participants)	September 17, 2018
	Interview – Participant #20	November 1, 2018
	Interview – Participant #27	November 13, 2018
	Interview – Participant #59	November 30, 2018
	Interview – Participant #21	December 17, 2018
	Follow-up Focus Group Session (4 participants)	April 18, 2019
	Interview – Participant #13	April 22, 2019
Graduates Never Registered	Interview – Participant M	April 1, 2019
	Interview – Participant S	April 3, 2019
	Interview – Participant X	April 15, 2019
	Interview – Participant A	April 29, 2019
	Focus Group Session (3 participants)	June 18, 2019

Figure 6: List of Data Collection Events

Focus Group Interviews

Focus group interviews were carried out with the participants in this study. Focus groups are a common method used in qualitative research to interview groups of people to glean their perspectives, thoughts, and experiences (Krueger, 1988). Within a research context, focus groups generally consist of a group of four to twelve people who share some common characteristics (usually ones that are related to the research study), but, ideally, who do not previously know each other. The limited size of the focus group allows everyone to be able to contribute while ensuring that people don't feel singled out (Krueger, 1988).

The approach used in a focus group session is to create a relaxed, conversational environment where the moderator introduces generative, open-ended questions to invite participants to engage in discussions. Often, participant comments feed off of one another, providing group insights that might not otherwise have been obtained through one-on-one interviews, which can be useful if time constraints prevent one-on-one contact with each participant. Other advantages of focus groups include its high face validity, relatively low cost, and ability to gather many sources of input in a minimal amount of time (Krueger, 1988).

For this study, I acted as the group facilitator and moderator for the focus group sessions. This is a very active and focused role, and it involved developing and presenting probing questions, guiding the discussion, and clarifying and expanding on comments as they arose with an over-arching view to extract detailed meaning and interpretation from participants rather than assuming meaning. An assistant moderator also participated in the focus group sessions to take notes on the mood, body language, and tone of the conversation as well as record interesting comments and remarks. The assistant moderators selected for this study were unfamiliar to the participants, but did have some knowledge of the study topic. Their presence was made to be as

unobtrusive as possible so as not to detract from the discussion. To maintain confidentiality, at the beginning of each focus group session, pseudonyms (a number, letter, or colour) were assigned to each participant and all notes and transcripts identified participants only by these codes. The focus group sessions were audio-recorded and transcribed. Notes, audio files, and transcriptions were held in secure files on my laptop. Data analysis relied on the transcripts, assistant moderator notes, and my notes.

One-on-One Interviews

Another common data collection method used in qualitative research are one-on-one interviews in which participants are individually interviewed by the researcher (McCracken, 2011). For the purposes of this study, the one-on-one interviews allowed me to follow up on commentary mentioned during the initial focus group (in the case of the Former Practicing Members group) and allowed for additional, sometimes more personal, information to be gathered from the participants. Interviews are considered to be a strong qualitative data collection technique as they allow for "greater depth and richness of information" (McMillan, 2012, p. 167), as the researcher can also observe non-verbal behaviours, which could indicate that further probing is required. While interviews do allow for the opportunity for additional probing and clarification, caution must be employed to ensure that researcher subjectivity doesn't lead to bias in interpreting the data (McMillan, 2012). The timing of the focus groups relative to one-on-one interviews also allowed for thought and reflection between the data collection events for all parties, which added to the insights brought to the next session.

One-on-one interviews were conducted with each participant in the study. Each interview was audio-recorded (with permission by the participants) and subsequently transcribed by a professional transcriptionist. During the interview, I took additional notes regarding key

points made, mood or body language of the participant, and other non-verbal cues that wouldn't otherwise be captured in the transcript. To aid in the comfort of the participants, I allowed them to suggest a location for the interview. As such, interviews were conducted in a variety of locations including; public libraries, coffee shops, restaurants, or the participant's home. An interview guide with probing questions was used to ensure key areas were explored (see Appendix D: Sample Interview Guides), I strived to maintain a relaxed and comfortable environment in which the participants felt comfortable sharing their thoughts and experiences. Referring to the interview guide throughout the interview also reminded me to be non-judgmental or leading in my comments to participants, and the continuously probe for meaning

Commonalities

Although one-on-one interviews and focus group sessions are considered to be two individual data collection techniques, there are some commonalities in their approach. For example, for both the interviews and the focus group sessions, I used interview guides to direct the flow of the dialogue. While the guides were not provided to the participants directly, in the invitations to the various sessions, general guidance was provided on the topics to be so participants were aware of the scope of the sessions. During the sessions, the interview guides were used to prompt discussion and to ensure all key areas were covered consistently with all participants, but were not read from verbatim.

It is important to note that the use of interview guides during both the one-on-one interviews and focus group sessions did not prevent my commitment to the qualitative research norm of emergent research design. As such, participants' comments were considered in subsequent sessions by adapting the interview guide as required.

With both the focus group sessions and one-on-one interviews, it was important to advise participants of the purpose, context, and motivation for the study (both from an EngGeoMB perspective, as well as my own motivation). Participants were also provided with details on how their confidentiality would be maintained throughout the study, they were given the opportunity to read and comment on the transcripts of any sessions in which they were involved, and they were invited to contact me at any time to discuss the status of the research or to review drafts of the research report.

Data Analysis

The way that data is analyzed in a qualitative study differs from that generally performed in quantitative research, due to the goal of inductive or emergent development of themes and potentially, grounded theory, rather than confirmation of an *a priori* theory. According to Lincoln and Guba (1985), data in a quantitative study are examined through deduction, verification, enumeration, and objective analysis (Lincoln & Guba, 1985). In qualitative research, data are often categorized as emic (data provided directly by the participants) and etic (the researchers interpretation of the emic data) (McMillan, 2012). The process of synthesizing emic and etic data in a qualitative study involves an approach that is inductive, generative, constructive, and subjective in nature (Lincoln & Guba, 1985). Thus, in qualitative studies, data analysis begins with the data and then derives hypotheses and theories from this data in an inductive and generative manner as opposed to starting with a hypothesis which is then either proven or disproven by the data, as is done in a quantitative deductive approach. Qualitative constructive analysis involves the development of themes arising from the data, but themes which are not necessarily based on 'counting' data points, but rather developed through analysis of participant comments. Finally, qualitative data analysis tends to be subjective in nature in that

themes are derived from terminology used by the participants rather than the researcher (Lincoln & Guba, 1985). Thus, data analysis in a qualitative environment is not a linear or mechanical process, it is one that is performed concurrently and iteratively with data collection through intuition and inductive reasoning (Taylor, Bogdan, & DeVault, 2016).

Qualitative data analysis involves three steps; data organization, data summary, and data interpretation (McMillan, 2012). Data organization involves reading through researcher and assistant moderator notes (etic data) and listening to audio recordings and reading through transcripts (emic data), to 'code' comments, phrases, or experiences that stand out. 'Codes' serve as a method for tagging data which can then be compiled into themes. Codes emerge from the data themselves, and once all data have been organized and coded, data summary can be performed. Data summary involves developing a short description to capture the nature of all the data exhibiting the same code. This leads to the development of 'categories' of data. A category "is formed from coded data as a more general and abstract idea that represents the meaning of similarly coded information" (McMillan, 2012, p. 299). Data interpretation then involves examining the categories for evidence of relationships or patterns among them that could lead to generalizations, themes, conclusions, or recommendations, and in relation to the conceptual and theoretical frameworks around which the study was developed. Data interpretation involves articulation of what the researcher has found and how this relates to the research questions posed and is often supported by participant quotes and researcher notes to help illustrate these points. Since the researcher plays such a central role in qualitative studies, a component of data interpretation is also an evaluation of the credibility of the data. Taylor, Bogdan, and DeVault (2016) recommend that researchers consider the impact that factors such as the researcher's role, their perspective on the research, the effect of other participants' presence, and solicited vs.

unsolicited comments, have on the findings of the study (Taylor, Bogdan, & DeVault, 2016). Data credibility is explored further in the following section.

Data Credibility

A research study is only useful if the data presented within it can be deemed to be trustworthy. In a quantitative research paradigm, trustworthiness is defined by the validity and reliability of the data. In a qualitative research paradigm, trustworthiness is defined by the credibility of the study. Credibility is "the extent to which the data, data analysis, and conclusions are accurate and trustworthy" (McMillan, 2012, p. 302). Credibility is essentially a gauge for how much confidence one has in the findings, themes, results, and conclusions that a study presents. According to Creswell (2009), credibility can be examined holistically using the following eight procedures:

1) Prolonged engagement (ensuring the study is conducted over a suitable period of time);
2) Member checking (allowing participants to provide feedback or interpretations on emic data);
3) Triangulation (ensuring data is collected from various sources, using various methods in various times and locations);
4) Negative case analysis (ensuring that contradictory views are examined);
5) Peer debriefing (obtaining feedback regarding credibility from a colleague who is familiar with, but sufficiently detached from, the study)
6) External audit (obtaining feedback regarding credibility from someone unfamiliar with the project);
7) Researcher reflection (including a self-reflection of biases, background, and perspectives); and

8) Thick descriptions (ensuring detailed and thorough descriptions - including verbatim quotes from participants).

Prolonged engagement was obtained by conducting the study over a period of approximately 18 months. The first nine months were focused on literature review, conceptual framework development, framing of research questions, participant selection, and development of interview guides. The following nine months were focused on data collection with time allotted between initial focus group sessions, one-on-on interviews, and follow-on focus group sessions to allow both the participants and myself to reflect on the study topic.

Both member checking and triangulation were used in the research. To satisfy the requirement for member checking, participants received electronic copies of the transcripts from both the focus group sessions and interviews in which they participated for review and comment. With respect to triangulation, the overall study's aim was to examine career persistence of two groups of women in engineering; Former Practicing Members and Graduates Never Registered. Further to this, the use of both focus group sessions and one-on-one interviews allowed for data to be collected from all study participants in a number of settings and times.

While external auditing was not formally conducted, negative case analysis was used in conjunction with peer debriefing as, throughout the study, discussions were held with my thesis advisor, my cohort of engineering education graduate students, as well as members of the CIPWIE committee.

While preparing for data collection, it became evident that my own perceptions and experiences may lead to biases within the study. Reflecting on my positionality within this

research topic became an important part of both the pre and post data collection phases of this study. My reflection on these biases is covered in the next section, *Role of the Researcher*.

The Methodology section of this report was written with 'thick descriptions' in mind in order to help clearly articulate the processes and procedures used so that others may replicate this study in a different environment. In the Findings section, details on the participants and quotes were used (while still maintaining confidentiality) to provide a rich narrative that demonstrates my deep level of engagement with the research.

Role of Researcher

A key differentiator between qualitative and quantitative research studies is the role that the researcher plays. By nature, quantitative studies should yield the same results when performed under similar conditions, regardless of who the researcher is (Sutton & Austin, 2015). However, in a phenomenological qualitative study such as this, the researcher plays a critical role in data collection, analysis, and subsequent interpretation, so the same study performed by a different researcher may yield complementary but different findings (Sutton & Austin, 2015). Thus, it is important that researcher positionality is established to identify, mitigate, and articulate biases such that the research findings can be understood in the context in which they were developed. In this context, 'biases' are not inherently pejorative, but identify positionality, which in the context of research "refers to the stance or positioning of the researcher in relation to the social and political context of the study – the community, the organization or the participant group" (Rowe, 2014, p. 628).

As part of establishing the positionality, identifying whether the researcher is an 'insider' or an 'outsider' is important. Insider researchers belong to the group that is under study, whereas outsider researchers do not (Sherry, 2012). Per Sherry (2012), insider researchers may have an

easier time accessing the desired participant pool due to preexisting relationships. Trust between participants and the researcher is often more easily established, which can lead to deeper, more meaningful participant input. Sometimes, however, participants can be leery about disclosing personal or sensitive information if they fear that their identity will be revealed. Thus, abiding by strict ethical guidelines is important (Sherry, 2012).

As a woman working in engineering in Manitoba for 20 years, I consider myself to be an insider researcher, even though I am a registered member of EngGeoMB and haven't left the profession. Having worked in both industry and academia, I have personal experience as to what it is like to be a woman in engineering, and have likely encountered cultural, workplace, and home-life issues similar to those of other women in engineering. Due to the pressures of working and raising three children, I have, over the years, contemplated alternate career choices, but have ultimately decided to remain in the engineering profession. This is a key element of my positionality relative to the study and to the participants. I was cognizant of the fact that some participants may think that I felt I was superior as I had decided to 'stick it out' in the profession. To combat this, I strived to maintain neutrality when engaging with participants, sharing enough information about myself to build trust, but not so much that I intimidated or turned them off. During data analysis, I made note of similarities in experiences between myself and the participants so that I could separate the two and ensure that I did not let my personal experiences override the participant stories.

Through my teaching and advising role as an Engineer-in-Residence at the Faculty Engineering at the University of Manitoba and my volunteer roles with EngGeoMB as the chair of CIPWIE and the coordinator of the Women in Engineering & Geoscience Mentorship Program, my name is recognizable by many women studying or working in engineering in the

province. While I believe this name recognition often served me well in my abilities to secure study participants, it also might have hindered the same. In all correspondence sent out requesting participants, my signature line included the term 'P.Eng.', indicating that I am a professional engineer. While wanting to be clear and upfront about my credentials, I recognize that some potential participants may have been turned off by these credentials and perhaps the perceived hypocrisy of a P.Eng. conducting a study on why women leave the profession. In addition, since the study was sponsored by EngGeoMB and conducted within the Faculty of Engineering at the University of Manitoba, there is a possibility that some women contacted to participate in the study chose not to do so due to concerns regarding confidentiality or due to negative experiences at either of these organizations.

In order to continuously be aware of my positionality throughout the study, I wrote analytic memos throughout the research process. These memos allowed me to step back from the data to try to look for trends or strategies to pursue going forward (Taylor, Bogdan, & DeVault, 2016). In addition, the use of interview guides and question prompts in both the focus group sessions, and one-on-one interviews provided a means for me to ensure that all important topics were addressed and that I didn't let my own perceptions influence the dialogue (McCracken, 2011).

The preceding sections of this chapter have provided an overview of the suitability of this research to a qualitative research approach, the theoretical framework used, the qualitative data collection and analysis, the credibility of the research, and the role of the researcher. The remaining sections of this chapter will focus on the specific research environment, recruitment, data collection, and data analysis protocols used and will finish with a discussion on the length of the study, ethical considerations, and limitations regarding the methodology used.

Research Environment

This study was conducted within the engineering environment in the Province of Manitoba. Manitoba has only one engineering school, the University of Manitoba – Faculty of Engineering, which offers bachelor, master, and doctor of philosophy programs in biosystems (biomedical – for graduate studies only), civil, computer, electrical, and mechanical engineering. The Faculty of Engineering had a total enrollment of 1807 undergraduate and 495 graduate students in the Fall 2018 academic term (including full-time and part-time students). 21.0% of undergraduate students and 27.9% of graduate students were female (Office of Institutional Analysis, 2019).

The profession of engineering in Manitoba is self-regulated through a professional association known as Engineers Geoscientists Manitoba (EngGeoMB). As per the 2016/17 Annual report (with year end June 30, 2017), EngGeoMB membership comprised 5904 Professional Engineers (9.6% of these were women) and 1459 Interns (17.5% of these were women) (Manitoba, 2019).

While these numbers help provide context on the size of the engineering profession in Manitoba, engineering students and current members of the association are not actually the desired participants for this study. Rather, this study aims to interview women who graduated from an engineering program at University of Manitoba and *did not* pursue registration with EngGeoMB (Graduates Never Registered), or are *former practicing members* of EngGeoMB (Former Practicing Members). Therefore, the research is situated within this group of women. Details on how women in these two categories were identified and recruited to participate in the study are provided in the section below.

Selection and Recruitment of Participants

For a qualitative study to provide useful and meaningful findings, the selection of an appropriate participant group is crucial. As opposed to quantitative study, where samples tend to be large and stable throughout the study, qualitative sample groups, in the context of a phenomenological study, tend to be smaller and should allow for flexibility of participant involvement in the data collection methods based on their comfort level.

As described in the previous section and in Chapter 1 (Introduction), this study identified two groups of women for investigation. The selection and recruitment of women in each of these two groups is outlined below. It should be noted that prior to the recruitment of any participants for this study, University of Manitoba Research Ethics Board approval was obtained (see Appendix A for the Research Ethics Board approval and study extension forms).

1) **Graduates Never Registered.** The target participants for this group were women who graduated from the University of Manitoba – Faculty of Engineering (ideally between the years of 2013-2016) but who did not register as an Intern with EngGeoMB.

Potential study participants in the Graduates Never Registered group were identified by obtaining a list, in accordance with REB privacy protocols, of female alumni from the Faculty of Engineering who graduated between the years of 2013-2016. This list was provided by the office of Advancement Services, Donor Relations at the University of Manitoba, and included contact information (mail and email) for all women obtaining engineering degrees at the bachelor of science, master of science, master of engineering, post-baccalaureate diploma in engineering, and doctor of philosophy levels. While it was possible for this list of graduates to be compared against the publicly available membership database found on the EngGeoMB

website to determine which women hadn't registered as Interns, it was determined by REB that this would be a violation of privacy. Therefore, an email was sent out to all alumni on the list (who had a Manitoba address listed) advising them of the study and asking them to complete a short survey to self-identify if they were not registered as an Intern or P.Eng. with EngGeoMB (or any other Canadian engineering regulator) and were interested in participating in the study. A copy of the survey, entitled *Recent Graduate Registration Status with Engineers Geoscientists Manitoba,* that was sent to the female engineering alumni can be found in Appendix B.

Women who responded to the survey and expressed interest in participating in the Graduates Never Registered study group were then sent a letter (via email) outlining the study in more detail and formally requesting their written informed consent to participate in the study. A sample of this informational letter and letter of informed consent can be found in Appendix C.

2) **Former Practicing Members.** The target participants in the group were women who were registered with EngGeoMB as either an Intern or a P.Eng., but let their membership lapse.

To determine the potential participant pool for the Former Practicing Members group, data were gathered by EngGeoMB by analyzing the membership lists year over year from 2013 to June 2018. Female-identifying members who did not renew their membership year over year during this period were added to an anonymized spreadsheet that included information such as date of initial membership, degree(s), engineering sector, and current membership status. Members not renewing their Intern or P.Eng. membership currently have three options available to them; withdrawn, written-off, or retired. Individuals are placed into the 'withdrawn' category if they contact the association to discontinue their membership. Individuals are 'written-off' if they do not pay the renewal fee and do not contact the association. Individuals can also request

to be placed into the ‘retired’ category, indicating that they are no longer practicing professional engineering, but wish to maintain membership (and use of the term P.Eng.) and voting privileges with the association. Retired status is offered at a reduced annual fee of $110 as of 2018 (Member Registration Fees, 2019). For the purposes of this study, women who entered the ‘retired’ category during the period of 2013 to June 2018 were included in the spreadsheet for initial analysis.

The spreadsheet of female Former Practicing Members prepared by EngGeoMB was forwarded in June 2018. In accordance with research ethics and privacy Acts, names and companies were removed by the association to protect the identities of the women. After analysis of the data, a list of target participants (identified by membership number) was prepared and sent to EngGeoMB. Details on the data analysis performed can be found in Chapter 4: Findings. The association, on behalf of the study, then sent an email to the target participant candidates notifying them of the study and asking them to contact me if they were interested in participating. Women who contacted me were sent further details on the study, along with the letter of informed consent as seen in Appendix C.

Data Collection Environment

Since this study focuses on women who have chosen not to pursue or continue to pursue licensure with Engineers Geoscientists Manitoba, it was important that all one-on-one interviews and focus group sessions be held at a neutral location (therefore not at either the Engineers Geoscientists Manitoba offices, or at the University of Manitoba) and in a location that was convenient for participants. The focus group sessions took place in meeting rooms at local public libraries, or, in one case, in the private room of a restaurant. The one-on-one interviews

were held in various locations selected by the participants including public library meeting rooms, coffee shops, restaurants, or in their home.

Focus group sessions were scheduled during a weekday evening timeslot so as to maximize participant attendance. One-on-one interviews were scheduled based on the availability of each individual. The majority of the one-on-one sessions were held in the evening (often coinciding with the end of the workday).

Compensation was not provided to participants for their involvement in the study, but, as an honorarium for their participation, the focus group sessions included dinner (pizza or sandwiches). Depending on the location and time selected for the one-on-one interviews, honorariums included coffee/tea or dinner.

Protocol for Data Collection

Data in support of this study were collected through the use of focus group sessions and one-on-on interviews held with the Former Practicing Members group and the Graduates Never Registered Group. The general process used when conducting these sessions was outlined in the section above entitled, *Data Collection Methods*. This section provides details on the specific protocol used for each group of study participants.

An initial focus group session was held with the Former Practicing Members group in September 2018 and took place at a local public library meeting room (a neutral location that was also central for participants). All five participants in this study group attended the focus group session. A follow-up focus group session with Former Practicing Members was held upon completion of the one-on-one interviews (with the exception of one) in a private room of a local restaurant in April 2019, with four of the five study participants in attendance. For the Graduates

Never Registered group, due to conflicting participant schedules, I was unable to organize an initial focus group meeting and instead chose to move directly to one-on-on interviews. A follow-on focus group session with the Graduates Never Registered group was held at a local public library in June 2019 and included three participants. All three focus group sessions were held from approximately 6:00-8:00pm to align with the availability of participants.

All three focus group sessions were moderated by myself with the support of an assistant moderator who took notes on the mood and body language of the participants and recorded key quotes or transitions in the discussion. The assistant moderator was positioned to the side of the group so as to be as unobtrusive as possible. Food and refreshments were made available throughout each of the sessions.

To create a relaxed atmosphere, and because participants did not necessarily know one another, they were invited to introduce themselves to the other group members if they felt comfortable doing so. The formal focus group session began with the assignment of a code for each participant to protect their identity. The codes used for the focus group sessions included numbers and colours (for the Former Practicing Members Group) and letters (for the Graduates Never Registered group). An audio-recorder was started to record the conversation to ensure that key points were captured. I then provided an overview of the research topic, reviewed the protocol regarding participant confidentiality and advised every one of their right to remove or revise comments from the transcripts or withdraw entirely from the study. The research questions were explored using an interview guide (as seen in Appendix D: Sample Interview Guides) for reference. I took care to ensure that all participants were able to contribute to the discussion as they felt comfortable and made notes on key issues raised that required further questioning. At the end of the focus group session, I thanked everyone for their participation,

advised them of the next steps in the research, and invited them to contact me if they had any questions or concerns. The assistant moderator and I conducted short debrief sessions immediately following the event.

The protocols used for one-on-on interviews were similar for both groups of participants. I held one-on-one interviews with each participant in the Former Practicing Members group between November 2018 and April 2019. Interviews with the Graduates Never Registered where held between April and June 2019. The interviews took place in various locations that were suitable to the participants including; library meeting rooms, coffee shops, restaurants, or their home. The sessions began with a few minutes of small talk to build rapport and put the participants at ease. During this time, the participant was invited to select a code that would be used to identify them throughout the interview and in subsequent transcriptions and documents. Participants in the Former Practicing Members groups selected a unique numeric code, while Graduates Never Registered selected alphabetic codes. An audio-recorder was used to record the interview for later transcription and data analysis. The interview began with a statement thanking the participant for contributing to the study, a review of the confidentiality protocol used for the study and a reiteration of their right to remove or revise comments from the transcripts or withdraw entirely from the study. The research questions were explored using an interview guide (as seen in Appendix D: Sample Interview Guides) for reference. Care was undertaken to ensure that my attention was focused on the participant and that any note-taking during their responses was minimal and was focused on key points for follow-up. At the end of each interview, I thanked the participant for attending, advised them of the next steps in the research, and invited them to contact me if they had any questions or concerns. Due to the nature of the probing questions used and personalities and openness of the participants, the interviews

varied in length from 30 minutes to 90 minutes. Following the interview, key take-away points were recorded from the session as well as points that required follow-up.

Protocol for Data Analysis

In qualitative research, data collection and data analysis are often performed concurrently (Taylor, Bogdan, & DeVault, 2016). As such data analysis began as the data were being collected via researcher notes taken during the interviews and focus group sessions. Once the sessions were complete, the audio files were sent for professional transcription and were received back within a 1-2 week period. Transcripts were double-spaced and the lines of text were numbered to facilitate researcher notes and coding. The transcripts were sent via email to the respective participants so that they could review the document and provide feedback or additional commentary. A researcher's notebook was also used to capture emerging themes and areas for further exploration. In this study, the emic data (data directly from the participants) was gathered via interviews and focus group sessions (which were transcribed) as discussed in the previous section. Etic data (data generated by the researcher) were gathered by synthesizing the transcripts and developing codes for key phrases or concepts. These codes were then used to organize the data. For this study, I used a combination of manual coding where printed transcripts were reviewed and 'marked-up' to help identify codes, and electronic coding using NVivo 12 software. An example both the manual and NVivo coding process can be found in Appendix E: Sample Coded Data. The coding process allowed me to examine the congruence between the emerging themes stemming from the data and the conceptual framework developed in Chapter 2 to identify areas for modification, expansion, or elaboration. Data analysis and interpretation of the organized, coded data was carried out until no new themes were identified.

During this process, I followed up with several participants via email to gather additional insight as required.

Timing and Length of the Study

Participant recruitment for this study began in summer 2018, upon receiving the Education/Nursing Research Ethics Board (ENREB) approval of the research protocol (#E2018:028 (HS21315)). A copy of the ENREB approval letter and extension letter can be found in Appendix A. Focus group sessions and one-on-one interviews were completed with the Former Practicing Members group between September 2018 and April 2019, and with the Graduates Never Registered group between March and June 2019. As is common with qualitative studies, the data collection and data analysis were generated congruently (McMillan, 2012), with data analysis extending through to summer 2019. Thesis writing took place between June and September 2019.

Ethical Considerations

While humans were used as participants in this research, there were no experimental treatments or interventions introduced during the study. Ethical considerations, therefore, relate to issues surrounding participant privacy, confidentiality, and anonymity. Since Manitoba has a relatively small engineering community consisting of one academic institution and approximately 7350 members in total (with only ~820 female members as of June 30, 2017) (Manitoba, 2019), it was important to ensure the confidentiality of the information provided by the participants. Confidentiality was addressed in the following ways.

Candidates in the Graduates Never Registered Group were contacted to self-identify their registration status with EngGeoMB and to indicate their interest in the study. While data regarding the registration rate of graduates was tabulated and assessed (see Chapter 4: Findings),

names were not used and graduates were not contacted on an individual basis to participate in the study. Data provided by EngGeoMB regarding Former Practicing Members did not include names or company information and candidates only became known to me when they contacted me directly to express their interest in participating in the study.

During the recruitment process, participants received information via the letter of informed consent (see Appendix C) regarding the confidentiality procedures to be used throughout the study including; use of pseudonyms in focus group sessions, interviews, transcripts, this thesis, and any papers stemming from this research; and removal of any identifying factors such as exact year of graduation or employers.

As indicated above, during interviews and focus group sessions, pseudonyms were used (different pseudonyms for each activity the participants were involved in). Transcripts and notes resulting from the interviews and focus group sessions were stored in a password-protected folder on my laptop which was securely stored in my work or home office. The transcripts were only provided to the participant(s) involved in the conversation upon which the transcript was based and to my thesis advisor and committee members as required.

Limitations of the Methodology

The final section of this chapter identifies some of the limitations of the methodology and procedures undertaken in this research. While some limitations are inherent to the research methodology selected, some limitations can be present due to the researcher involvement in the process. These limitations and the associated mitigation strategies employed are discussed below.

While interviews and focus groups are a commonly used data collection method in qualitative studies, they are not without their limitations. One potential issue is that they are situational, meaning that participants in a different environment, on a different day, may respond to questions in a different manner (Taylor, Bogdan, & DeVault, 2016). This can be further exacerbated in a focus group environment where participants may feel that they need to temper or adjust their responses based on the mood or tone of the group. The effects of these situational responses were mitigated somewhat since both one-on-one interviews and focus group sessions were held with each participant, thus allowing me to record and compare responses in two different situations. This approach also allowed me to spend more time with each participant thereby potentially building rapport and trust needed to elicit honest responses. A second limitation of an interview/focus group data collection approach is that it relies on researcher contextualization and interpretation of emic (participant) data. It is possible that the researcher could misinterpret a participant's comment with respect to tone or terminology. For example, if a participant provides a sarcastic response to a question, this sarcasm will not be identified in the transcript. Issues with contextualization and interpretation of participant data were mitigated by taking notes on the mood and tone of the interview/focus group, listening to the audio-recordings of the sessions while reviewing the transcript and adding mood and tone notes directly to the transcript, reiterating points made by participants for their agreement or clarification, asking questions in another way, and by providing copies of the transcripts to the participants for review, reflection, and additional commentary.

Another potential limitation with interviews and focus groups is the effect that the audio recording can have on both the participants and the researcher (Taylor, Bogdan, & DeVault, 2016). Similar to when people temper their comments in a group setting to meet the tone and

mood of the group, people may temper their comments if they know they are being recorded. To mitigate this as much as possible, I tried to establish rapport and trust with each participant by engaging them in non-research related conversations prior to beginning the data collection to help put them at ease. The interview questions were designed to be neutral in tone so that true responses could be obtained in a non-argumentative or defensive way. Finally, to minimize the 'fear factor' for the recorder (for both the participants and myself), it was placed in an unobtrusive place during sessions so as not to detract from the conversation.

A concern for researchers working in any research methodology is the risk that their biases or interpretations will affect the study results (Cohen & Crabtree, The Interpretivist Paradigm, 2006). Therefore it was critical that I remained aware of this risk and implemented strategies to mitigate it such as utilizing well-formulated interview guides and questions, clarifying points made by participants where necessary, and other trustworthiness measures reviewed earlier.

It is also important to note that the findings of this study are limited to the qualitative approach used and the research questions explored. Unlike quantitative research where the aim is to generalize findings outside of the study constraints, the results of this qualitative study apply only to the environment in which it was undertaken, the participants involved, and at a particular point in time.

This chapter has provided a detailed description of the qualitative research methodology used to better understand factors related to career persistence of women in engineering in Manitoba. Through focus group sessions and one-on-one interviews with Former Practicing Members and Graduates Never Registered women, data were gathered to explore participant experiences within, and perceptions of, the profession. The objective of this study is to establish

themes and patterns in order to facilitate a deeper understanding of why women leave the engineering profession.

Chapter 4: Findings

The results of this study uncovered themes related to the understanding of career persistence of women in engineering in Manitoba. This chapter provides details on the findings of the qualitative data collection and analysis protocols discussed in Chapter 3 (Methodology). The first two sections of this chapter provide an analysis of the data gathered as part of the recruitment process for both Former Practicing Members and Graduates Never Registered. This is followed by a section that provides information on each participant's background so as to provide context for the information gathered during interviews and focus group sessions. The remaining sections of this chapter focus on reporting the findings from the various sessions held, organized and presented according to themes that arose from the data. Chapter 5 (Discussion) will then expand on these findings by relating them to the conceptual framework presented in Chapter 2 (Literature Review) and expanding upon this where necessary.

Care was taken to maintain the integrity of the data by using verbatim quotations where possible to increase trustworthiness of the study and to protect the confidentiality of the participants. Occasionally, quotes have been modified to remove grammatical errors or to remove participant identifiers such as phrases of speech, organization names, or specific dates. A different pseudonym was used each time a participant was engaged in an interview or focus group session, so participants had up to three unique pseudonyms assigned to them throughout the study to further ensure confidentiality. Pseudonyms used included letters, numbers, and colours. Throughout, quotes from interviews are identified only by the participant pseudonym used for that particular session and the transcript page number where the quote was taken (e.g. M, 23). For quotations arising from the focus group sessions, the sessions are identified first by number (where 1 = the first focus group session held and 3 = the last focus group session held by date), along with the participant identifier, and transcript page number (e.g. FG1, Pink, 23).

Analysis of Former Practicing Members Data

Information regarding the participant pool for the Former Practicing Members group required access to member data held at EngGeoMB. In early July 2018, staff members at EngGeoMB provided a spreadsheet that included all self-identifying female members whose active membership with the association (as either an Intern or practicing P.Eng.) lapsed during the period beginning January 1, 2013 and ending June 30, 2018. Names were removed from the data so as to maintain confidentiality of the Former Practicing Members; however each data point was assigned a number in ascending order of the date of initial membership with the Association. While data were not provided for active members, gaps in the spreadsheet numbering indicate that women assigned to those missing numbers were still active members at the time of the review. Data provided on 'Former Practicing Members' included information such as discipline of study, location of study, date of degree(s), date of initial membership with EngGeoMB, any subsequent changes in membership status (such as a transition from Intern to P.Eng. or from 'Practicing' status to 'On Leave'), date of membership lapse, and membership lapse status (which will be detailed later on in this section). It should also be noted that the list of women whose membership lapsed between January 2013 and June 2018 was vetted by EngGeoMB to include only women whose first province of registration was Manitoba as it is common for engineers to be registered in multiple Canadian jurisdictions.

As of June 2018 there were approximately 1050 women (12.5% of total membership) registered with EngGeoMB as either Interns or P.Eng.'s. The list of Former Practicing Members provided by the association indicated that 195 women withdrew membership, moved to a non-practicing category, or otherwise let their membership lapse during this five-and-a-half year period. This number indicates a membership loss of approximately 18.5% of all female

members, and approximately 2.3% of total membership (men and women, Interns and P.Eng.'s). Review of the data revealed that 42 of the 195 women were Interns at the time of membership lapse (21.5%) and 153 were P.Eng.'s (78.5%). Data regarding engineering education indicated that 37% of non-practicing members obtained at least one of their engineering degrees from the University of Manitoba, 38% obtained at least one of their engineering degrees at another Canadian university, and the remaining 25% were educated exclusively outside of Canada. Nearly three quarters (74.3%) of the 195 women included in the data obtained an undergraduate degree in engineering, 19% have a master's degree and 6.7% have a doctorate degree.

The discipline of engineering study and work experience for all 195 women was reviewed and is summarized in Figure 7 below.

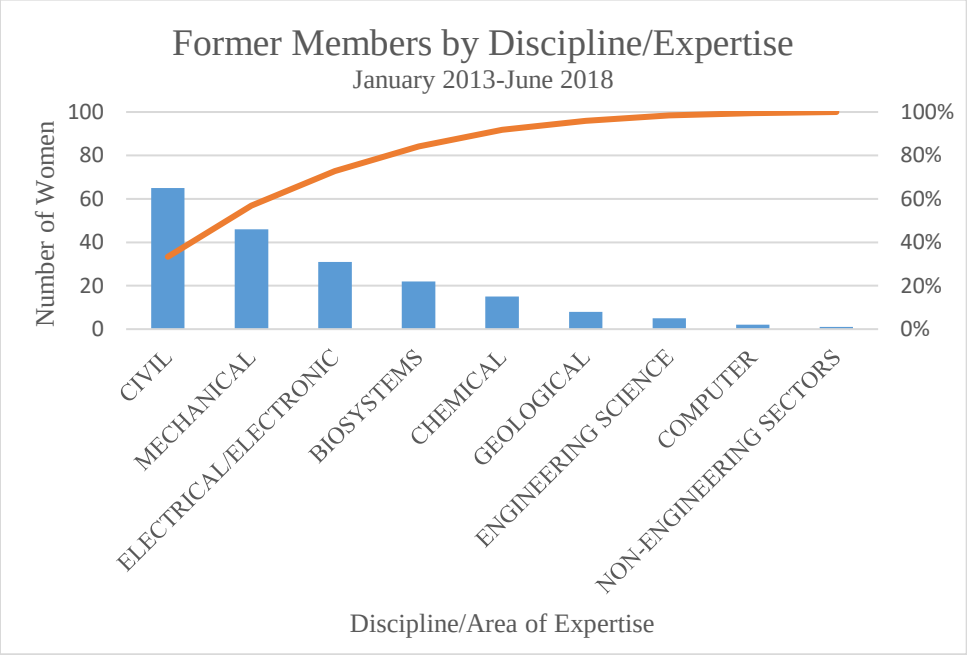


Figure 7: Former female members of EngGeoMB by area of discipline/expertise, Jan. 2013 – Jun. 2018

While employers were removed from the individual records to maintain confidentiality, staff members at EngGeoMB reviewed the data and provided a summary of the 'type' of

employer that these women worked for prior to their membership lapse. Figure 8 below identifies these findings.

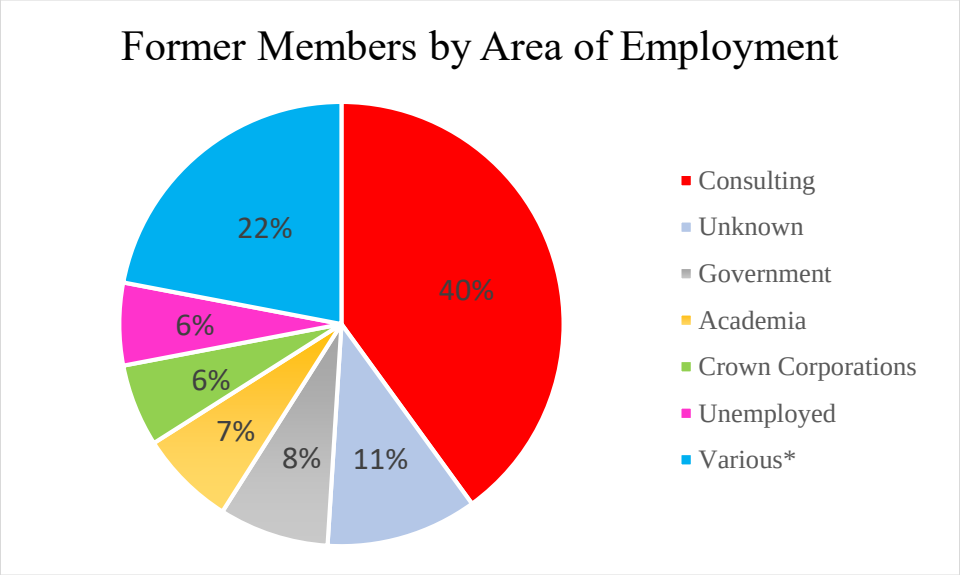


Figure 8: Areas of employment of female members whose membership lapsed between January 2013 and June 2018.

From the data, approximately 40% of Former Practicing Members worked in consulting, 11% had unknown employment (it is not a requirement for members to disclose their employer to EngGeoMB), 8% were government employees, 7% worked in academia, 6% worked for crown corporations, 6% were unemployed, with the remaining 22% split amongst other industries such as manufacturing, oil & gas, utilities, mining, and healthcare. These data were compared to the 2016 Salary Survey results tabulated by EngGeoMB (Engineers Geoscientists Manitoba, 2016). This survey was open to all 4,665 Association members who listed their primary residence as Manitoba. This number included Interns (engineering and geoscience) and Professional Engineers or Geoscientists and was made up of 4,018 mem and 647 women. Overall, the survey received 1,351 responses (84.8% of responses were from men, 14.7% were

from women). One of the questions on the survey asked participants to indicate the industry sector in which they were employed. The question was not mandatory, and as such, 968 responses were received (not broken out by gender). Based on the responses, in 2016, 23.6% of respondents worked in utilities, 21.7% worked in consulting, 7.8% in manufacturing and in construction, 7.2% in transportation, and aerospace 6.2%. The remaining categories were specified at percentages lower than 5% each to make up the total (Engineers Geoscientists Manitoba, 2016). These values differ significantly than those found with Former Practicing Members data, where they reported working nearly twice as often in consulting as was reported in the 2016 Salary Survey.

A year over year comparison of the discrete number of women whose active membership lapsed during the examination period revealed a startling trend as seen in Figure 9. Between 2013 and 2017, the number of lapsed memberships per year increased nearly fourfold, and the trend appears to continue into 2018 (considering that the 2018 data ended in June).

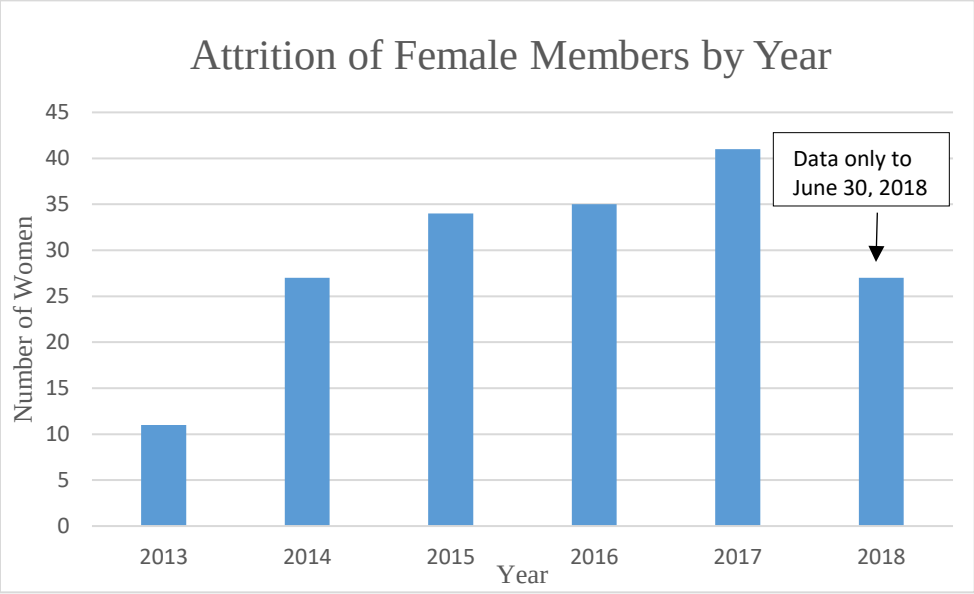


Figure 9: Number of female EngGeoMB members whose active membership status lapsed by year, from 2013-June 2018

One of the most critical pieces of information included in the data provided by EngGeoMB was regarding the various ways in which these women 'left' active membership with EngGeoMB (i.e. their lapsed membership status). This information helped to focus in on the subset of women most suitable to participate in this study. Figure 10 illustrates the various ways in which women let their active membership status lapse.

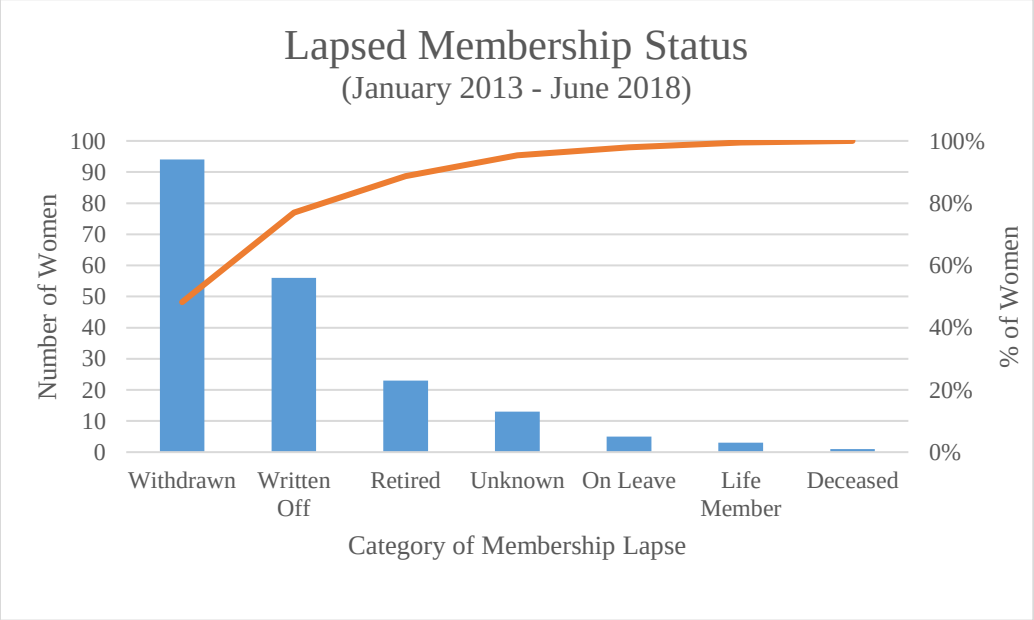


Figure 10: Reason for women's change from active to lapsed membership status with EngGeoMB between January 2013 and June 2018.

Former Practicing Members in the 'Withdrawn' category include women who contacted the Association to discontinue membership. 48.2% of women who let their membership lapse during the time period studied did so by actively withdrawing their membership. Those in the 'Written Off' category, which make up 28.7% lapsed memberships, include women who did not pay membership renewal fees, did not contact the association despite follow-up communication

regarding overdue renewal fees, and, therefore, were subsequently removed from membership. Members who no longer wish to practice engineering, but would like to maintain membership (and use of the term 'P.Eng.') and voting privileges with the association can request to be placed in the 'Retired' category for a reduced annual fee ($110 in 2018 per http://www.apegm.mb.ca/Fees/html#SpecialStatus). There are no minimum age requirements for Retired membership. Retired members are required to return their seal and, should they wish to return to active/practicing status, they must apply through the Continuing Competency Committee (Engineers Geoscientists Manitoba, 2019). During the period from January 2013 to June 2018, 11.8% of active female membership attrition was due to 'retirement'. An 'unknown' reason for membership lapse was identified in 6.7% of cases. The final three reasons for membership lapse (On Leave, Life Member, Deceased) make up the remaining 5.4% of women. EngGeoMB offers an 'On Leave' category for "Professional members who will be away from practice for several years and are intending to return to practice" (Engineers Geoscientists Manitoba, 2019). Members entering the 'On Leave' category are required to return all seals and are advised to maintain a record of professional development should they wish to reapply for active/practicing status. This is a relatively new membership category as it was only introduced via a bylaw change in 2016. 'Life Members' are engineers who have retired from active practice and all gainful employment, are at least 65 years of age, and have been a member of the Association (or another Canadian engineering regulator) for 30 years. Life Members pay no annual dues but are given the same rights, responsibilities, and privileges as members in the Retired category (Engineers Geoscientists Manitoba, 2019).

Of primary importance to this study are women in the first five categories, namely women who withdrew membership, were written-off, retired (at an early age), were on leave, or

were identified with an unknown reason for membership lapse. Also, since the study focuses on understanding factors that lead women away from the profession or professional licensure in Manitoba, it was important to distinguish women listed in the spreadsheet by age, last known residence, as well as category of membership lapse. For the purposes of the study, women, aged 55+ at time of membership lapse were removed from the participant pool. While their experiences in the engineering profession are important ones, their age and duration of active membership indicates that they persisted in the profession, and therefore, they are not the target study group for this research. In addition, women whose last known address was listed as outside of Manitoba were removed from the recruitment pool for a number of reasons. Due to limitations of the data available and its anonymity, I was not able to determine if these women were still practicing in another jurisdiction, nor was I able to determine how substantial their work experience in Manitoba had been. In addition to the fact that the study methodology was based on face-to-face interviews and focus group sessions and that I did not have budget available for travel, the ultimate reason for removing candidates with a last known residence outside of Manitoba was that it didn't align with the focus of the study, which is to understand career persistence of women in engineering *in* Manitoba. Once women aged 55+ (17 records) and those with addresses outside of Manitoba were removed (116 records), 56 target study participants remained. 35 of these women were Interns at time of membership lapse and 21 were professional members. The average age of this recruitment pool of women was 36 (with a low of 26 and a high of 51).

The list of 56 former active members was forwarded to EngGeoMB staff who, in accordance with privacy legislation, sent an email on my behalf to these women advising them of the study and asking them to contact me if interested in participating. Six women initially signed

letters of consent, but only five women went on to participate in the study. The findings from the interviews and focus group sessions held with this Former Practicing Members group will be described later in this chapter.

Analysis of Recent Engineering Graduate Data

In order to identify participants for the Graduates Never Registered group, I contacted the Advancement Services/Donor Relations group at the University of Manitoba and, following REB protocol, obtained a list of all women who graduated from the Faculty of Engineering between the years of 2013 and 2016. This list included names and last known contact information (email address) of women who had received Bachelor of Science, Master of Science, Master of Engineering, Post Baccalaureate Diplomas (awarded through the Internationally Educated Engineers Qualification Program – IEEQ), and Doctor of Philosophy degrees from any engineering discipline. While there were 269 female graduates during this period, the list provided by Advancement Services/Donor relations included information on 224 women based on contact restrictions requested by some alumni. Figure 11 illustrates the distribution of degrees awarded to 224 women between 2013-2016. Where women obtained more than one engineering degree during this time period, only the highest degree obtained is shown.

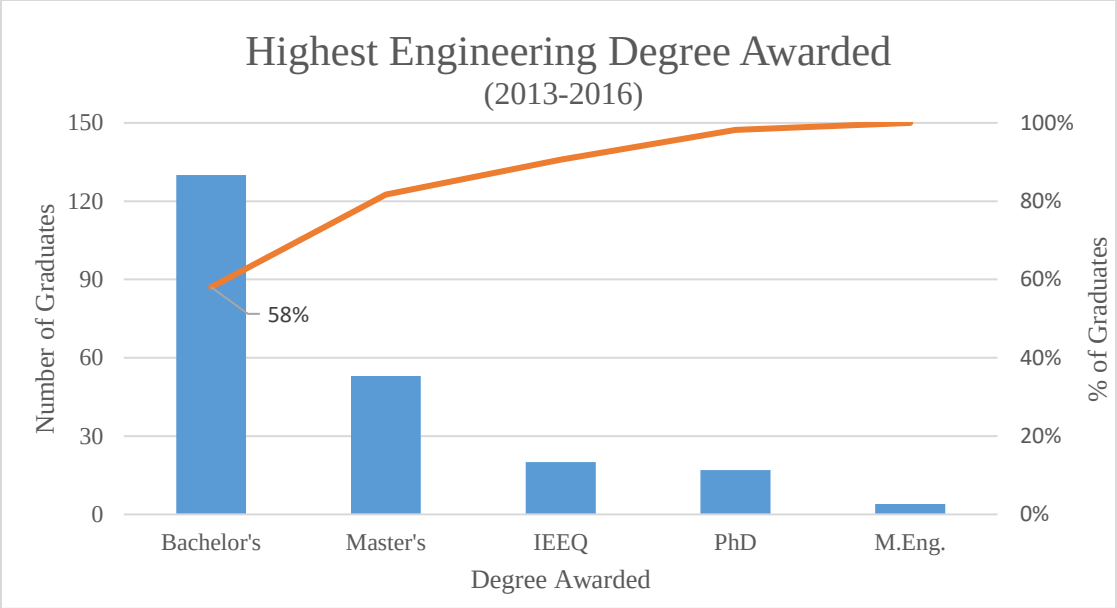


Figure 11: Degrees awarded to female engineering students at the University of Manitoba between 2013-2016

From the data, 58% of women graduated with a Bachelor's degree, 24% with a Master of Science degree, 9% from the IEEQ program, 7% with a PhD, and 2% with a Master of Engineering degree. Data provided by Advancement Services/Donor Relation included, for undergraduate degrees, details on the discipline of degree awarded. This information was not available for Master's or PhD degrees awarded. The distribution of undergraduate degrees by discipline is summarized in Figure 12 below.

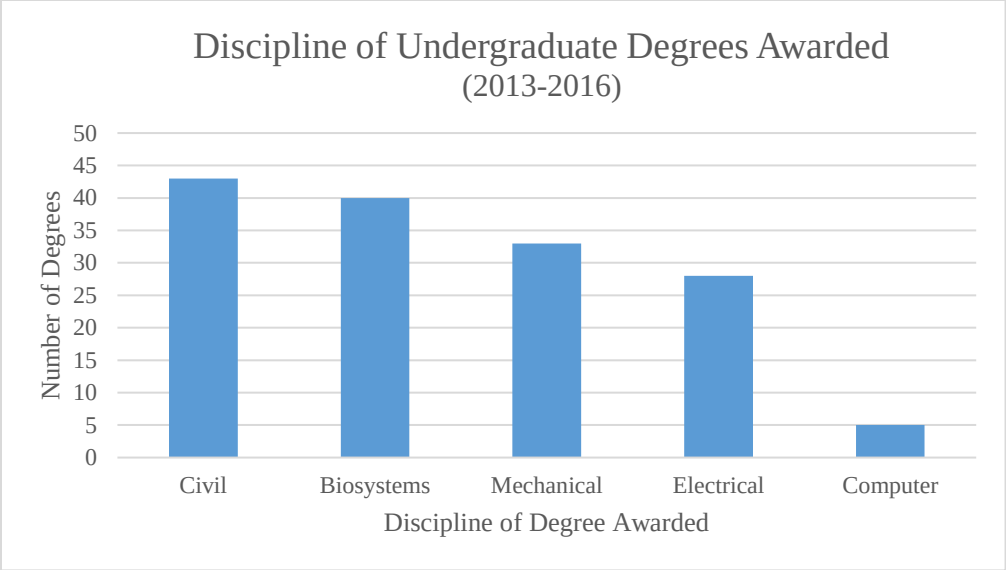


Figure 12: Discipline of undergraduate engineering degrees awarded to women at University of Manitoba between 2013-2016

Of the 149 undergraduate engineering degrees awarded to women, 29% were in civil engineering, 27% in biosystems engineering, 22% in mechanical engineering, 19% in electrical engineering, and 3% in computer engineering. These data align with the 'degrees awarded' data from 2013-2016 available through the Office of Institutional Analysis at the University of Manitoba (Office of Institutional Analysis, 2019).

Further review of the information provided by Advancement Services/Donor Relations revealed that 40 of the 224 graduates listed current addresses outside of Manitoba (quantity 34) or Canada (quantity 6). Since this study focuses on understanding career persistence of women in engineering in Manitoba, these 40 women were removed from the candidate pool. However, it is quite possible that not all of the remaining 184 graduates between 2013-2016 still reside in Manitoba as there is no requirement to update your personal address with the University of Manitoba upon graduation. Nonetheless, per the REB protocol, all 184 women were contacted

via the last known email address provided to Advancement Services/Donor Relations to advise them of the study and ask them to complete a short survey if they had not yet registered with Engineers Geoscientists Manitoba and were interested in participating in the study. Eight women responded to the survey, with three signing letters of consent to participate. However, due to various circumstances, only one was able to participate in the study in the end. An additional three participants in the Graduates Never Registered group heard about the study via word of mouth and reached out to me to participate.

While REB protocol restricted me from directly comparing the list of female graduates between 2013-2016 to the list of members of Engineers Geoscientists Manitoba as a tool for recruitment for the study, I was able to use these data to better understand the registration rate of recent engineering graduates. By removing anyone whose address with Advancement Services/Donor Relations was listed outside of Manitoba, I compared, name by name, the remaining list of 184 women against the publicly available membership directory found on the EngGeoMB website (http://www.enggeomb.ca/Directory.html). This comparison revealed that 113 out of 184 women (61.4%) were registered with EngGeoMB as either an Intern or a P.Eng. at the time of analysis (which was conducted in July 2018). Thus, 38.6% were not registered and working towards professional licensure. It should be noted that this number may not be completely accurate as there is a possibility that some of these women could actually reside in another province (as there is no requirement to update contact information as an alumni) and are registered in other jurisdictions. However, it is my assessment that this analysis forms a reasonable estimation of the "path to licensure" for engineering graduates in Manitoba when compared to the estimated calculated by Engineers Canada. In its 2018 National Membership Information Report, Engineers Canada estimated that only 47.7% of engineering graduates

(combined male and female) went on to pursue a professional engineering designation (Engineers Canada, 2018). The data regarding licensure pursuit of female engineering graduates in Manitoba appears to be significantly more favourable at 61.4%.

The recruitment phase described in this section itself provided valuable insights into the licensing choices and pathways of women in the engineering profession in Manitoba. These data are already a valuable contribution of this thesis, given that these data are not otherwise collected or correlated at EngGeoMB and/or the University of Manitoba. The findings from the interviews and focus group sessions held with the four participants in the Graduates Never Registered group are discussed later in this chapter.

The Study Participants

To provide context, this section presents background information on each of the study participants, including education and work experience. The Former Practicing Members group consisted of five women while the Graduates Never Registered Group consisted of four women. To protect the confidentiality of the participants, they are identified by the number (for Former Practicing Members) or letter (for Graduates Never Registered) that were used during the one-on-one interview sessions. In addition, details, such as exact year of graduation and companies of employment, have been removed.

Former Practicing Members

Participant #20 graduated with a civil engineering degree from a university in Ontario in the late 1990's. During her time in school, she participated in cooperative work placements at a

number of engineering organizations. After completing her undergraduate degree, she worked in the construction consulting industry at two different organizations and obtained her professional engineering designation four years after graduation. During this period she also took maternity leave for six months. She continued working in consulting while concurrently working towards a master's degree in civil engineering at the University of Manitoba. She finished her master's degree while on maternity leave. She extended this leave to five years and then returned to the workforce in an engineering role with a government agency. She worked in this role for five years and then took five years of personal leave before leaving her position and moving to the 'Retired' category with EngGeoMB. She is open to the possibility of returning to the engineering workforce and chose the 'Retired' category as it seemed to make this possibility more realistic as this status allows her to remain connected to the Association.

Participant #27 graduated with a mechanical engineering degree from the University of Manitoba in the late 1990's. She worked as a summer student at two different engineering firms during her undergraduate studies. Upon graduation she took a job with a small manufacturing company. After approximately two years she moved to a production engineering position with an aerospace company and approximately two years later moved to an engineering management position in the transportation industry. She obtained her professional designation approximately four years after graduation. Approximately six years after graduation she took an opportunity to own a small non-engineering related business. After the arrival of her first child, an imbalance in work and family led her to sell her business. For the last nine years, she has focused her efforts on her family. She is in the 'Retired' category with EngGeoMB. She is open to the possibility of returning to the engineering workforce in the future and chose the 'Retired' category as it

seemed to make this possibility more realistic as it allows her to remain connected to the Association.

Participant #59 graduated with an undergraduate degree in civil engineering from the University of Manitoba in the early 2010's. Upon graduation, she took a job with a small engineering consulting firm and registered as an Intern with EngGeoMB. She did not have any experience working in engineering prior to this position. After two years, she took a one-year maternity leave and then returned to work for one more year before resigning from her position to focus on her family, which now includes three children. She withdrew her membership with EngGeoMB approximately 2.5 years ago. She expressed interest in returning to the engineering profession when her children are school-age.

Participant #21 completed a science degree at an Ontario university in the mid-1990's and then, wanting to expand her job opportunities, completed an undergraduate degree in civil engineering degree at a different university in Ontario in the late 1990's. Due to lack of job prospects in Ontario, she relocated to Manitoba and worked in an engineering capacity for a government agency for approximately two years. She then moved to a utility company, and focused on planning, remaining there for five years and obtaining her P.Eng. designation. After taking approximately two years off for personal reasons, she returned to the workforce in two different non-engineering related roles before being hired as an engineering subcontractor in a government-funded program. When she became pregnant approximately 10 years ago, she left her position to focus on her family. She did not qualify for maternity leave as she was considered to be self-employed. For the last 10 years, she has focused on raising her two children. She is in the 'Retired' category at EngGeoMB. She is also open to the possibility of

returning to the engineering workforce at some point in the future and chose the 'Retired' category with EngGeoMB as it allows her to remain connected to the profession.

Participant #13 graduated with a mechanical engineering degree from the University of Manitoba in the mid-2000's. She did not participate in the Cooperative/Industrial Internship Program (Co-op/IIP) during her studies (the Co-op/IIP program offered at the University of Manitoba assists students in finding engineering-related job placements for terms ranging from 4-16 months to complement their engineering studies), but did spend one summer conducting research for a professor at the University of Manitoba and one summer working in industry in an engineering capacity. Upon graduation she took a position with a local manufacturing company in the sales department and registered with EngGeoMB as an Intern. After working there for four years, she left to pursue a degree in the arts in Ontario. She was a few months shy of obtaining her professional designation. Due to financial constraints while pursuing her second degree, she withdrew her membership with EngGeoMB. After completing her arts degree two years later, she remained in Ontario working for the parent company of the firm she had been with in Manitoba. During this time, she did not register with Professional Engineers Ontario (the regulatory body in that province). Approximately two years later she transferred back to Winnipeg and has been working in a senior level sales and marketing management position since. She has not reinstated her membership with EngGeoMB.

Graduates Never Registered

Participant A graduated from the University of Manitoba within the last five years with an undergraduate degree in mechanical engineering. She did not participate in Co-op/IIP during her studies, however, she did find her own engineering-related summer employment while completing her degree. She spent three summers working at a local utility company in the

programming department but was somewhat disappointed that the work didn't align with her engineering discipline. Hoping to find engineering summer employment that was more related to her discipline of study, the next summer she took a position with an aerospace company in the training department. In the final year of her engineering studies, Participant A worked on a capstone design project in the healthcare area as part of a required final year course in mechanical engineering and became very interested in this field. Upon graduation, she was able to secure a job with the healthcare organization that sponsored the capstone project and has been working there ever since. While the organization does have a small engineering department within it, she is not currently working in that department and does not describe what she is doing as engineering and, therefore, has not registered with EngGeoMB as an Intern. She is interested in pursuing either a graduate degree to advance her knowledge in the area she's currently working in or another position within her company that would have more of an engineering focus. If she were to secure a more engineering focused role, she would be interested in pursuing professional licensure and sees value in having such a designation.

Participant S graduated with a mechanical engineering degree from the University of Manitoba within the last five years. While she didn't participate in Co-op/IIP during her studies, she did find her own engineering-related summer jobs, spending three consecutive summers working at a local engineering consulting company. Upon graduation, she began working full-time with the same consulting firm. She quickly realized that she was not happy in this role, and, approximately eight months after graduation, resigned her position. After taking three months off, she took a summer job with a moving company. At the end of that summer, she found a permanent full time job unrelated to engineering with a small local company. She has been working there since and is very happy in her position. She was registered with EngGeoMB as a

student member and as an Intern, gaining nearly 18 months of experience between her summer and full-time positions, but withdrew her membership shortly after leaving the engineering consulting firm. Despite having registered with the Association, it seemed more reasonable to include her in the Graduates Never Registered study group due to her limited working experience and recent graduation.

Participant M graduated from the University of Manitoba within the last five years with an undergraduate degree in biosystems engineering and moved immediately into pursuing a master's degree in engineering. While in her undergraduate studies she did not participate in Co-op/IIP, nor does she have any other work experience in engineering. Having not yet worked in an engineering position, she is unsure if professional licensure if right for her or if her graduate studies work would qualify as experience towards her P.Eng. designation.

Participant X graduated from the University of Manitoba with a degree in industrial engineering in the early 2000's. She did not participate in the Co-op/IIP program, nor did she have any other engineering related summer or part-time jobs during her schooling. Upon graduation she took a position with a technology based healthcare firm for approximately a year doing time studies and process analysis. Looking for new opportunities she then spent a year at a local food and beverage manufacturing organization and focused on recruitment. Finding that this wasn't the right fit for her, she then transitioned to a term position in program management related to youth outreach. From there, she moved to a project management role at a local aerospace company where she worked for nine years. During this time she completed a certificate program in Project Management and obtained professional credentials in this area. She then transitioned to a term position in project management with a local utility company. When the term position ended, she took a project management role with a government agency

where she has been working for almost a year. Participant X contemplated pursuing her professional designation upon graduation and at several other points over the years, but, ultimately, came to the decision that her career path interests were in the area of project management and that a professional engineering designation was not required for this pursuit.

Key Themes Arising from the Data

The data analysis protocol outlined in Chapter 3 (Methodology), which included manual and electronic coding of transcript data, followed by organization and synthesis of the data, has allowed key themes and supporting sub-themes to be uncovered. Figure 13 is a pictorial representation of these key themes and sub-themes.

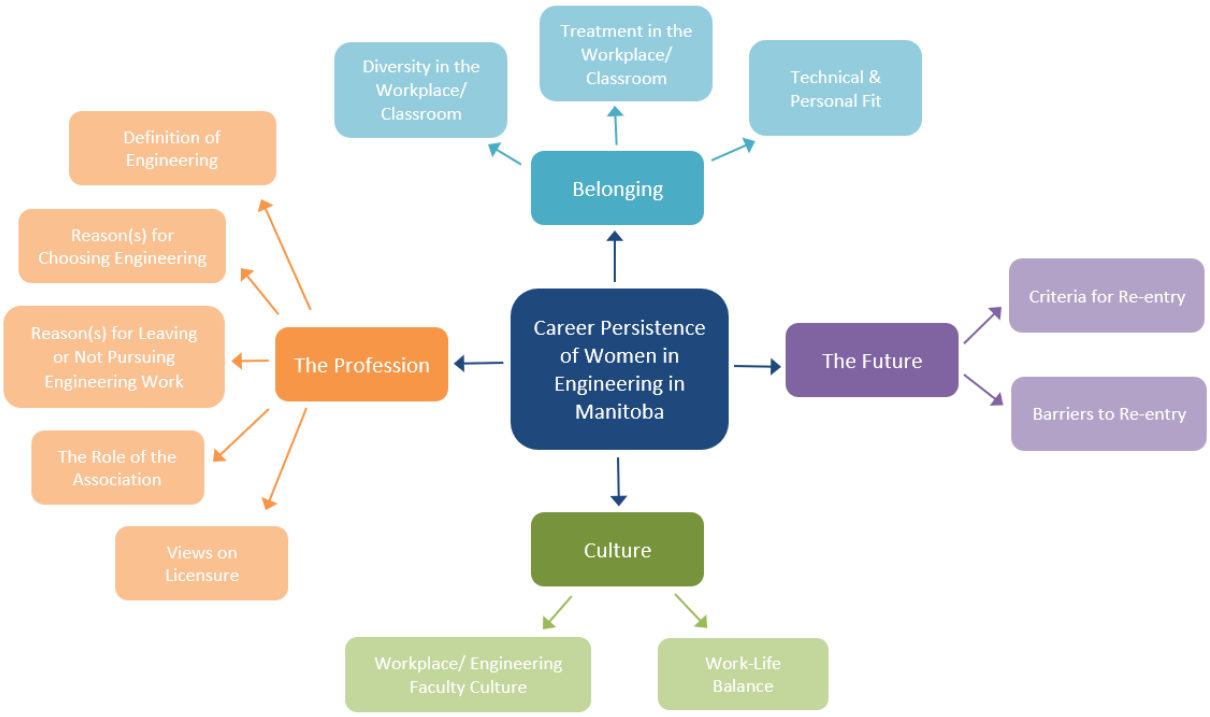


Figure 13: Themes and sub-themes arising from the data

The four key themes arising from the data include The Profession, Belonging, Culture, and The Future. Supporting sub-themes such as Views on Licensure, Technical and Personal Fit, Work-Life Balance, and Barriers to Re-entry act to provide additional insight into various aspects of each key theme. The following sections present the findings according to each key theme identified along with details on findings in each sub-theme and how they support and address the overall research question posed, which is: *What are the elements of women's experiences in the engineering profession that both enable and deter their persistence in the profession, and how do these elements or factors interact with one another over time & space?*

Perceptions of the Profession

From the data collected through interviews and focus group sessions, an overarching theme related to participants' perceptions of the profession arose. Under this main theme, supporting themes emerged, including; participants' definition of engineering, their reason(s) for choosing engineering, their reason(s) for discontinuing or not pursuing engineering licensure, their perceptions on the role of the Association, and their views on licensure. The findings in each of these supporting themes and how they tie to the overarching theme of The Profession are discussed in the sections that follow.

The Definition of Engineering

In its Act, EngGeoMB defines the practice of engineering as "any act of planning, designing, composing, measuring, evaluating, inspecting, advising, reporting, directing or supervising, or managing any of the foregoing, that requires the application of engineering principles and that concerns the safeguarding of life, health, property, economic interests, the public interest or the environment" (Government of Manitoba, 1998). While this is a lengthy definition, it remains somewhat vague as the term 'engineering principles' itself is not defined

and is, therefore, open to interpretation. Even though all participants in this research have studied engineering, when asked to define engineering, no one had a confident answer readily available. During the follow-up focus group session with Former Practicing Members, the group landed on a definition describing engineering simply as "problem-solving". This very broad definition helps illustrate the challenge that many engineers face when trying to describe what they do. As Participant Blue alleged:

> I asked a lot of people when I went into school, 'what does an engineer do?' and literally nobody could tell me. The best answer I got was, 'if you've seen or touched anything today an engineer was involved in its creation'. (FG2, Blue, 10/11).

Participants also agreed that:

> Engineers don't have the public face that many other professions have either. So a doctor, we know what doctors do because we go see a doctor, you know what lawyers do because you hope to never see a lawyer. And accountants, you know they deal with money and numbers, even if you're not sure what they do at their desks, but an engineer, what's the public face of an engineer? It's a much more challenging question. (FG2, Pink, 11).

The comments from participants seem to indicate that a lack of a clear definition of engineering interacts with a lack of desire or need to pursue licensure. In other words, if one does not have a clear picture that their work constitutes the practice of engineering, or how professional licensure would help them in their work, they may be less likely to pursue licensure. This is further discussed in the section below entitled Views of Licensure.

Reasons for Choosing Engineering

When asked why they chose to pursue a degree in engineering, the responses focused on an aptitude for math and science and the wide variety of job opportunities available in engineering. One said that engineering was "a four-year program where you could get out and there were lots of job opportunities, and the opportunities were diverse… I liked the idea of lots of options. And I liked the challenge of it" (#27, 15). Another participant indicated that "it seemed like engineering was a solid career compared to the sciences, and also the practical aspect that I thought was different than science" (M, 4). Participant #13 stated "What can I do as an engineer? Basically anything" (#13, 11).

Several participants indicated that they received encouragement to pursue engineering from influencers such as guidance counsellors, teachers, and parents, which on the surface can appear to be a very positive thing. However, while this encouragement was well-intended, it added to the pressure to make the 'right' decision regarding educational choices. For example, participant X stated "there was a big push from my parents actually… to be quite honest with you, I wanted to go into psychology" (X, 8). Participant S stated that she was influenced by a family friend to pursue engineering because she was good and math and science. She stated "so I applied and I got in, so that's why I did it. But I actually did not want to go to university but I went because I wanted to play sports" (S, 12). Participant A said that music was "actually my first choice" but that "you can't get a job in music…probably" (A, 15). And Participant #3 said "I was pressured to, you're good at math, you're good at science, you're a girl, you should go into engineering. I wanted to be an architect." (FG1, #3, 20).

Reasons for Leaving or Not Pursuing Engineering Licensure

From the data it was clear that there was no singular reason why the women interviewed left the engineering profession or chose not to pursue engineering licensure after graduation. However, some commonalities between participants were identified. For example, two women in the Former Practicing Members group stated that their decision to leave the profession was related to personal health implications (Participants #20, 21). Participant #20 stated "I was forced to retire for medical reasons…the story's more complex than that I guess, but that's the short version" (#20, 2). Due to the strenuous nature of her job, Participant #21 said that "when I found out I was pregnant, I thought, 'okay, we're not going to take any chances here', and it was hard for me to do, but I quit" (#21, 4). Factors related to work-life balance and family also played into participants' decisions to leave or to continue to stay out of the profession. Participant #27 stated that "right now my family's just gotten really comfortable with me being around home" (#27, 8), and Participant #59 described her experience trying to juggle working in engineering and raising a young family as follows:

> Daycare just didn't work. It just didn't work with site inspections, most of the time if I'm sent out for site inspections, I don't get home until 8 o'clock at night. It just didn't work (5). I couldn't really focus on what I was doing at work with what was going on with the kids and it was not worth it (13).

Participants A and M expressed concerns that the work they are doing wouldn't qualify as engineering so, therefore, they have postponed pursuing licensure. This brings into question what the definition of engineering work is, how well it is understood by graduated engineers, and how well it is articulated by the Association. These points were also discussed in the preceding section on The Definition of Engineering.

Of the participants that are still working outside of the home, only one, participant S, is working in an area that is completely unrelated to engineering and doesn't draw upon her engineering skills in her day-to-day tasks. Participants A, X and M, while having chosen not to pursue licensure at this point, are working in positions where their engineering skills do contribute to their success in their roles, even if they don't consider themselves to be working in the field of engineering. However, without assessment by the Experience Review Committee at EngGeoMB (the committee responsible for reviewing and assessing Intern reports as part of the licensure process), it is unclear if the work they are doing would be sufficient to constitute engineering practice and be considered as experience towards professional licensure.

Perceptions of the Role of the Association

In an attempt to better understand participants' interactions with, and perceptions of, EngGeoMB, they were asked to describe the role that the Association plays. This proved to be a heated question for some participants with responses that included "to monitor everyone's work" (A, 19), "to collect our money" (FG2, Blue, 15), and "I have my doubts about it when the membership goes up. I don't personally feel like I'm getting anything more back from it than I was getting before." (#27, 14). However, there was general consensus that the role of the Association is to protect the public by providing member oversight. As Participant Pink indicated "to me the role of the association is to at least give the perception to the public of safety and trust in the profession" (FG2, Pink, 15). However, what is evident from this study is that the value proposition of the association is not clear or well understood by some of its members and former practicing members.

Views on Professional Licensure

As a follow on to questions regarding the role of the Association, participants were also asked during interviews and focus group sessions to express their views on professional licensure. There was general consensus from participants that the P.Eng. designation is valuable, with Participant #59 indicating that achieving her P.Eng. designation was "the goal" (#59, 15), and Participant #27 remarking "I think there's some value. It does show an additional level of work experience that you put in and the fact that you've written an ethics exam" (#27, 13). However there was some indication by participants that perhaps the value of licensure is dependent on the area of engineering work. For example, Participant #27 stated "I'm not sure if it's valuable in other fields in engineering where they're not doing drawings or something that would be stamped, like computer engineering – there's probably not any value to having it" (#27, 13/14). In the Former Practicing Members initial focus group session, Participant #3 stated that if "you're in that grey area of engineering where its specifications and management and rather than [design], there are so few practicing engineers who actually use their stamp, a very small percentage. So if that was the bar, most practicing engineers wouldn't need their designation" (#3, 19). These comments indicate a perceived link between professional licensure and the use of one's professional seal as the right-to-practice.

While four of the Former Practicing Members participants have stepped away from the profession, all four indicated that they didn't want to step away fully from the profession in the event that they wanted to return in the future. As such, three of them found that 'Retired' status was the only Association membership category available to them at the time of their departure that kept this connection to the profession (the fourth Former Practicing Member decided to 'Withdraw' her member, but remains open to the possibility of returning to the profession in the future). In the initial focus group session with Former Practicing Members, participant #3 spoke

about her thoughts on staying connected to the engineering profession and maintaining her P.Eng. designation in the 'Retired' category: "It feels really hard to let go of entirely because I've earned it. And I don't know if the next phase of my career is going to require an engineering designation, it certainly may help but I don't know yet. I'm keeping it mostly for nostalgia" (FG2, #3, 18).

Summary

An interesting finding was that nearly all participants struggled to articulate a clear definition of 'engineering', despite having been educated in and, in some cases, even having worked in the field. When asked why they chose to pursue an engineering education, responses focused on two views; they chose engineering because it would lead to a wide variety of career opportunities, and/or they chose engineering because they either felt they were, or were told they were 'good at math and science'. This is evidence that influencers such as teachers, guidance counsellors, and parents can play key roles in determining career choices of young women.

It is clear from the comments provided by participants that their reasons for discontinuing practice or not pursing licensure are diverse and individual. While some expressed leaving to focus on family, this was not the sole deciding factor. Further to this, several participants indicated that they may wish to return to practice in the future. Graduates who have never registered expressed concern and a lack of confidence that their work would constitute suitable engineering experience towards licensure.

From the comments made by participants, it seems that while there is a consistent personal view that there is value in professional licensure overall as it is a sign of technical

competence, there is a less consistent view on the overall value of licensure in environments where there is no legal requirement for sealed engineering work.

Perceptions of Belonging

A second theme that emerged from the data was related to participants' sense of belonging (or lack of belonging) in the engineering profession. Findings on supporting themes related to belonging, including; diversity in the workplace or classroom, treatment in the workplace/classroom, and technical and/or personal fit, are explored below.

Diversity in the Workplace/Classroom

It was evident from the data that diversity in the workplace with respect to both gender and ethnicity and in terms of both the presence of and the attitude towards diversity is highly dependent on the organization. Some women interviewed worked in companies where there were lots of women in both technical and leadership roles. These tended to be large organizations or government agencies. Speaking to her role working in government, Participant #20 said it was "the most diverse group of people I've ever worked with, immigrants from different countries, different genders, sexual orientation, the whole gamut - a sprinkling of what you'd expect to see in the real world." (#20, 8). The smaller companies, consulting firms, and manufacturing environments in which the women in this study worked tended to be less diverse. Said Participant #20 of another experience she had while working in consulting, "it was very white male with a couple of women" (#20, 9).

Diversity tended to be seen as a positive attribute in the workplace by the participants. As one woman said about an engineering summer job she had "there was a lot of females as well as males and a lot of females in technical roles, so you didn't feel like you stood out in that sense

– you worked as part of a team and it was diverse. I enjoyed that job a lot" (#27, 11). She, however, had a very different experience at another company stating "I guess I felt pretty overwhelmed there. As I gained experience I felt more comfortable in some ways, but, in general, it was hard to be a female in an all-male, old school, kind of generation" (#27, 13).

In contrast to a lack of diversity seen in many engineering work environments, participants did not report a lack of diversity in the engineering classroom as being an issue or concern, other than noting that engineering schools clearly still struggle with achieving gender diversity. The continued shortage of female professors and instructors in engineering was noted as well.

Treatment and Support in the Workplace/Classroom

Per the data, fair and equitable treatment and support, unfortunately, tends to vary based on the organization. Participants perceptions of treatment and support in the workplace varied from environments that were described as a "very pleasant workplace, very supportive" (#59, 6) and "a good environment – I was well-respected and treated as part of the team" (#20, 24) to feelings of isolation. As participant X describes: I was stuck on the evening shift. I just think I didn't have the experience or the support for being on an island on the evening shift with a bunch of people who have been there for 30 years looking at this 25 year old, and thinking 'what do you know?' (X, 28)

Unfortunately, there were also reports of poor treatment that was specifically gender-based. Participant #20 speaks to her experiences after having announced her pregnancy at work:

> My first while there was really good, they pushed hard and I learned lots and it was a positive experience overall until I got pregnant. And then I went from

> receiving bonuses, having positive reviews, getting good projects to being reprimanded and having a formal review before I went on maternity leave. At that review, they told me about all the negative things I was doing and how I was unable to cope with my job. I was sick with my pregnancy and so it was hard for me, I cut out everything from my social life. I did the best I could at work, but I was sick." (#20, 4).

Some participants described having to prove themselves before being recognized as a valuable and equal team member. As described by Participant #12:

> At first he (my manager) thought it was a horrible idea that they would hire me. He had his doubts about me being female, and an engineer, and being from Ontario. But it didn't take long before he started to appreciate where I was coming from and what I had to offer and we worked together really well as a team. So yeah, they were super, they were supportive" (#12, 11/12).

Other than an isolated incident, discriminatory or inequitable treatment in the classroom or within the university environment was not noted by participants.

Technical and/or Personal Fit

A key element of belonging often has to do with how one feels they naturally conform or 'fit' within the work environment from both a technical skill and personal or cultural standpoint. For the Former Practicing Members interviewed, comments tended to focus on a misalignment in personal/cultural fit, while the Graduates Never Registered tended to centre on technical fit. According to one Former Member, "I guess when I look back on it, it was more comfortable for me when I worked at the organizations that had lots of engineers working there" (#27, 10).

During the Former Practicing Members focus group session, participant #12 described her experiences with technical versus personal fit:

> Probably at the beginning there were more negative experiences particularly as a female. I'd say just towards the end, it was more so just the incompatibility of my personality and the work expectations, but I was still loving what I was doing. In fact in some ways, some of the responsibilities at work, it was a perfect fit. But, it was probably the relations part that did me in. So for the most part the work experiences and the actual technical work was wonderful, very positive, which is also why I want to make sure I don't burn any bridges and keep my options open. I'd love to do it again. (FG1, #12, 33).

The importance of a personal or cultural fit with the organization was also noted by participant #15 who noted "I still sometimes think, I just didn't find the right fit that if I had got on with a different company maybe things would have gone differently" (FG1, #15, 22).

By contrast, the Graduates Never Registered group tended to speak to a lack of technical fit, or a disconnect or feeling of discomfort with the technical aspects of engineering. For example, Participant S said "I always felt like it wasn't really for me…I don't know if I ever actually really enjoyed it" (S, 13). When Participant A was asked if she had had enough information in her first year to make the right decision on her choice of engineering discipline to pursue she stated "I don't think I did because now looking back, I wish I had done biosystems because that would be perfect for what I'm doing right now' (A, 16). This ties to a sense of disconnect she felt in the summer jobs she pursued in mechanical engineering – there just wasn't a good technical fit in her mind.

Summary

There is much literature that indicates that feelings of belonging contribute to overall satisfaction in one's career. The women in this study expressed positive feelings of belonging in organizations where they felt recognized and valued, where treated equitable, and where there was more diversity in the workforce. However, because diversity and treatment vary by organization, one's sense of belonging in the profession can be affected by these various experiences at different organizations. Fit, whether it be from a technical or a personal standpoint (or a combination of both) also appeared to be a contributing factor to the participants' decisions to discontinue or not pursue engineering practice.

Cultural Experiences in Engineering

Cultural experiences in engineering was another key theme arising from the data. Participants' experiences with respect to workplace culture and engineering faculty culture, and work-life balance are detailed below.

Workplace/Engineering Faculty Culture

It was clear from participant comments that workplace culture contributed to either positive or negative feelings with respect to being a woman in engineering. It was also clear that cultural experiences varied by organization and were often tied to how policies and procedures were administered. Participant #3 describes her experience working for a federal government agency:

> Working for the federal government was an entirely different experience because the policies are very set, you get five family days in a year which you can take for any reason, you have so many personal days, volunteer days and sick leave. And

> my bosses there were always very flexible in terms of allowing me to leave early to pick your kids up from daycare because they're sick, things like that were never a problem, because there was policy and structure in place" (FG1, #3, 10).

In contrast, Participant S described the culture at a local consulting firm as "very stressful and it seemed that everyone had too much on their plate" (S, 4). Being a recent graduate, she felt she was given too much responsibility too soon without proper support, which led to personal stress for her as well.

Some participants also expressed that a 'bro culture' that tends to exclude women (whether intentionally or unintentionally) still exists in some engineering organizations. As Participant #13 noted:

> When I would go to engineering events… I just felt like, you know the guys would sit there and talk about their skiing or their boating, or fishing, just kind of traditional men type stuff, and even though I'm really into sports I always just found I have nothing in common with these guys (FG3, #13, 8).

Experiences related to the current cultural environment in the Faculty of Engineering at the University of Manitoba was explored with women who had graduated from this institution within the last 10 years. Since four of the participants in this study graduated more than 15 years ago, their experiences, while certainly valid, may not be representative of the current culture, so they are not included in these findings. For those more recent graduates, their experiences with the culture in the Faculty of Engineering were generally positive with respect to student-to-student and student-to-faculty interactions. However, there were some concerns expressed regarding the overall rigor of the engineering programs as described by Participant M:

> Most everyone's struggling and I can see it in my TA [Teaching Assistant] as well, everyone's so stressed, so stressed, and a lot of the times it's just like the load of the courses, too much content in every class, the exam schedule and things like that, which I think, I think that should be taken into account. (M, 48).

Other participants indicated a disconnect between what perceptions of what engineering will be versus what it actually is in industry. As Participant Pink stated "I don't think very many of the university program prepare us for what real life is going to look like" (FG2, Pink, 5).

Work-Life Balance

One of the main factors cited by Former Practicing Members regarding their decision to discontinue practice was a lack of work-life balance. Long hours, travel, and concerns over health are all work-life balance related issues experienced by women in this study. More detailed findings related to work-life balance were explored in the previous section of this chapter on *Reasons for Leaving or Not Pursuing Licensure.*

In contrast to the Former Practicing Members group, work-life balance, while important to all participants in study, was not identified by women in the Graduates Never Registered group as a factor in their decision not to pursue engineering licensure. It is worthwhile to note that none of the women in the Graduates Never Registered group have children.

Summary

Clearly, from the findings presented above, cultural experiences in the engineering workplace and in the engineering classrooms vary from person to person and organization to

organization. It appears from the data that larger organizations have more rigorous policies and procedures to support work-life balance than smaller organizations. While the engineering classrooms tend to be more culturally sensitive and supportive than in the past, the Faculty culture is still one focused on academic rigor more so than preparation for the workforce.

Plans for the Future

Two key areas that were explored in the focus group sessions and interviews with both groups of women were related to their plans for the future. Were they interested in returning to the engineering profession in the future and, if so, under what conditions? Significant time was spent during data collection exploring participants perceived barriers to entry/re-entry into the profession. These findings are detailed below.

Criteria for Re-entry

Four of the five Former Practicing Members indicated that they would consider returning to the engineering workforce in the future and, at such time, would consider re-applying for licensure. This is a very important finding in that it indicates that despite some negative experiences, these women have not been completely turned off by the profession. The fifth Former Practicing Member was an Intern at the time of her membership lapse and, while currenting working in an engineering-related role, does not perceive a need to pursue licensure at this time. For the participants considering future re-entry into professional practice a common criterion for re-entry was an option for part-time employment to support work-life balance as all of these participants have at least two children. As Participant #12 stated "I would echo the desire for part-time work or some level of engagement that's, that's less than 60, 70 or 80 hours a week. Something that allows more work life balance and that can be quite challenging in this particular career" (FG1, #12, 7). So while a desire for part-time employment is a strong criterion

for participants with children to consider re-entry into the profession, the lack of part-time opportunities can be seen as a barrier and will be further discussed in the following section.

Participants also expressed a desire for further clarity and perhaps assistance with the re-licensing process, especially after long periods of absence from the workforce. This is further described in the *Barriers to Re-entry* section that follows.

A final key criterion for re-entry is a desire for a good 'fit' when choosing a company to work for. As Participant Pink describes: "The things I was looking for were very much around culture and fit, I wanted an environment where I could be myself, where the culture fits me so I didn't have to bend for the culture." (FG2, Pink, 22). Finding the right 'fit' goes hand-in-hand with job flexibility and part-time work opportunities as it would be unlikely for participants to find a good fit with an organization that didn't promote these types of work-life balance policies.

Barriers to Re-entry

In the previous section, participant's criteria for re-entry were described. Unfortunately, their criteria for re-entry were also listed as their perceived barriers to re-entry, an indication that they don't believe that what they're looking for is readily available in industry today.

With regards to opportunities for part-time employment to support work-life balance priorities, Participant #27 stated that "I've gotten the vibe that there's not as much part-time work, especially for the job that I was doing before. It would have been very hard to have done that as a part-time person." (#27, 9). Participant #57 describes her perception of opportunities to re-enter the workforce on a part-time basis as follows:

> Now that I've been out of the workforce for a while and my kids are getting bigger and I'm trying to re-enter, it is challenging having that gap in your resume,

> but also I would really like to do something part-time and I think that's a difficult thing to find in engineering, but that's just been my experience so far. (FG1, #57, 6)

So not only is there a perception of a lack of part-time opportunities, but there is a perception that they might be limited on the type of work they would be able to do on a part-time basis. These statements also tie to another barrier to re-entry, which is dealing with a gap on one's resume if they had been away from the workforce for a number of years. As Participant #20 puts it, "I'm an outsider, I'm an unknown commodity and then I've got this gap in my employment that I'm not entirely sure how to navigate" (#20, 10). Despite some expressions of lack of confidence in addressing the resume 'gap', participant #12 argued why she would make the ideal employee:

> So when, when you think about it, if I was applying somewhere, I've had my kids, I'm not going anywhere, you could get 20 years of work out of me versus somebody who is young and chances are they're going to be trying different departments and areas and they could be leaving for a while to have a family. Then, you know, in a way I'm a great candidate for you if just spend a few months training me to get me specialized in the work you want to do, I'm here for you. (FG1, #12, 16)

While the statement made by participant #12 above demonstrates confidence in her abilities internally, she still expressed a lack of confidence in knowing how to get 'back in the game' after an extended absence from the workforce. As participant #3 stated:

> I'm not sure about myself and I don't know how acceptable the gap in my employment is going to be and I don't know how to market myself and I'm not entirely sure how to become an engineer again, and so there's this lack of confidence loop from having been away and not having any kind of role model in terms of how to go back. When it came to going from high school to engineering school to starting a career it was all just kind of set out, this is how you do it. I don't know anyone who has done what I'm trying to do. I have no frame of reference or model that says that I can be or will be successful at this, or anyone to talk to about how I navigate it. I have no idea. I'm kind of making it up as I go along and trying to sell myself, but yeah, I lack confidence. (FG1, #3, 26)

Further to a lack of confidence surrounding how to deal with a resume gap and navigating a job search, participants also expressed some concern with the clarity of the process and steps required for reinstatement of their license to practice. It seems to be a 'chicken and egg' scenario. Companies are expecting mid-career aged engineers to have the ability to seal work, but those returning from an extended leave may require a certain amount of current work experience to be deemed eligible for seal reinstatement. Without the seal, job opportunities may be limited, but without the job, opportunities for reinstatement of the professional seal are limited.

For the Graduates Never Registered, barriers are be related to *entry* into the profession (and pursuit of licensure) rather than re-entry. A key barrier noted by the two women in this group who would be most readily open to considering licensure was a lack of confidence that the work they are doing actually constitutes the practice of engineering. As participant A states "I'm a technician, I'm not designing…that's why I've never registered [with EngGeoMB]" (A,

10/11). When Participant M was asked why she didn't register with the Association upon graduation, her response was "Well I guess because I don't know if I can do it" (M, 32).

Summary

While several women in this study indicated that they would be open to either returning to the engineering workforce and re-applying for licensure (for Former Practicing Members), or would be open to beginning the licensure process (for Graduates Never Registered), they did identify some key criteria for re-entry and some barriers preventing them from moving forward in this regard. Criteria for re-entry such as opportunities for work-life balance through part-time employment, assistance with license re-instatement, and finding the right job 'fit' were raised. By corollary, barriers for re-entry point to a lack of part-time opportunities (which also ties to finding the right 'fit'), a lack of confidence in navigating a return to the workforce and in addressing an extended workplace absence (resume gap) with potential employers. This also led to some concern on the license re-instatement process. Graduates Never Registered expressed a lack of confidence that their work would constitute engineering practice suitable for meeting work experience requirements in the Intern Program.

This chapter has provided a review of the findings, organized by key themes and sub-themes arising from the data collection and analysis conducted. Chapter 5 discusses these findings in the context of the conceptual framework presented in Figure 5 of Chapter 2 (Literature Review) and other relevant literature to identify implications for better understanding career persistence of women in engineering in Manitoba.

Chapter 5: Discussion

The following research question guided the design of the study: *What are the elements of women's experiences in the engineering profession that both enable and deter their persistence in the profession, and how do these elements or factors interact with one another over time & space?* More specifically, the initial study design explored factors that contributed to choices to pursue engineering as a career initially, choices not to pursue licensure, choices to leave the profession, perceptions of the profession and the value of professional licensure. This chapter first discusses the findings with respect to the data obtained from the Former Practicing Members and Graduates Never Registered candidate pools, and then discusses the major elements of the research findings through a comparison to the conceptual framework developed in Chapter 2 Literature Review to highlight implications for understanding career persistence of women in engineering in Manitoba.

Discussion on Former Practicing Members Data

The data outlined in Chapter 3 Findings on women who had let their membership lapse between January 2013 and June 2018 provides some interesting points for discussion. While 195 women were identified on the initial list of Former Practicing Members, once the list was edited for province of residence and age, 56 women remained. This still represents a loss of approximately 4% of the total number of women who are members of EngGeoMB, which is significant. The data also showed the average age of women who let their membership lapse was 36, approximately the one-third to half-way mark through their career years. This age hints towards a link to membership lapse and common events that occur in one's life at this particular point such as family care (whether that be for children or aging parents) or transitions into more senior leadership roles (that may be extending beyond traditional engineering roles). The concern here is that these women, on average, are leaving (or stepping back) from the profession

at a point in which they might have become role models for younger engineers coming up the pipeline. A lack of female role models in engineering has been long attributed to being a barrier for recruitment of young women into the profession (Hill, Corbett, & St Rose, 2010; Milgram, 2011) and it appears that, in Manitoba, we are experiencing a potential drain of female role models. It is important to note also that participants self-selected into this study, and because of this may not be fully representative of the women who leave engineering. All the women who participated in this study, despite having never entered the profession or having left active practice, had some positive things to say about their time in either engineering school or the engineering workforce. While they may still act as a positive role model to the profession by speaking to the good points of engineering to their friends, family, and children, others who have left (and who did not participate in this study), may not share these positive sentiments. Indeed, the reason why some women chose not to participate in the study may be because of negative experiences that they do not wish to discuss. Some may maintain a 'professional silence' so as not to discourage other young women from considering engineering, while others may outright discourage the profession.

Another important point about the data provided by EngGeoMB is that 35 of the 56 women identified were Interns at the time of their membership lapse. In terms of progress towards the 30 by 30 goal in Manitoba, the impact of these 35 women over a five-year period not persisting on to licensure is significant considering that over the last five years, the discrete number of newly licensed women in Manitoba is approximately 25-30 per year. In this study, two participants in the Former Practicing Members group were Interns at the time of their membership lapse. One withdrew her membership as an Intern to focus on her family, while the other withdrew as she didn't see an immediate need for a P.Eng. designation, but these are only

two stories – there are 33 more stories over the last five years that could (and should) be explored. In this regard, it is advisable that EngGeoMB consider implementing a form of 'exit' interview or survey for women (and men) who do not renew their membership or request transfer to a non-practicing category, similar to those performed in industry when an employee leaves a company. *That they left* the profession is only one data point, *why they left* can provide a myriad of data points. The information gathered through these exit interviews/survey can provide additional insight into factors that led to decisions to discontinue professional practices and could highlight opportunities to remove barriers. However, because of potential sensitivities in the myriad of reasons that an individual may let their membership lapse or transfer to a non-practicing category, an exit survey would need to be carefully design and implemented to gather meaningful data.

The EngGeoMB data on Former Practicing Members indicated that there 23 women moved into the 'Retired' category during the period from January 2013 to June 2018, while only five moved into the 'On Leave' category. During discussions with Association staff as part of this research, I learned that EngGeoMB only recently instituted the 'On Leave' category per Bylaw 7.1.3 in 2016. This membership category was developed for "Professional members who will be away from practice for several years and are intending to return to practice may enter the On Leave category. Examples of situations appropriate for this category are: extended parental leave, and long-term disability." (Engineers Geoscientists Manitoba, 2019). Members 'On Leave' retain the right-to-title, but give up their right-to-practice and must return professional seals. In addition, members are encouraged to maintain a log of their continuing professional development should they wish to return to practice, upon which they will be referred to the Continuing Competency Committee for review. It would appear that the 'On Leave' category

might be a more appropriate membership category than ‘Retired’ for the participants from this study who have stepped away from practicing to focus on their families, however none of the participants in this study were aware of the new ‘On Leave’ category, so it would be prudent for EngGeoMB to reach out to members in the ‘Retired’ category to advise them of the ‘On Leave’ option. Having non-practicing members assigned to the membership category that best represents their status would help provide a clearer overall picture of the Association’s membership and insight into unique characteristics and demographics of the various categories which might lead to opportunities for additional membership support.

Discussion on Graduates Never Registered Data

The data outlined in Chapter 3 Findings regarding female engineering graduates from the University of Manitoba between 2013 and 2016 provides some interesting points for discussion. While there were 224 female graduates over this four-year period (from all engineering disciplines, and all engineering degree categories), when province of residence was limited to Manitoba, 184 women remained. Of these women, 71 were found not to be members of EngGeoMB (representing 38.6% of the study pool). While there may be some uncertainty in this number due to self-reporting of home address (some women may actually reside outside Manitoba and may be registered in another jurisdiction), it is still a significant number. Assuming a four-year time to licensure, one could conclude that these 71 graduates over the period from 2013-2016 could have represented another 10-15 new professional engineers per year had they registered. These numbers would have a significant impact on Manitoba’s 30 by 30 metric.

However, the 30 by 30 goal, is just that - a goal. The larger, more important objective is to encourage professional licensure of all members (women and men) to sustain a self-regulated

profession whose mandate is the protection and safety of the public and the environment. While a statement outlining the value proposition of licensure does exist on the EngGeoMB website (http://www.enggeomb.ca/pdf/Registration/ValueProposition.pdf), ensuring that this value proposition is clearly and repeatedly articulated to students and other prospective members is vital. As seen in the comments from participants in this study (see Chapter 3 Findings), even former professional members do not necessarily see the 'value' of licensure in areas outside of traditional engineering design and use of one's stamp to seal engineering drawings, so, clearly, continued efforts to articulate the value proposition of licensure are still needed. However, all of the onus cannot fall upon the Association to encourage licensure, support also needs to come from educational institutions who train engineers and from organizations who employ engineers. EngGeoMB has already taken the initiative to engage these groups through the 30 by 30 Coalition – a cohort of 15+ of Manitoba's largest employers of engineers (which includes both industry partners and the province's two largest academic institutions – the University of Manitoba and Red River College). It is important that this group clearly understands the value proposition of professional licensure and that they use their influence to encourage graduated engineers in this regard.

Relationship of Findings to the Conceptual Framework

The conceptual framework presented in Figure 5 illustrates the career persistence of women in engineering as a balance between retention and attrition. As the literature suggests, women will likely experience both positive and negative events, but it is the balance of these experiences that will likely dictate their career persistence in the profession. In this study, the balance between retention and attrition is also viewed through the lens of professional licensure and its implications on persistence as well.

While the women interviewed in this study did provide examples of experiences in engineering that fell on the 'Retention' side of the scale, such as enjoyment of their job and supportive workplaces (as noted in Chapter 4 Findings), the discussion will focus on the factors that supported their decisions to discontinue their license, not pursue licensure, or leave the profession in the context of the conceptual framework from Figure 5 as this was ultimately their decision. In other words the discussion will focus on the 'attrition' side of the scale which includes; lack of opportunity for advancement, lack of continued interest in engineering, intention to pursue another profession, dislike of the engineering culture, and job inflexibility. Participants views on professional licensure will also be discussed.

Lack of Opportunity for Advancement

While lack of opportunity for advancement and limited salary were cited in the works of Fouad et al. (2012) and Hunt (2016) as factors leading women away from the engineering profession, these items did not arise in the discussions with the women in this study. However, several of the Former Practicing Members did express concern about a lack of opportunities for *returning* to the workplace, particularly on a part time basis. During the Former Practicing Members focus group session, participants were also concerned that, due to the gap in their resumes, they would have to be willing to take more junior positions than they were otherwise qualified for based on their years of experience (both in and out of engineering). These barriers to re-entry to the profession are discussed in more detail later in this chapter.

Lack of Continued Interest in Engineering

Only Participant S from the Graduates Never Registered group indicated that a lack of continued interest in engineering was her primary reason for not continuing to work in an

engineering field. In fact, she felt that engineering wasn't the right fit for her early into her education, but persisted due to both self-induced and external pressure to complete her degree. Participant X from the Graduates Never Registered group chose not to pursue work in engineering not due to a lack of interest in engineering, but due to more interest in the field of Project Management.

Even though only one participant indicated a lack of interest in engineering was her primary reason for not continuing in the profession, all four participants in the Graduates Never Registered Group indicated that they have questioned their technical 'fit' in the profession (i.e. their ability to feel confident and interested in their work and career outlook), at one point or another or felt some pressure from influencers to pursue an education in engineering in the first place due to their propensity for math and science. These influencers included teachers, guidance counsellors, and parents. While well-intentioned, these influences might actually end up nudging women towards career options not completely aligned with their interests or career expectations. This misalignment can be further exacerbated by the fact that engineering is relatively exclusive, meaning that those outside of the profession (and even those within it) often have a hard time articulating what engineers actually do, ostensibly because engineering services are rarely provided directly to an individual, the way that medical, legal, accounting, and other professional services are, so most people don't have direct dealings with the engineering profession. Women may be guided towards the profession without fully understanding what it is. This signals a need for engineering regulators to ensure that the profession, and the various career options within it, can be well-understood by the general public, and in particular, influencers such as teachers and guidance counsellors.

Intention to Pursue Another Profession

While previous studies by Fouad et al. and Hunt have found that some women pursue engineering with the intent of using it as a stepping stone into another career path or profession, this phenomenon was not directly present in the participant groups studied in this research. Of the participants in the Former Practicing Members group, all women either left the workplace entirely, or are working in an engineering environment but have chosen not to pursue licensure. For participant S from the Graduates Never Registered group, who is not currently working in an engineering-related field, her decision to pursue an alternate career path was related to a lack of fit with the field of engineering itself, which then necessitated a career change. Participant X in the Graduates Never Registered group is now working in a field indirectly related to engineering, but this career path evolved over time based on the tasks and skills she had enjoyed in her previous engineering and non-engineering related positions. Participant A found a job in the healthcare sector based off of an industry-sponsored capstone design project she completed in her final year of engineering studies. Though there are engineers working at her organization, she feels the work she is currently doing does not constitute the practice of engineering and had therefore not applied to become an Intern with Engineers Geoscientists Manitoba. In her case, there was no perceived intention to pursue a career outside of engineering, she just found a job she really enjoys that might be considered to be on the fringes of engineering.

Despite a lack of direct evidence of the use of engineering as a 'stepping stone' to another career in the group of women self-selecting to participate in this study, there is some evidence of this phenomenon in the data obtained from the University of Manitoba during the participant search for Graduates Never Registered. This data lists 224 female engineering graduates from the Faculty of Engineering at the University of Manitoba who graduated with a degree between

the years of 2013-2016. In addition to engineering degrees awarded, the data also included any additional degrees awarded to these women during this period. A review of the list indicates that 2 women obtained a Doctor of Medicine degree and one obtained a Master of Occupational Therapy degree after completing their undergraduate degrees in Biosystems Engineering. At the time of writing this thesis, none of these women were registered with Engineers Geoscientists Manitoba.

Since these women were not directly part of this study, their reasons for choosing an undergraduate degree in Biosystems Engineering are not known, but, arguably, this choice could be considered to be more academically grueling than other undergraduate degrees options that would qualify one for graduate degrees in Medicine or Occupational Therapy. One could speculate that the physics, mechanics, design, and problem-solving skills obtained through the Biosystems Engineering undergraduate program would add a unique and beneficial skillset to a doctor or occupational therapist. Additionally, while their career choice appears to be focused in the healthcare area, are they not still practicing 'engineering' in the true sense of the definition of engineering which states "any act of planning, designing, composing, measuring, evaluating, inspecting, advising, reporting, directing or supervising, or managing any of the foregoing, that requires the application of engineering principles and that concerns the safeguarding of life, health, property, economic interests, the public interest or the environment" (Government of Manitoba, 1998).Evaluation, inspection, and advising are cornerstones of the type of services provided by doctors and occupational therapists, and one could argue that engineering principles such as mechanics, design methodology, and problem-solving would apply. Clearly, those working in healthcare are protecting the human health and life. Thus, according to this assessment, the work they are doing constitutes engineering practice. So what is preventing these

women, including Participant A, from becoming registered as Interns and working towards the professional engineering designation? It could be due to a number of factors. Firstly, it could be related to a misunderstanding on what 'engineering principles' are. If someone assumes that 'engineering principles' relate strictly to concepts such as thermodynamics or stress analysis and not a broader definition which includes principles such as design, problem-solving, and sustainability among others, they may think that the work does not constitute the practice of engineering. This may be related to the deeply ingrained identity of the engineering profession as providing *technical* solutions to the public's needs; this boundary of technical vs. non-technical is subconsciously applied to determine whether a certain scope of work is 'engineering work' or not. A second reason, which ties to the first, is a lack of confidence in claiming that the work constitutes engineering. Women, in particular, may be concerned that their work wouldn't be considered as 'engineering' and therefore, lack the confidence in applying for professional licensure. And, finally, due to the first two items mentioned, there is likely a lack of role models and licensed mentors, not only to model one's career after, but also to act as the sign-off authority required for submission of Intern work experience reports required to obtain licensure.

Dislike of Engineering Culture

It is clear from the focus group sessions and interviews held with women in both the Former Practicing Members and Graduates Never Registered groups that the perception of engineering being a 'bro culture' does, in fact, exist in many organizations. While none of the participants indicated that a dislike of the engineering culture was their primary reason for discontinuing or not pursuing licensure, nearly every participant provided examples of how the engineering culture was not conducive to their workplace expectations. Experiences varied from small micro-aggressions such as being asked to take notes in meetings or organize company

potlucks to more blatant forms of gender discrimination such as harassment when announcing a pregnancy. These micro-aggressions can feel like 'death by a thousand cuts' or like being weighed down by 'a ton of feathers'. While each cut or feather (i.e. each gender-based micro-aggression) is not a deal breaker, the continuation and accumulation of them over time become intolerable.

Despite the unsettling cultural norms that seem to exist in some engineering organizations, women who worked in larger organizations, or for government agencies, described a culture that was more diverse and equitable in terms of the workplace environment, the application of policies and procedures, and workforce itself. While there is clearly work that needs to be done to create more equitable and welcoming work environments in engineering, there are examples of organizations that are making the necessary changes. Perhaps these organizations can be used to set the bar for industry best practices for supportive and respectful workplaces that others can follow. Unfortunately, organizational culture shift is not something that can be achieved overnight, indeed, efforts towards less androcentric engineering workplace cultures have been ongoing for many years, with much work left to do. This is clearly a systemic issue – cultural change will only come with full, and consistent, support and commitment from senior leaders.

Job Inflexibility

Job inflexibility, in the context of this study, implies a work environment that is not conducive to part-time or flex-time options or does otherwise not support work-life balance or requirements for family care. It was clear from discussions with participants that job inflexibility and/or an inability to find the right balance between work and family care was a key factor in four of the Former Practicing Members' decisions to leave the engineering profession. Their

stories appear to support the assumption that family responsibilities are predominantly assigned to women. This assumption has at least two elements: that family should take priority over paid work outside of the family domain; and, that women are inherently more responsible for family 'management' than men. Since men, who don't often carry the majority of the family management duties, are most likely the ones in the positions of decision-making power within organizations, the need for policies that allow more job flexibility are not recognized, and therefore, they don't exist. There is a strong argument to be made that flexible job options would be beneficial for all and would promote equity among employees. But for this to happen, an all-sex / all-gender shift needs to occur at the leadership level to create systems that both women *and* men can take advantage of that will allow them to develop their careers while also experiencing the fulfillment of family life. There is evidence that demographic shifts in the workforce are supporting this desire for flexibility and increase work-life balance for all workers, not just women and mothers (Emslie & Hunt, 2009; Schultz, Hoffman, Fredman, & Bainbridge, 2012).

View of Licensure

Previous studies that have explored attrition of women from the engineering profession have not explored the specific implications of this in terms of the engineering regulatory environment. In discussing views on licensure, all the women who participated in this study agreed that there is value in having a P.Eng. designation – value in terms of demonstrated technical competence and respect, and in terms of opportunities for advancement. However, several participants also stated that the P.Eng. designation is more valuable in environments where use of a professional seal is required. In many industry sectors, engineers may never be required to use their seal, hence its value is somewhat more implicit than explicit.

These views of licensure could be interpreted as fairly one-dimensional in that they seem to reflect mostly on one's personal benefits (i.e. 'what's in it for me' thinking) rather than what it means for professional identity (both personally and collectively), public interest, and public perception of the engineering profession. This may highlight an ongoing need for the Association to continually promote the profession, underscore its many manifestations and roles, and keep ongoing discussions of the meaning of licensure, the right-to-practice, and the right-to-title in the public domain. It may additionally reflect that early-career views of licensure tend to be inward-looking, and these women may not have been in the profession long enough to internalize their view of licensure to the public interest and public perception.

Additional Implications Regarding Persistence

While the literature review highlights several studies that have explored women's reasons for leaving the engineering profession, to my knowledge, there haven't been any studies that have explored specific barriers and/or criteria for *re-entry* into the engineering profession and within a regulated environment. This was a focus area during the focus group sessions and one-on-one interviews carried out with both groups of participants in this study. While some of the barriers to re-entry tie to the original reasons for leaving the profession, in particular, dislike for the culture and job inflexibility, additional barriers were also identified.

One of the key barriers to returning to practice discussed with Former Practicing Members related to a lack of confidence which manifested itself in several ways. There was concern over how to address the 'gap' in their resume for their years in a non-practicing category and how to confidently speak to the skills they had gained while managing a household and relating these skills to the engineering work environment. Addressing and understanding a career gap is important for not only the job seeker, but the employer as well. This is particularly

important since engineering is not a profession where career gaps are common amongst its practitioners. Participants also expressed concerns about applying for jobs for which they weren't fully qualified, or that they would be forced to apply for more junior positions due to their extended time away. Even things such as updating their resume or preparing for an interview seemed daunting, let alone the concept of transitioning back to even a part-time position and adjusting to the impact that this would have on family life. Finally, those participants who had been non-practicing for a number of years expressed a lack of confidence in the process involved in applying for reinstatement of their engineering license. The aforementioned concerns are reflective of the studies that consistently show that women have less confidence in their abilities when compare to men with the same qualifications (e.g. when women are asked to self-assess their performance, they will generally assess themselves weaker than their supervisor's assessment of them, while men generally assess themselves stronger than their supervisor's assessment of them). These concerns also reflect an absence of a collective history or precedent practices that women could draw upon for support and role modeling. For example, at the time of the first focus group session and the majority of the interviews conducted with the Former Practicing Members group, there wasn't a clear procedure for reinstatement of licensure listed on the EngGeoMB website. However, in January 2019, the Association released a comprehensive document entitled 'Return to Active Practice' (http://www.apegm.mb.ca/pdf/Guidelines/Active_Practice_Guideline.pdf) which provides specific procedures for license reinstatement based on the number of years of absence from the profession. This guide was discussed at the follow-up focus group session held with Former Practicing Members in April 2019 and was met with a positive response. This guide may

increase confidence and clarity in the license reinstatement process, but it doesn't address the other areas of concern expressed by the Former Practicing Members.

Over the past few years, a concept known as a 'returnship' has been gaining traction as a way to ease those who have been on a long term career hiatus back into the workforce (Wingard, 2019). Returnships operate similarly to an undergraduate Internship or Cooperative Education program – in this case, companies provide term employment (usually between 6-12 months) aimed at a re-introduction to the workplace. Returnship employees are provided with case-specific training (also called re-skilling or up-skilling) to bring practitioners up to speed on advancements in the field since their departure and are often paired with a mentor for guidance and support. Many large organizations such as General Motors and Goldman Sachs have been using returnship programs with much success – for both the returning employees and for the company themselves (Wingard, 2019). It is clear that if four Former Practicing Members interviewed as part of this study indicated that they would be interested in support to re-enter the engineering workforce in the future, there must be other women (and men) in the same situation. Exploration of a returnship program in Manitoba to support non-practicing members who wish to return to practice would be beneficial to the Association, industry, and the members.

A second key barrier to re-entry (or even first time entry) into the engineering profession identified primarily by the Graduates Never Registered Group, but also by two of the Former Practicing Members who were Interns at the time of their membership lapse, was concern over the rigors of the Pre-Registration/Intern Program. This process involves;

- Successful completion of the Act, Bylaws, and Code of Ethics (ABC) test (with a pass rate of 90%);

- 4 years of eligible supervised work experience (minimum) – with reporting of this experience required at (ideally) 6-month intervals;
- At least 48 hours of professional development over four years;
- At least 48 hours of volunteer service over four year;
- Successful completion of the National Professional Practice Exam (NPPE); and
- 3 Professional References (after 36 approved months of work experience) (Engineers Geoscientists Manitoba, 2019).

While this process is quite clearly laid out, it does appear quite daunting while you are in the midst of it (I can verify that this was my own experience, having been through this program as well). The challenge of completing the Intern Program can be exacerbated if one works in organizations that either don't have P.Eng. mentors that can support the Intern or don't support professional licensure (as in providing time and assistance in helping the Intern meet these requirements). A concept that has been discussed within the Engineers Canada 30 by 30 Champions group is the idea of an 'Intern Cohort' program. This program could have an annual or semi-annual intake of Interns that would meet on a quarterly or semi-annual basis to work on their experience reports, study for the NPPE, and otherwise receive guidance from the Association on the path to licensure. The program could provide the supports necessary to increase the graduation to licensure conversion rate, while also having the added benefit of creating a community of future practitioners, which could have positive implications for long-term retention in the profession. This 'Intern Cohort' program is something that should be explored further by EngGeoMB.

Participant Update

Since beginning this study, there have been two notable updates to the status of participants. One of the Former Practicing Members has decided to return to the engineering workforce on a full-time basis and has recently had her practicing status re-instated after following the Association's Return to Active Practice procedure (Engineers Geoscientists Manitoba, 2019). She indicated to me that the process went smoothly and that she felt well-supported by the Association. In addition, one of the Graduates Never Registered recently contacted EngGeoMB for an assessment of her work to determine if it would qualify her to register as an Intern. At the time of writing, it was not known if this assessment was successful, but it does demonstrate her desire to pursue engineering licensure. If two out of nine women have taken initiative towards professional practice, there are likely other women in similar situations in Manitoba. It behooves the Association to reach out to these women, consider 'returnship' and 'Intern cohort' programs, and to use their connections with Manitoba's engineering employers to highlight best practices in creating equitable, diverse, inclusive, respectful, and supportive workplaces for all employees.

It is clear from this study that women's career persistence in engineering is a multi-dimensional and multi-faceted issue. A number of factors are at play in their decisions regarding their career path in engineering, with the scale tipping towards 'attrition' rather than 'retention'. The good news is that a number of these women have indicated a desire to return to practice in the future, and have provided some insight into the criteria upon which they would return and the barriers that they suspect they would face upon re-entry. These factors, such as requirements for part-time or flexible employment and support with the re-entry process, are systematic and all-

gender in nature and solution will require an approach involves educational institutions, industry, and the Association.

The final chapter of this thesis provides details on some final considerations involved in good qualitative research including; a statement of limitations, questions for additional research, a reflection on my experiences conducting this research, and final conclusions.

Chapter 6: Concluding Comments

Statement of Limitations

Due to the interpretative and iterative nature of qualitative research, it is important to recognize that the findings and discussion presented must be considered in the context provided in Chapter 3 Methodology. It is particularly critical for the reader to consider the theoretical perspective applied and the background and role of the researcher in this study. It is also important to note that the findings of this study relate only to the experiences of the women who voluntarily participated in this study and cannot, therefore, be readily generalizable to other women's experiences regarding career persistence in engineering in Manitoba or other regions or jurisdictions. Further to this, the strength of understanding of any issue relies on having solid data as a foundation. Due to the lack of availability of the 'On Leave' membership category prior to 2016, or a lack of awareness of this category, some members (both women and men) may have been forced to select the 'Retired' category or let their membership lapse, neither of which may have truly reflected their intentions for discontinuing practice. Therefore, a full understanding of factors that influence career persistence may be hampered by the vagueness in the dataset and membership categories of potential participants.

A key concern with studies involving participant self-selection is that it may lead to one-dimensional views of the research topic. While participant self-selection was utilized for this study, the diverse participant responses and experiences indicate that this approach did not compromise the research.

Questions for Further Research

While this study purposefully applied a qualitative research approach to add to the collective understanding of women's career persistence in engineering in Manitoba, a quantitative approach would have merits as well. A quantitative approach would allow data to

be gathered from a larger group, perhaps even nationally, and could provide a more generalizable understanding of women's career persistence in engineering in the Canadian regulatory environment.

While the scope of this study was limited to increasing the understanding of women's career persistence in engineering, understanding men's career persistence in the profession is also important. With data on career persistence of men, comparisons could be made that could point to factors that are similar between genders and those that are gender specific.

A unique contribution to our understanding of career persistence of women in engineering that this study has brought to light is that women who leave the engineering profession may not do so permanently. However, there may not be sufficient opportunity or robust processes in place to support their return to work. Prior to this study, there has been little, if any, research conducted regarding barriers and criteria for *re-entry* into the engineering profession. While the stories of the women participating in this study provide some insight into the issues faced in this area, there is certainly room for more research in this regard. The cohort of women who have left engineering, but may want to return as some point in the future offers an opportunity to support both industry's needs for experienced engineers and the profession's need for more female role models.

Through observations of comments made by participants in this study, there is some evidence of a potential link between an engineering organization's size and/or ties to government and their adopting of mature EDI-related policies that make the workplace more welcoming and supportive to women (and all people). This potential link could be explored further through a study that examines EDI policies at organizations of various sizes.

Finally, investigation into more accurate methods for determining the 'graduation-to licensure' rate at both the provincial and national level (and for both women and men) would aid in providing a better understanding of the engineering regulatory environment in Canada.

Personal Reflection

Due to the interactive nature between the participants, the research environment, and the research in a qualitative research, it is impossible for the researcher to remain unaffected in some manner by the research. To that end, it is important to reflect upon the experience so that lessons learned can be carried forward to future endeavours. Throughout this study I was faced with a mixture of feelings. I was very excited to begin the study, but soon realized that an academic study of this nature would require much more rigor than I was used to. Due to my Winter 2018 teaching load, the research got off to slower start than planned. The REB and participant selection phases were conducted during the late spring and summer of 2018 when I had fewer obligations, and as such, I found this phase rather enjoyable. As an engineer who is accustomed to more quantitative types of inquiry, I felt quite comfortable with the analysis of the data sets provided for participant selection. The data collection phase, carried out between September 2018 and June 2019, was, at times, overwhelming. Coordinating interviews and focus group sessions around participant availability, my full-time work responsibilities, completion of a Certificate in Higher Education Teaching program, and a household with three children (and a dog who needed walking) proved to be quite difficult and resulted in significant personal stress and lack of work/life balance (some of the exact same things cited by participants as factors in their decisions to leave engineering!). Despite this, I also found the data collection phase to be extremely gratifying. I thoroughly enjoyed getting to know the participants and hearing their stories, many of which resonated with my personal experiences working in engineering. I found

myself reflecting on my own decisions and the factors that were at play in making them. I found data analysis, which overlapped with data collection and spanned from October 2018 to August 2019, to be enjoyable and insightful, but also somewhat tedious in nature. Preparation of the thesis, which began in July 2019 and was completed in October 2019 was perhaps the most difficult part of this process for me. While I had a clear idea of what the data were telling me, articulating it in a logical and meaningful manner was challenging. In conducting this study, I felt a huge obligation to both the participants and the Association to the find the elusive 'magic bullet' reason why women leave engineering, however, I felt that I was left with more questions than answers (as indicated by the long list of questions for further research). While disheartening, I take some personal solace in the fact that this topic has been researched for over two decades and that 'magic bullet' has yet to be found. This indicates that it truly is a 'wicked problem' and will require systematic changes to the profession, all along the pipeline.

From an evaluation perspective, there were both areas that worked well and areas for improvement. On the positive side, I feel that the qualitative research approach undertaken for this study was appropriate for the type of information I was seeking and, since I hadn't been exposed to this type of research methodology before, provided me with an excellent learning opportunity, especially under the guidance of Dr. Friesen who has considerable experience with this type of research paradigm. I felt that I did a good job of building the necessary trust with the participants by articulating my positionality and being relatable and approachable. An area in which I felt I struggled in the beginning was in the data collection phase. While I did use an interview guide, I felt that the early focus group session and one-on-one interviews were somewhat awkward, but it was something that I feel that I improved upon throughout the process. While I do have a background and credentials in Project Management I feel that I could

have done a better job in assessing the risks associated with the study including competing personal and work priorities, scheduling conflicts with focus group and interview sessions, and the amount of time required to prepare this thesis.

Overall, this proved to be a valuable learning experience for me personally and I take pride in knowing that this work has resulted in a better understanding of factors that enable and deter women's career persistence in engineering in Manitoba and provides some concrete recommendations to support both new graduates and former members wishing to return to active practice.

Conclusion

This study was undertaken in the context of a phenomenological qualitative research approach using epistemological lenses of interpretivism and feminist empiricism. Through one-on-one interviews and focus group sessions, the study examined the experiences of five women who were Former Practicing Members of Engineers Geoscientists Manitoba and four women who did not pursue engineering licensure upon graduation from an engineering program at the University of Manitoba. The research questions were developed to explore participants' experiences in the engineering faculty and workplace and the factors that led them away from licensure. The findings from these interviews and focus group sessions were compared and contrasted with a conceptual framework that was developed based on existing literature in this area.

The findings contributed to the collective understanding of why women leave the profession, and a unique perspective surrounding the implications in a regulatory environment. It was clear from the stories told by the women who participated in this study, that their reasons for discontinuing or not pursuing licensure are often multi-faceted and are determined by the

overall balance between retention factors and attrition factors. Workplace conditions such as job inflexibility and how this relates to balancing work and family life, and a dislike for the engineering culture were noted by several Former Practicing Members as the main contributing factors for their attrition. For Graduates Never Registered, a main concern was that their work didn't align with their perceived definition of engineering and that their work experience would not be accepted as progress towards the four years required to obtain a professional license. This was combined with concerns over the rigor of the Intern Program and a lack of confidence in completing it. The implementation of an 'Intern Cohort' program could address this concern while also increasing the graduation to licensure conversion rate and potentially increasing the overall long-term career retention. The study also identified criteria for re-entry into the profession which included job flexibility and cultural fit (the opposite of the main reasons cited for leaving). Confidence building opportunities such as 'returnships' could be seen as positive way for Former Practicing Members to ease back into the profession whilst providing industry with a pool of experienced engineers.

References

Abri, J. H. (2006). Women in engineering: Stories of attrition and retention. Colorado State University.

Andrews, G. C. (2014). *Canadian Professional Engineering and Geoscience Practice and Ethics* (5th ed.). Toronto: Nelson Education Ltd.

APEGA. (2019, May 4). *News.* Retrieved from APEGA Web site: https://www.apega.ca/news/status-women-canada-grant/

Association of Professional Engineers Australia. (2019, 09 22). *PEng - Professional Engineer*. Retrieved from Association of Professional Engineers Australia Web site: http://www.professionalengineers.org.au/professionalengineers/

Ayre, M., Mills, J., & Gill, J. (2013). 'Yes I do belong': the women who stay in engineering. *Engineering Studies, 5*(3), 216-232.

Baram-Tsabari, A., & Yarden, A. (2008). Girls' biology, boys' physics: evidence from free-choice science learning settings. *Research in Science & Technological Education, 26*(1), 75-92.

Bureau of Labor Statistics. (2019, 09 16). *Employment and wages of engineers in 2015*. Retrieved from Bureau of Labor Statistics Web site: https://www.bls.gov/opub/ted/2016/mobile/employment-and-wages-of-engineers-in-2015.htm

Cohen, D., & B, C. (2006, July). *Assumptions of Feminist Paradigms*. Retrieved from Qualitative Research Guidelines Project: http://www.qualres.org/HomeFemi-3519.html

Cohen, D., & Crabtree, B. (2006, July). *The Interpretivist Paradigm*. Retrieved from Qualitative Research Guidelines Project: http://www.qualres.org/HomeInte-3516.html

Creswell, J. W. (2009). *Research Design: Qualitative, Quantitative, and Mixed-Methods Research (2nd Ed.).* Thousand Oaks: Sage.

Dawis, R. V. (2005). The Minnesota theory of work adjustment . (S. D. Brown, & R. W. Lent, Eds.) *Career Development and Counseling: Putting Theory and Research to Work*, 3-23.

Dawis, R. V., & Lofquist, L. H. (1984). *A Psychological Theory of Work Adjustment.* Minneapolis, MN: University of Minnesota Press.

Emslie, C., & Hunt, K. (2009). 'Live to Work' or 'Work to Live? A Qualitative Study of Gender and Work-life Balance among Men and Women in Mid-Life. *Gender, Work & Organization*, *16*(1), 151-172.

Engineering Council. (2019, 09 22). *About Us*. Retrieved from Engineering Council Web site: https://www.engc.org.uk/about-us/

Engineering Council. (2019, 09 22). *Professional Registration.* Retrieved from Engineering Council Web site: https://www.engc.org.uk/professional-registration/

Engineering Council. (2019, 09 22). *UK-SPEC.* Retrieved from Engineering Council Web site: https://www.engc.org.uk/engcdocuments/internet/Website/UK-SPEC%20third%20edition%20(1).pdf

Engineers Australia. (2019, 09 22). *Chartered Engineer*. Retrieved from Engineers Australia Web site: https://www.engineersaustralia.org.au/For-Individuals/Chartered-Engineer

Engineers Australia. (2019, 09 16). *Registration of Engineers*. Retrieved from Engineers Australia Web Site: https://www.engineersaustralia.org.au/News/registration-engineers

Engineers Australia. (2019, 06). *Statistics.* Retrieved from Engineers Australia Web site: https://www.engineersaustralia.org.au/sites/default/files/resources/Public%20Affairs/2019/The%20Engineering%20Profession%2C%20A%20Statistical%20Overview%2C%204th%20edition%20-%2020190613b.pdf

Engineers Canada. (2017, 09 25). *30 by 30: Engineers Canada*. Retrieved from Engineers Canada website: https://engineerscanada.ca/diversity/women-in-engineering/30-by-30

Engineers Canada. (2018). *2018 National Membership Information.* Ottawa: Engineers Canada.

Engineers Canada. (2019, 07 29). *30 by 30: Engineers Canada*. Retrieved from Engineers Canada web site: https://engineerscanada.ca/diversity/women-in-engineering/30-by-30

Engineers Canada. (2019, 09 22). *About Engineers Canada*. Retrieved from Engineers Canada Web site: https://engineerscanada.ca/about/about-engineers-canada

Engineers Canada. (2019, July 29). *About: Engineers Canada*. Retrieved from Engineers Canada web site: https://engineerscanada.ca/about/about-engineers-canada

Engineers Geoscientists Manitoba. (2016). *2016 Salary Survey Report.* Winnipeg: Engineers Geoscientists Manitoba. Retrieved 10 06, 2019, from http://www.apegm.mb.ca/pdf/SalarySurvey/survey2016.pdf

Engineers Geoscientists Manitoba. (2017). *Annual Report 2016-2017.* Winnipeg: Engineers Geoscientists Manitoba.

Engineers Geoscientists Manitoba. (2017). *Strategic Plan 2017-2022.* Winnipeg: Engineers Geoscientists Manitoba.

Engineers Geoscientists Manitoba. (2019, 08 30). *Legislation.* Retrieved from Engineers Geoscientists Manitoba Web site: http://www.enggeomb.ca/pdf/Bylaws.pdf

Engineers Geoscientists Manitoba. (2019, 10 10). *Member Registration.* Retrieved from Engineers Geoscientists Manitoba: http://www.apegm.mb.ca/MIT.html

Engineers Geoscientists Manitoba. (2019). *Resignation or Transfer to Non-Practising Status.* Retrieved 10 02, 2019, from Engineers Geoscientists Manitoba Web site: http://www.enggeomb.ca/pdf/NonPractisingForm.pdf

Engineers Geoscientists Manitoba. (2019, January). *Return to Active Practice Guideline.* Retrieved 10 8, 2019, from Engineers Geoscientists Manitoba Web site: http://www.apegm.mb.ca/pdf/Guidelines/Active_Practice_Guideline.pdf

Ettinger, L., Conroy, N., & Barr, W. I. (2019). What Late-Career and Retired Women Engineers Tell Us: Gender Challenges in Historical Context. *Engineering Studies, 11*. doi:10.1080/19378629.2019.1663201

Fouad, N. A., Chang, W.-H., Wan, M., & Singh, R. (2017, June 30). Women's Reasons for Leaving the Engineering Field. *Frontiers in Psychology*, pp. 1-11.

Fouad, N. A., Singh, R., Fitzpatrick, M., & Liu, J. (2012). *Stemming the tide: why women leave engineering.* Milwaukee: University of Wisconsin-Milwaukee. Retrieved from http://www.daweg.com/documents/resources/Stemming_the_Tide.pdf

Geisinger, B. N., & Raman, D. R. (2013). Why They Leave: Understanding Student Attrition from Engineering Majors. *International Journal of Engineering Education, 29*(4), 914-925.

Government of Manitoba. (1998, June 29). *The Engineering and Geoscientific Professions Act.* Retrieved from Government of Manitoba Web site: http://web2.gov.mb.ca/laws/statutes/ccsm/e120e.php

Grand Canyon University - Center for Innovation in Research and Teaching. (2019, 07 18). *Research: CIRT*. Retrieved from Center for Innovation in Research and Teaching: https://cirt.gcu.edu/research/developmentresources/research_ready/phenomenology/phen_overview

Hewlett, S. A., Marshall, M., & Sherbin, L. (2013, December 1). How Diversity Can Drive Innovation. *Harvard Business Review*.

Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington: American Association of University of WOmen.

Hundleby, C. (2011). Feminist Empiricism. In C. Hundleby, *Handbook of Feminist Research: Theory and Praxis* (pp. 28-45). SAGE.

Hunt, J. (2016). Why do women leave science and engineering? *he Industrial and Labor Relations Review 69(1)*, pp. 199-226.

Ingram, S. (2007). Assessing the Impact of Career and Family Choices in Mid-life: Striking the Right Balance for Women Engineers in Their 40s*. *International Journal of Engineering Education, 23*(5), 954-959.

Ingram, S., & Mikawoz, I. (2006). An Investigation of Canadian Women Engineers: Exploring the Role of Educational Work Experiences in Shaping Career Paths. *36th ASEE/IEEE Frontiers in Education Conference - S2G-13.* San Diego: IEEE.

Institution of Mechanical Engineers. (2017). *Stay or Go: The Experience of Female Engineers in Early Career.* Institution of Mechanical Engineers. Retrieved 09 22, 2019, from https://www.imeche.org/policy-and-press/reports/detail/stay-or-go.-the-experience-of-female-engineers-in-early-career

Krueger, R. A. (1988). *Focus groups: A practical guide for applied research.* Thousand Oaks: Sage Publications, Inc.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry.* Beverley Hills: Sage.

Main, D. (2017, 09 24). *Who are the Millenials?* Retrieved from Live Science web site: https://www.livescience.com/38061-millennials-generation-y.html

Manitoba, E. G. (2019, 07 19). *About: Engineers Geoscientists Manitoba.* Retrieved from Engineers Geoscientists Manitoba Web site: http://www.apegm.mb.ca/pdf/AnnualReports/2017AnnualReport.pdf

McCracken, G. (2011). *The Long Interview.* Newbury Park: SAGE Publications, Inc.

McMillan, J. H. (2012). *Educational Research: Fundamentals for the Consumer, 6th Edition.* Boston: Pearson Education, Inc.

Member Registration Fees. (2019, 08 28). Retrieved from Engineers Geoscientists Manitoba Web site: http://www.enggeomb.ca/Fees.html

Merriam-Webster. (2019, 07 18). *Dictionary*. Retrieved from Merriam-Webster Web site: https://www.merriam-webster.com/dictionary/epistemology

Merriam-Webster. (2019, 09 20). *Dictionary*. Retrieved from Merriam-Webster Web site: https://www.merriam-webster.com/dictionary/profession

Milgram, D. (2011). How to recruit women and girls to the science, technology, engineering, and math (STEM) classroom. *Technology andEngineering Teacher,, 71*(3), 4-11.

Mills, J., Bastalich, W., Franzway, S., Gill, J., & Sharp, R. (2006). Engineering in Australia: An Uncomfortabe Experience for Women. *Journal of Women and Minorities in Science and Engineering, 12*, 135-154.

National Society of Professional Engineers. (2019, 09 22). *How to get licensed*. Retrieved from NSPE Web site: https://www.nspe.org/resources/licensure/how-get-licensed

NCEES. (2019, 09 16). *Number of licensees by state*. Retrieved from NCEES Web Site: https://ncees.org/licensure/number-licensees-state/

O'Callaghan, E. M., & Enright Jerger, N. D. (2006). Women and girls in science and engineering: understanding the barriers to recruitment, retention and persistence across the educational trajectory. *Journal of Women and Minorities in Science and Engineering, 12*(2-3), 209-232.

Office of Institutional Analysis. (1999-2018). *Undergraduate and Graduate Students Combined Enrolment Reports.* Retrieved from University of Manitoba web site: http://umanitoba.ca/admin/oia/students/1397.html

Office of Institutional Analysis. (2019, 07 19). *Undergraduate and Graduate Students Combined Enrolment Reports*. Retrieved from University of Manitoba Web Site: http://umanitoba.ca/admin/oia/media/student_enrol_F18.pdf

Office of Institutional Analysis, U. o. (2019, 09 12). *Degrees, Diplomas, and Certificates* . Retrieved from University of Manitoba Web site: http://umanitoba.ca/admin/oia/students/1433.html

Olesen, V. (1994). Feminism and models of qualitative research. In *Handbook of Qualitative Research* (pp. 158-174). Thousand Oaks: Sage Publications.

OSPE. (2018, 05). *#LetsBreakBarriers in STEM.* Retrieved from OSPE Web site: http://www.letsbreakbarriers.ca/uploads/1/0/5/2/105271507/breaking_barriers_white_paper_report_single.compressed.pdf

Oxford. (2019, 09 21). *Dictionary*. Retrieved from Lexico Web site: https://www.lexico.com/en/definition/profession

Ranson, G. (2003, January). Beyond 'Gender Differences': A Canadian Study of Women's and Men's Careers in Engineering. *Gender, Work, and Organization, Vol 10, No. 1*, pp. 22-41.

Regoniel, P. A. (2015, January 5). *Conceptual Framework: A Step by Step Guide on How to Make One.* Retrieved from SimplyEducate Web site: https://simplyeducate.me/2015/01/05/conceptual-framework-guide/

Rowe, W. E. (2014). Positionality. In SAGE, *The SAGE Encyclopedia of Action Research.* London: SAGE.

Schultz, N. J., Hoffman, M. F., Fredman, A. J., & Bainbridge, A. L. (2012). The Work and life of Young Professionals: Rationale and Strategy for Balance. *Qualitative Research Reports in Communication, 13*(1), 44-52.

Sherry, M. (2012). Insider/Outsider Status. In SAGE, *The SAGE Encyclopedia of Action Research* (p. 433). Thousand Oaks: SAGE.

Smith Doerr, L., Alegria, S., & Sacco, T. (2017). How Diversity Matters in the US Science and Engineering Workforce: A Critical Review Considering Integration of Teams, Fields, and Organizational Contexts. *Engaging Science, Technology, and Society*, pp. 139-153.

Stanford University. (2019, 07 30). *Engineering and Technology Case Studies: Demonstrate Gender Methods in Design*. Retrieved from Gendered Innovations at Stanford web site: https://genderedinnovations.stanford.edu/case-studies-engineering.html

Sutton, J., & Austin, Z. (2015). Qualitative Research: Data Collection, Analysis, and Management . *The Canadian Journal of Hospital Pharmacy*, 226-231.

Taylor, S. J., Bogdan, R., & DeVault, M. (2016). *Introduction to Qualitative Research Methos: A Guidebook and Resource.* Hoboken: John Wiley & Sons, Inc.

University of Cumbria. (n.d.). *Gibbs' Reflective Cycle.* Retrieved October 17, 2019, from Cumbria University Web site: https://my.cumbria.ac.uk/media/MyCumbria/Documents/ReflectiveCycleGibbs.pdf

University of Manitoba. (2017, 11 14). *Office of Institutional Analysis*. Retrieved from University of Manitoba web site: http://umanitoba.ca/admin/oia/media/student_enrol_F17.pdf

University of Manitoba. (2018, 04 03). *Office of Institutional Analysis*. Retrieved from University of Manitoba web site: http://umanitoba.ca/admin/oia/media/Undergraduate_Degrees_by_Degree_Pgm_Maj_Gender_2017.pdf

Wall, K. (2019). *Insights on Canadian Society: Persistence and representation of women in STEM programs.* Ottawa: Statistics Canada.

Wingard, J. (2019, February 13). *Are Returnships The Key To Relaunching Your Career?* Retrieved 10 9, 2019, from Forbes Web site: https://www.forbes.com/sites/jasonwingard/2019/02/13/are-returnships-the-key-to-relaunching-your-career/#50fdf40c3cdf

Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a collective intelligence factor in the performance of human groups. *Science 330,* 686-688.

Yonemura, R., & Wilson, D. (2016). Exploring Barriers in the Engineering Workplace: Hostile, Unsupportive, and Otherwise Chilly Conditions. *American Society for Engineering Education, 2016 Conference.* New Orleans: ASEE.

Appendix A: Education/Nursing Research Ethics Board Approval Certificate

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

PROTOCOL APPROVAL

TO: **Kathryn Atamanchuk** (Advisor: Marcia Friesen)
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB) [redacted]

Re: **Protocol #E2018:028 (HS21315)**
"Understanding Women's Career Persistence in Engineering in Manitoba"

Effective: April 2, 2018 **Expiry:** April 2, 2019

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved the above research. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Approval is granted only for the research and purposes described in the application.
2. Any modification to the research must be submitted to ENREB for approval before implementation.
3. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
4. This approval is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
5. A Study Closure form must be submitted to ENREB when the research is complete or terminated.
6. The University of Manitoba may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans.*

Funded Protocols:
- **Please mail/e-mail a copy of this Approval, identifying the related UM Project Number, to the Research Grants Officer in ORS.**

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

AMENDMENT APPROVAL

April 9, 2018

TO: **Kathryn Atamanchuk** **(Advisor: Marcia Friesen)**
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB) [redacted]

Re: **Protocol #E2018:028 (HS21315)**
"Understanding Women's Career Persistence in Engineering in Manitoba"

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved your Amendment Request received on **April 3, 2018** to the above-noted protocol. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*.

This approval is subject to the following conditions:

1. Approval is given for this amendment only. Any further changes to the protocol must be reported to the Human Ethics Coordinator in advance of implementation.
2. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
3. Amendment Approvals do not change the protocol expiry date. Please refer to the original Protocol Approval or subsequent Renewal Approvals for the protocol expiry date.

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

AMENDMENT APPROVAL

June 29, 2018

TO: **Kathryn Atamanchuk** **(Advisor: Marcia Friesen)**
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB) [redacted]

Re: **Protocol #E2018:028 (HS21315)**
"Understanding Women's Career Persistence in Engineering in Manitoba"

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved your Amendment Request received on **June 27, 2018** to the above-noted protocol. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*.

This approval is subject to the following conditions:

1. Approval is given for this amendment only. Any further changes to the protocol must be reported to the Human Ethics Coordinator in advance of implementation.
2. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
3. Amendment Approvals do not change the protocol expiry date. Please refer to the original Protocol Approval or subsequent Renewal Approvals for the protocol expiry date.

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

AMENDMENT APPROVAL

March 14, 2019

TO: **Kathryn Atamanchuk** **(Advisor: Marcia Friesen)**
Principal Investigator

FROM: **Joseph Gordon, Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2018:028 (HS21315)**
Understanding Women's Career Persistence in Engineering In Manitoba

---

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved your Amendment Request received on **March 13, 2019** to the above-noted protocol. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Approval is given for this amendment only. Any further changes to the protocol must be reported to the Human Ethics Coordinator in advance of implementation.
2. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
3. Amendment Approvals do not change the protocol expiry date. Please refer to the original Protocol Approval or subsequent Renewal Approvals for the protocol expiry date.

UNIVERSITY OF MANITOBA | Research Ethics and Compliance

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Email: humanethics@umanitoba.ca

RENEWAL APPROVAL

Date: **March 14, 2019** **New Expiry: April 2, 2020**

TO: **Kathryn Atamanchuk** **(Advisor: Marcia Friesen)**
Principal Investigator

FROM: **Joseph Gordon, Chair**
Education/Nursing Research Ethics Board (ENREB)

[redacted]

Re: **Protocol #E2018:028 (HS21315)**
"Understanding Women's Career Persistence in Engineering in Manitoba"

Education/Nursing Research Ethics Board (ENREB) has reviewed and renewed the above research. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Any modification to the research must be submitted to ENREB for approval before implementation.
2. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
3. This renewal is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
4. A Study Closure form must be submitted to ENREB when the research is complete or terminated.

Funded Protocols:
- **Please mail/e-mail a copy of this Renewal Approval, identifying the related UM Project Number, to the Research Grants Officer in ORS.**

Appendix B: Recent Graduate Status with Engineers Geoscientists Manitoba - Survey

UNIVERSITY OF MANITOBA Recent Graduate Registration Status with Engineers Geoscientists Manitoba

Hello!

This survey is an initial phase of an academic research study on the career persistence of women in engineering in Manitoba. This study is being conducted by the University of Manitoba in partnership with Engineers Geoscientists Manitoba.

As you are likely aware, women are underrepresented in the engineering profession. In Manitoba, only 10.1% of professional engineers are women. Similar numbers exist across Canada. Recognizing the need for a profession that better reflects society, Engineers Canada established the 30 by 30 goal in 2014. This goal aims to have women account for 30% of newly licensed engineers by the year 2030 (please visit https://engineerscanada.ca/diversity/women-in-engineering/30-by-30 for more details). In 2016, 15.1% of newly licensed engineers in Manitoba were women. This study will examine two groups of women to understand why some women choose to not enter the engineering profession after graduation (or not pursue licensure) and why some women leave the profession at various points after obtaining their professional designation. Understanding the factors that contribute to these decisions are a critical piece to achieving the 30 by 30 goal.

In this initial phase, we are trying to identify women who have *never registered*, or are *no longer registered* with Engineers Geoscientists Manitoba. If you fall into one of these two categories and are interested in learning more about this study, I invite you to complete this short survey, which should only take 2 minutes of your time. Once responses are received I will contact you to provide further details on the study.

If you are currently registered with Engineers Geoscientists Manitoba as an Engineer-in-Training or as a Professional Engineer, there is no action required on your part.

This research has been approved by the Education / Nursing Research Ethics Board. If you have any concerns or complaints you may contact Kathryn Atamanchuk or the Human Ethics Coordinator (HEC) at 204-474-7122 or email humanethics@umanitoba.ca.

Notice Regarding Collection, Use, and Disclosure of Personal Information by the University:
Your personal information is being collected under the authority of The University of Manitoba Act. The information you provide will be used by the University for the purpose of this research project, and to provide you with a copy of the findings (if applicable). Your personal information will not be used or disclosed for other purposes, unless permitted by The Freedom of Information and Protection of Privacy Act (FIPPA). If you have any questions about the collection of your personal information, contact the Access & Privacy Office (tel. 204-474-9462), 233 Elizabeth Dafoe Library, University of Manitoba, Winnipeg, MB, R3T 2N2.

Sincerely,

Kathryn Atamanchuk, P.Eng.
Biosystems Engineering Graduate Student
email: kathryn.atamanchuk@umanitoba.ca
phone: 204-480-1414

* 1. First Name

* 2. Last Name

* 3. What is your current registration status with Engineers Geoscientists Manitoba?

- ◯ Never registered (as an Engineer-in-Training or P.Eng.)
- ◯ No longer registered (as an Engineer-in-Training or P.Eng.)

* 4. Are you registered as an EIT or P.Eng. with any other provincial/territorial engineering regulatory body (eg. APEGA, PEO, etc.)?

- ◯ Yes
- ◯ No

5. If you are interested in learning more about this study and opportunities to participate in it, please provide a preferred email address at which you can be contacted.

Appendix C: Sample Information Letter and Letter of Informed Consent

UNIVERSITY OF MANITOBA

Faculty of Engineering
Department of Biosystems Engineering

Department of Biosystems Engineering
University of Manitoba
Winnipeg, MB, R3T 5V6
Telephone: 204-480-1414
Email: kathryn.atamanchuk@umanitoba.ca

July 13, 2018

Research Project Title: Understanding women's career persistence in engineering in Manitoba

Principal Investigator: Kathryn Atamanchuk, P.Eng.
Contact information: kathryn.atamanchuk@umanitoba.ca or 204-480-1414.

You are invited to participate in a study on the career persistence of women in engineering in Manitoba. As you are likely aware, women are underrepresented in the engineering profession. In Manitoba, only 10.1% of professional engineers are women. Understanding the factors that cause some women to leave the profession is critical to understanding how we can increase the number of women that participate in engineering in Manitoba.

This consent form, a copy of which will be given to you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Background: Recognizing the need for a profession that better reflects society, Engineers Canada established the 30 by 30 goal in 2014. This goal aims to have women account for 30% of newly licensed engineers by the year 2030 (please visit https://engineerscanada.ca/diversity/women-in-engineering/30-by-30 for more details). In 2016, 15.1% of newly licensed engineers in Manitoba were women.

Objective: This study will examine two groups of women to understand why some women choose to not enter the engineering profession after graduation (or not pursue licensure) and why some women leave the profession at various points after obtaining their professional designation. Understanding the factors that contribute to these decisions are a critical piece to achieving the 30 by 30 goal.

Your involvement: Should you agree to participate in this study, you would be asked to participate in the following activities. You can choose to participate in any or all of the activities below. I expect that the activities will take place between September to December 2018.

- One (1) focus group interview (group interview) of approximately 120 minutes duration, held at a time and place convenient to all participants. A focus group interview is a relaxed atmosphere of guided conversation. Refreshments will be provided. This interview will be used to collect some general information and impressions, as a group, of your experiences as engineers and your experiences in the engineering workplace.
- One (1) one-on-one interview with me of approximately 60-90 minutes duration, held at a time & place convenient to you. This interview will focus on your personal experiences of your experiences as engineers, your experiences in the engineering workplace, and what you are doing now.
- One (1) focus group interview (group interview) after all the one-on-one interviews with participants are complete, of approximately 90-120 minutes duration and held at a time & place convenient to all participants. This focus group interview will be used to let you know of the general / preliminary findings of the interviews, and to get your perspectives and impressions of any areas that have not been fully discussed or clarified.

Feedback: The one-on-one interviews and focus groups will be audio-recorded and professionally transcribed by a third-party professional transcription service. I will send each participant a copy of the transcript of the interviews (group and one-one-one) in which you participated, within one month of the date of each session. You will be invited to send me any feedback or comments on the transcript. As well, I will send all participants a summary of the findings of the study and draft copies of any manuscripts / publications that come out of the study. You will be asked to provide any comments back to me within six weeks of your receipt of a transcript or summary or draft copy of the work. Please see the attached page to indicate your interest in receiving this information.

Confidentiality: Before providing written consent, you should be aware of the following measures that are designed to protect the confidentiality of the data you contribute to the study:

The focus group interview sessions will be held at a time and neutral location suitable to the group, and I will be moderating the sessions (leading the discussion) with the support of an assistant moderator. As you may have experienced previously, focus groups are a carefully planned, informal group discussion. They are designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment. The discussion is relaxed, comfortable, and often enjoyable to the participants as they share ideas and experiences. The purpose of a focus group is to gather data on the opinions, attitudes, and perceptions of the group. As opposed to a structured question and answer session, the format will be conversational and relaxed. I will use a prepared interview guide with open-ended questions to guide the conversation, and I will work to ensure the atmosphere is one in which you feel

comfortable disclosing your feelings, perceptions, and opinions relative to the study topic. Our discussion during the focus group sessions will be audio-recorded and transcribed. I will provide and operate the audio-recorder. The audio recording will be transcribed by a professional transcription service. You will be invited to review the transcript and send any comments of clarification, correction, or additional thoughts and ideas to me. I will make any corrections identified by participants and will add any additional information provided after the focus group sessions. The revised transcript will again be provided to all participants for review and comment. Your identity as a focus group participant will be kept confidential. The assistant moderator will be present only to take notes on the non-verbal features of the focus group session, including the mood and tone as well as key thematic turning points in the discussion that can later be correlated to the transcript. In all notes, summaries, and publications arising out the research, I will identify participants only by a letter or number, and to enhance your anonymity, I will use a different code or number for you than the one used during the one-on-one interview.

An explicit assurance of confidentiality will be given prior to the focus group interview session. As the focus group moderator, I will not reveal the identity of any of the focus group or interview participants and I pledge to keep the data confidential. The assistant moderator will also sign an assurance of confidentiality. In any reports or publications based on the session, all quotations, citations, or paraphrases will be made generic with respect to unique personal features or identifiers, including but not limited to your gender, age, employer, ethnicity, and speech habits. **If you choose to participant, you are also agreeing to keep confidential the discussion and conversations during the focus group and the identities of the other participants.**

The one-on-one interview will be held at a time and neutral location suitable to you, and I will be moderating the session (leading the conversation). As opposed to a structured question and answer session, the format will be conversational and relaxed. I will use a prepared interview guide with open-ended questions to guide the conversation, and I will work to ensure the atmosphere is one in which you feel comfortable disclosing your feelings, perceptions, and opinions relative to the study topic. The discussion during the one-on-one interview will be audio-recorded and transcribed. I will provide and operate the audio-recorder. The audio recording will be transcribed by a professional transcription service. You will be invited to review the transcript and send any comments of clarification, correction, or additional thoughts and ideas to me. I will make any corrections that you identify and will add any additional information provided after the one-on-one interview. The revised transcript will be provided to you for review and comment. Your identity as an interviewee will be kept confidential. In all notes, summaries, and publications arising out the research, I will identify you only by a letter or number.

I will keep all the data (audio recordings, transcripts, summary notes) in a locked filing cabinet in my office at the University of Manitoba; electronic data will be kept in a password-protected file on my laptop computer, to which only I have password access. Only I will have access to the

filing cabinet and the laptop computer, and I will be responsible to control access to the data to my thesis advisor, the assistant moderator, as well as to the participants who receive an individual transcript or summary as part of the member-checking process. Per the University of Manitoba's Advisor Student Guidelines, only myself and my thesis advisor, Dr. Marcia Friesen, will have access to all data collected during the study. That includes both the identifiable study data (e.g. consent forms, participant contact information) and non-identifiable data (transcripts from interviews and focus groups where names have been removed). The data will be destroyed at the end of the study. Paper copies of transcripts, notes, summaries, manuscripts, and any other documents related to the study will be shredded with a confidential shredding service. Electronic copies of any documents related to the study will be deleted from the computer or storage desk (e.g. USB stick) on which they are stored. The destruction of data will occur once all publications arising from the study have been accepted for publication, but in no case will it be later than October 2022 (five years after the study began).

Dissemination of Research Results: The research will be disseminated via one or two conference papers, at least one journal article, and at least one seminar over the next five years. The following dissemination venues will be considered:

- Conferences: Manitoba Community for Women in Engineering, Science, Trades, and Technology (MCWESTT) 2019, Canadian Coalition for Women in Engineering, Science, Trades, and Technology (CCWESTT) 2020, Engineers Geoscientists Manitoba Ingenium Annual Conference, Canadian Engineering Education Association Annual Conference
- Journals: Journal of Women and Minorities in Science and Engineering; Journal of Gender Studies;
- Seminars: Engineers Geoscientists Manitoba seminars, Faculty of Engineering research seminars, Engineers Canada seminars, Canadian Coalition for Women in Engineering, Science, Trades, and Technology (CCWESTT) seminars
- Articles: The Keystone Professional (the quarterly magazine published by Engineers Geoscientists Manitoba)

Right to withdraw: Before providing written consent, you should be aware that you have the right to withdraw any of your comments or withdraw completely from this study at any time, and that any disclosures or data you provide are held in complete confidence. If you choose to withdraw at any time during the study, you can do so my letting me know in person, by email, by phone, or by regular mail. You do not need to provide a reason for withdrawing. If you choose to withdraw, all data that you already provided to the study will be destroyed.

Risks and Benefits: There are no significant risks foreseen in this research. The minimal risk that you may be identified through the data you provide to the study has been addressed through the confidentiality measures. Many participants find interviews and focus groups to be

a pleasant experience, allowing them to share their personal stories and develop new personal understandings of their own stories through the process of telling them to another person.

Compensation: I should also let you know that no compensation is being offered for your participation. Refreshments will be provided during the interview and focus group sessions.

UNIVERSITY OF MANITOBA

Faculty of Engineering
Department of Biosystems Engineering

Department of Biosystems Engineering
University of Manitoba
Winnipeg, MB, R3T 5V6
Telephone: 204-480-1414
Email: kathryn.atamanchuk@umanitoba.ca

INFORMED CONSENT FORM

For participation in the study entitled: Understanding women's career persistence in engineering in Manitoba

Your participation in this study is entirely voluntary. Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. My contact information is as follows:

Kathryn Atamanchuk, P.Eng.

Mailing address: E2-262 EITC; Office location: E1-374 EITC

University of Manitoba, Winnipeg, Manitoba, Canada R3T 5V6

Tel 204-480-1414; Fax 204-474-7676; E-mail kathryn.atamanchuk@umanitoba.ca

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way. This research has been approved by the Education/Nursing Research Ethics Board. If you have any concerns or complaints about this project you may contact the above-named person or the Human Ethics Coordinator at 204-474-7122. A copy of this consent form will be given to you to keep for your records and reference.

Notice Regarding Collection, Use, and Disclosure of Personal Information by the University

Your personal information is being collected under the authority of *The University of Manitoba Act*. The information you provide will be used by the University for the purpose of this research project, and to provide you with a copy of the findings (if applicable). Your personal information will not be used or disclosed for other purposes, unless permitted by *The Freedom of Information and Protection of Privacy Act* (FIPPA). If you have any questions about the

collection of your personal information, contact the Access & Privacy Office (tel. 204-474-9462), 233 Elizabeth Dafoe Library, University of Manitoba, Winnipeg, MB, R3T 2N2.

Please sign below to indicate your informed written consent to participate in this study:

_____

Participant's Name	Participant's Signature	Date

Researcher's Name	Researcher's Signature	Date

Receiving a copy of the findings: If you wish to receive copies of the interview transcripts, a summary of the findings or the study, and copies of the manuscripts that arise out of the study, please provide your preferred email address below:

Preferred email address: _____

Thank-you for your interest in this study.

Sincerely,

Kathryn Atamanchuk, P.Eng.
Biosystems Engineering Graduate Student
University of Manitoba

Appendix D: Sample Interview Guides

Former Practicing Members - Initial Focus Group
Date: Sept 17, 2018 – Fort Garry Public Library Meeting Room, 1360 Pembina Hwy
Time: 6:00-8:30pm

As participants arrive at the focus group session, they can introduce themselves to each other, the researcher, and the assistant moderator. The researcher will hand out tent cards and ask each participant to create an alias for themselves which will be used throughout the focus group to prevent names from being used in the audio recording. Once everyone has arrived and is settled, the researcher will start the audio recording and will begin by stating the date, time, location, her name, the assistant moderator's name, and the number of participants. The researcher will then make the following statement:

Thank you for agreeing to participate in this study. Everything you say will be held in confidence. The purpose of this focus group is to begin to understand your experiences as an engineer and the factors that contributed to your decisions to not currently continue membership with Engineers Geoscientists Manitoba. The questions have been designed to explore these areas. The goal is to see our time together as a relaxed conversation and not a structured question-and-answer period. You are free to withdraw any of your comments or withdraw completely from this study at any time, and you are under no obligation to answer any of the questions. The session will be recorded and the audio-recording will be transcribed, and in the transcription and in any supplementary notes, I will use a code only to identify you, and will not use any quotations that would identify you specifically. A copy of the transcription will also be returned to you for your review, and the audio-recording will be destroyed at the end of the study. The assistant moderator will be present only to take notes on the non-verbal features of the focus group session, including the mood and tone as well as key thematic turning points in the discussion that can later be correlated to the transcript. ***As mentioned earlier, all comments you provide will be held in confidence and the expectation is that you keep confidential participant identities and all comments from today's session as well.*** *Do you have any questions about these procedures?*

After answering any questions that arise, the researcher will being the conversation by asking each participant to introduce themselves (using their selected alias) and provide the following information about themselves:

- When did you graduate from engineering? What was your program of study?
- Do you have any other degrees or credentials?
- What have you been doing since you graduated? Where have you worked, etc.?

After all participants have introduced themselves, the research will ask the following prompt questions (as required) to get the conversation flowing. The goal is that the conversation flows and is led by the participants.

Prompt Questions:

- If you're not working in engineering, what factors contributed to that choice or decision?
    - Where have you worked? In what capacity/role? For how long?
    - What has your personal life path been since graduation?
    - Has your career path been as expected? If not, how is it different than your expectations?
    - Are you doing what you want to be doing?
- Why did you originally choose to pursue an engineering degree?
    - What is your definition of what an engineer does?
    - Does this definition represent what you did while working in engineering?
    - Did you participate in coop or have summer jobs during your engineering degree?
    - Did your engineering job(s) represent what you thought you would be doing as an engineer? Why or why not? Did your workplace environment(s) meet your expectations of what you thought an engineering workplace would be? Why or why not?
    - Have you experienced any barriers in the engineering profession? If so, what were/are they?

- What is your view of professional licensure?
    - What do you see as the value of being a Professional Engineer?
    - What factors contributed to your decision to leave engineering and/or not continue registration with the association?
    - What factors would cause you to consider re-entering the engineering profession (or re-instating your membership with Engineers Geoscientists Manitoba)?

Assistant Moderator:

- The assistant moderator will be present only to take notes on the non-verbal features of the focus group session, including the mood and tone as well as key thematic turning points in the discussion that can later be correlated to the transcript.
- The assistant moderator should not engage directly with the participants during the recorded portion of the focus group (pre and post focus group chit-chat is fine!)
- Observations noted by the assistant moderator should include a reference to the participant who it relates to (using their alias)
- Things to keep an eye/ear out for:
    - Changes in body posture that correspond to speech (e.g. excitement in speech accompanied by arm waving)
    - Facial signals (e.g. frowning, furrowed brow, tears, smiles, etc.)
    - Signs that someone has something to say (e.g. raised hand, restlessness, etc.)

Appendix E: Sample Coded Data

KA: Excellent. And so you left that position for maternity leave.

P: Yeah, I left for maternity leave and then I, I was planning to work for a little longer, I mean for a long time, but just the finding daycare and all that kind of trouble its just not worth it (chuckle).

Profession - Reasons for leaving

KA: So you worked for the consulting firm for two years and then a mat leave.

P: Yeah, mat leave and then…

KA: One more year.

P: Yeah, and then that was…

KA: Okay. And the reasons for leaving?

P: Was because daycare just didn't work, or it was a private babysitter at different ends and yeah, it just doesn't work with site inspections, most of the time if I do get sent out for site inspections I don't get home until like 8 o'clock (chuckle).

Profession - Reasons for leaving

Culture

KA: Right, there's that extra travel time.

P: Yeah, it just didn't work.

KA: Did you ever talk to management about the options for part-time, was that something that they'd ever done.

P: They let me work part-time.

Culture - workplace

KA: Okay.

P: Like when I came back I worked part-time, but its, its still just, yeah just the site inspection its like we need you to go here, its not like I can say, I mean I did say no and they said okay that's, that's fine we understand your reason but its not like it doesn't feel good to have say somebody kind of pick up the slack because just because you have a kid and you have to go pick up your kid so I'm going to have to go do your site inspection kind of thing.

Belonging - Fit (personal) work-life balance?

KA: Okay. So you didn't get push back from the company.

P: No, I never did.

Culture - treatment

KA: Okay, excellent. Do you know if there was other people that worked part-time too, was that a common thing within the company?

P: Yes, there was yeah, there was another mechanical engineer, female mechanical engineer who, in the summertime she works part-time because of the, of her kids' school schedule I guess so.

Culture to work-life balance

KA: Okay.

P: And she actually graduated ten years ago before she started working so.

KA: Hmm, interesting.

→ Culture

P: Its nice to hear that they will hire somebody who had such a long, I mean it seems long I guess in the industry, such a long lapse of time between your graduation and your first, very first job, but yeah.

→ Belonging – treatment

KA: So how would you describe the culture then you found it that since this was the only company you worked at - how was that, that company culture?

P: Its, its pleasant.

KA: Pleasant.

Belonging – treatment/support

P: Very pleasant workplace, very supportive and yeah.

KA: And so how long have you been away from work and choosing to be with your family.

P: 20[redacted]

KA: 20[redacted] okay.

P: Is that right, yeah, yeah 20[redacted]

KA: Okay, so about [redacted]...

P: [redacted] years, yeah.

KA: [redacted] years. And what are your thoughts about the future, do you have ideas of going back to engineering at some point or.

P: I'd like to go back to this company (chuckle).

Future

KA: You'd like to go back (chuckle).

criteria for re-entry?

P: They said anytime we'll, we can discuss if you want to start part-time, whatever works for you, you're welcome to come back, I mean hopefully I can.