30 by 30 Environmental Scan

Prepared for Engineers Geoscientists Manitoba

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The Scan

In December 2017, the governing Council of Engineers Geoscientists Manitoba approved $795,000 of funding to be put toward measures to increase the percentage of newly licensed engineers who are women to 30% by the year 2030. The initiative was introduced to engineering associations across Canada by Engineers Canada and is commonly referred to as '30 by 30'. Organized into three phases, Engineers Geoscientists Manitoba's plan for the 30 by 30 initiative involved first the development of a marketing plan and hiring of staff for the initiative. As part of Phase One, marketing firm, Juliet Creative, was hired and the Association's 30 by 30 marketing campaign was launched in April 2018. As part of Phase Two, staff for the initiative were hired, a committee to oversee the initiative was formed and became active, and this Environmental Scan to aid in the development of a Strategic Plan for the initiative was created.

The Environmental Scan exists as the exploration phase of Engineers Geoscientists Manitoba's 30 by 30 Strategic Plan process. To create the Environmental Scan, published literature and information was examined to identify social, economic, technological, political and legal context and trends which may offer evidence for short- and long-term decision making for reaching 30 by 30. This document includes a review of findings and recommendations relevant for Canada's, and particularly Manitoba's, 30 by 30 initiative. Using cross-provincial and cross-territorial, cross-national, and cross-professional comparisons, as well as intersectional and vertical segregation analysis, the aim of this document is to provide a foundation of up-to-date knowledge for 30 by 30 strategic planning and any further research the initiative may involve.

Acknowledgement

The Environmental Scan was created with the support and guidance of many partners of the 30 by 30 initiative. These partners include members of Engineers Geoscientists Manitoba's: Engineering Changes Lives Provincial Steering Committee; Committee for Increasing the Participation of Women (CIPWIE); Indigenous Professionals Initiative Committee (IPIC); and Government Relations Advisory Committee (GRAC). Other partners include: other provincial associations, with particular thanks to staff at the Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS) and the Association of Professional Engineers and Geoscientists of Alberta (APEGA) for the knowledge that they shared; faculty and staff at the University of Manitoba, particularly the Manitoba Faculty of Engineering; Engineers Canada; and Engineers Geoscientists Manitoba Council and staff, with special acknowledgement to the Government Relations Department which is overseeing the 30 by 30 initiative for the Association and to the 30 by 30 staff. Thank you.

I would also like to acknowledge and thank Engineers Canada's nationwide 30 by 30 Champions group for allowing access to information from their knowledge sharing platform for this scan.

A number of industry members and employers have been approached and are collaborating with the Association on the 30 by 30 initiative. Special thanks to both Manitoba Hydro and to Boeing for coming to the Association and sharing their plans and ideas for how they intend to increase diversity in their workplace and to reach 30 by 30.

Finally, I would like to acknowledge the members of Engineers Geoscientists Manitoba. It is with your participation and continued membership that adoption and funding toward initiatives such as this one is made possible. This initiative offers not only the potential to better the engineering profession, but to help advance society as well. Thank you.

Process

There is a plethora of information on the topic of women's participation in Science, Technology, Engineering and Mathematics (STEM). The information presented in the Environmental Scan was found in secondary data sources by means of literature reviews, data searches and through recommendations. The findings and research presented herein is by no means exhaustive, however, it is from well recognized sources and is suggestive of trends and patterns that are useful to be aware of, if not solely for succeeding in accomplishing 30 by 30, for gaining greater insight to the profession of engineering and to a significant pattern that exists in societies around the globe.

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I. Introduction

Today, women earn the majority of university degrees in Canada and in most developed countries around the world (Buchmann & DiPrete, 2006). This trend appears to be increasing as levels of tertiary education attainment continue to increase with women at the forefront of the pursuit (Buchmann & DiPrete, 2006; Moyser, 2017). In Canada for instance, as of 2015 the proportion of women with a university degree had increased by a factor nearly two times that of men with a university degree and as of 2016, 61 per cent of women between the ages of 25 to 64 in Manitoba had a tertiary certificate, diploma or degree while the same achievement for men was 51.1 per cent (Manitoba Women's Advisory Council, 2018; Moyser, 2017).

Despite significant growth in the levels of education pursued by women in western industrialized countries, there continues to be a disproportionate underrepresentation of women in STEM (science, technology, engineering and mathematics) university programs (Buchmann & DiPrete, 2006; Council of Canadian Academies, 2012; Drury *et al.,* 2011; Seron *et al.,* 2018; Steinke *et al.,* 2007). The underrepresentation in these fields has become a trend in itself as other previously male-dominated fields such as law and medicine have advanced in their representation of women more quickly along with women's increasing demand for university education in western developed countries since World War II (Bradley & Charles, 2009). In Canada, women began accounting for over 30 per cent of new entrants to the legal profession in the 1980s, for over 30 per cent of accepted medical students at that same time, and have accounted for nearly 50 per cent of medical students since the 1990s (Menkel-Meadow, 1986; Sullivan, 1990). Meanwhile it is estimated that women accounted for 20 per cent of Canada's engineering undergraduate student body in 2015 and accounted for an average of 17.2 per cent of newly licensed engineers in Canada in 2016 (Engineers Canada, 2015a; Engineers Canada 2018b).

Previously widely considered and still commonly referred to by some is the suggestion of gendered innate ability or gender essentialism relating to STEM fields, whereby biologically predisposed qualities enable men to be more conducive to be skilled at or to exhibit 'brilliance' at STEM than women (Chestnut *et al.,* 2018; Council of Canadian Academies, 2012; Ellingsaeter, 2013; McDaniel, 2015; O'Shaughnessy *et al.,* 2016). The idea that girls and women need additional, more 'masculine', traits to be capable of succeeding in STEM academic studies as well as boys and men, or the notion that inclusion of women to a STEM domain may threaten to lower quality of the field is a nod to this ideology of a predisposed gendered aptitude which has been widely discredited and found to lack scientific merit (Chestnut *et al.,* 2018; Holman *et al.,* 2018). Perhaps the most commonly thought of measure for predicting individual future success in a STEM field is childhood ability in mathematics (Council of Canadian Academies, 2012; OECD PISA, 2015; Riegle-Crumb *et al.,* 2017; Robinson-Cimpain *et al.,* 2014; Statistics Canada, 2017). Using this measure alone, the fact that there is significant variation in mathematics success between sexes around the world, and the common finding of girls demonstrating greater mathematics ability than boys in standardized testing suggest that biological differences do not account for the underrepresentation of women in STEM (Canadian Council of Academies, 2012; McDaniel, 2015; Robinson-Cimpain *et al.,* 2014). Instead, as these findings highlight and as research suggests, the underrepresentation of women in STEM studies and careers is best explained as occurring in response to external, socially constructed forces (Herman *et al.,* 2012; Menkel-Meadow, 1986; Robinson-Cimpain *et al.,* 2014).

There are numerous examples of how lack of heterogeneity and lack of diversity in societal groups can risk the well-being and safety of a society, particularly in groups which have power and influence over others such as those in government, or those working in the technology and engineering sectors (Herring, 2009). Artificial Intelligence (AI) and AI-based technologies for instance are recognized as having permeated much of the functioning of western developed societies (Buolamwini & Gebru, 2018). From AI designs for health care and law enforcement to designs for smart phones, many previously human-made decisions are now being made by or are being made with the help of AI algorithms (Buolamwini & Gebru, 2018).

When these algorithms and technologies are designed primarily by a group which does not reflect the diversity of the society they are designing for, not only are the designs impeded, but societal function and the personal well-being of those not considered is risked as well (Buolamwini & Gebru, 2018). This is demonstrated by recent examples of discovered algorithmic discrimination, such as where the word 'man' was related in an AI system analogy to 'computer programmer' and the word 'woman' was related to 'homemaker', believed to have occurred as a result of using biased data which trained the algorithms to discriminate (Buolamwini & Gebru, 2018).

Computer vision technology, such as that used for facial recognition, has also been discovered as performing in discriminatory ways in certain cases, performing more effectively for lighter skinned or male users than for darker skinned or female users in some instances to the point that one machine learning algorithm design demonstrated a maximum error rate of 34.7% for identifying darker-skinned females in facial recognition while demonstrating a maximum error rate of mere 0.8% for lighter-skinned males (Buolamwini & Gebru, 2018). These findings highlight not only the need for additional intersectional review and audit of AI technologies, but also of the importance of having diversity in teams which design for a diverse society (Buolamwini & Gebru, 2018).

Having diversity in such professions, like engineering, is underlined by these examples as being a matter of public interest. These matters relate to Engineers Geoscientists Manitoba's mandate to advocate when there is a threat to the public interest as outlined in *The Engineering and Geoscientific Professions Act* of Manitoba (The Engineering and Geoscientific Professions Act, 2018).

Working toward increasing gender parity and equal opportunity within the engineering profession in society also addresses moral and ethical concerns of gender inequality, a topic which Canada formally took a stand on with its declaration of support for the UN Convention on Elimination of All Forms of Discrimination against Women in 1979, and with the creation and adoption of *The Canadian Charter of Rights and Freedoms* and updates to *The Canadian Human Rights Act* in the 1980s (Council of Canadian Academies, 2012). Increasing equality of outcome for men and women in Canada's STEM sectors supports these national positions, particularly as many STEM and STEM-related positions are recognized as being some of the highest paying and most important disciplines for a nation's development, however, also as being male-dominated in the industrialized world (Council of Canadian Academies, 2012; Ihsen *et al.,* 2008; Leaper *et al.,* 2012; Mlambo & Mabokela, 2017).

It is widely understood that underutilization of women diminishes national human capital and undermines prosperity and development (Pearson *et al.,* 2015). There exists a business case for diversity based on this understanding which recognizes that competition for the best engineering students and employees in today's society and to be competitive on a global scale requires innovative practices that support women and other marginalized groups such as visible minorities and Indigenous Peoples (Canadian Committee on Women in Engineering, 1992; Leaper *et al.,* 2012; Schäfer, 2005; WinSETT Centre, 2014). While increasing or maintaining diversity within an institution or organization can be a challenge, companies made up of more diverse groups have been found to demonstrate greater performance, produce more considerate and effective solutions to problems, be more creative, and have higher levels of well-being than less diverse company teams (Herring, 2009; Schmuck, 2017). Recent studies of surgical teams for instance have also found increased gender balance on teams to be correlated with greater demonstrations of collaboration and reduced conflict, and large-scale studies have found that companies tend to exhibit higher fiscal performance when they have more women on their board or in management, which was further supported in a study by the Conference Board of Canada (Calnan & Valiquette, 2010; The Economist, 2018).

Today, efforts toward increasing the recruitment and retention of girls and women in STEM seem to be placing less emphasis on requiring them to fit a particular norm (Faulkner, 2009; Rees, 2010). Instead, there appears to be an increase in the recognition that rather than focus on changing girls and women, changes to institutions and societal culture hold greater promise of long-term increases in equal opportunity and diversity within the engineering profession in Canada.

Critical Mass Theory

Introduced by social scientist Rosabeth Kanter in the late 1970s, the idea of critical mass reached popularity with the help of a publication by political social scientists Drude Dahlerup in the 1980's examining diversity in group and organizational culture within politics (Dahlerup, 2006; Park, 2017). Kanter's theories on the outcomes of changing group composition, particularly based on groups where a group minority makes up 15 percent or less of a group as "tokens" or where the minority composes upwards of 15 percent to 40 percent of the group, were used to inspire Dahlerup's idea that 30 percent may be a proportion at which a minority group has sufficient representation within a larger group to be substantially influential on its decision-making and to have power to change its group dynamic (Dahlerup, 2006). The idea of critical mass has further been understood by some as a threshold number from which a minority group's momentum toward change may accelerate faster than it would at lower numbers (Park, 2017).

Adopted and proposed by the United Nations 2003 Equal Opportunity Commission, the idea that 30 percent is the critical mass needed for substantially increasing a minority group's representation within a larger group has been widely adopted by many (Park, 2017). However, many researchers are critical of the single crucial number and little empirical evidence has been found to support 30 percent as the point of representation required in order for a minority group to visibly influence change (Dahlerup, 2006; Park, 2017). Kanter did not identify a particular number as a critical mass point in her original work for instance, and researchers, including

Dahlerup, maintain that the establishment and enforcement of safe and supportive environments for group minorities is more important than reaching a particular minority proportion of representation (Park, 2017). Critical mass has reduced potential for instance when a minority population, such as women in engineering, are not connected with one another, feel it is too stigmatizing to interact with one another, or do not wish for others like them to be in their position (Sagebiel & Dahmen, 2006). While research confirms the power of increased proportional representation for minorities, findings also highlight the importance of recognizing that varying critical masses exist for various outcomes desired and that there may be no single all-important critical mass number (Dahlerup, 2006; Williams *et al.,* 2014). Dahlerup proposes that women, a common minority in politics, might have influence on a political party's agenda when they make up just 15 percent of the party, but that it may take women representing 40 percent of the party to have policies specific to women introduced (Dahlerup, 2006). While working toward the national goal of increasing the percentage of newly licensed engineers who are women to 30 percent, it is important to acknowledge the idea that there exist various critical masses and that reaching a certain number of representations is only part of what is needed to substantially initiate and sustain long-term change (Dahlerup, 2006; Faulkner, 2009).

Where did '30 by 30' come from?

In 2010, APEGA launched the goal to work toward having women compose 30 percent of its newly licensed engineers by 2030. Engineers Canada supported the idea and proposed the goal be adopted at a national level with endorsement from all Canadian regulators in the years following. By 2015 the first national figures were published and a dedicated webpage and communication resource was created for the Canadian initiative of increasing the number of newly licensed engineers who are women to 30 percent by the year 2030, coined '30 by 30'. Today, all Canadian provincial and territorial engineering associations have begun taking steps toward reaching the 30 by 30 goal (Engineers Canada, 2018a). Associations are working toward reaching 30 by 30 in a shared national manner such as through participating in Engineers Canada's 30 by 30 Champion meetings and information sharing platform, and are also working toward the 30 by 30 goal independently (Engineers Canada, 2018a). Below is a summary of how Engineers Geoscientists Manitoba has been working toward achieving the 30 by 30 goal.

Engineers Geoscientists Manitoba 30 by 30 Initiative

As of December 31, 2016, women accounted for 15.1% of newly licensed engineers at Engineers Geoscientists Manitoba (Engineers Canada, 2018a).

In December of 2017, the Council of Engineers Geoscientists Manitoba approved $795,000 to be put toward efforts for the Association to have thirty percent or more of its newly licensed engineers be women by 2030. It was decided that the 30 by 30 funding would be used for an initiative that would take place in three phases and over the course of two years, from January 2018 to December 2019. The first phase began in January 2018, and involved the development of a marketing plan for the initiative for which marketing firm Juliet Creative was engaged. The second phase of the initiative also began at this time with the hiring of dedicated staff for the 30 by 30 initiative and with the creation of a provincial steering committee for the initiative.

In partnership with Juliet Creative, key barriers to reaching 30 by 30 were identified and a poster campaign was designed to engage middle school students on the topic of underrepresentation of women in engineering. In April 2018, Engineers Geoscientists Manitoba’s 30 by 30 initiative titled “Engineering Changes Lives” was presented alongside its poster campaign at a well-attended event held at the provincial legislative building. Posters were sent to over 350 middle schools in Manitoba and a radio advertisement about the poster campaign was run for three weeks in May when schools were receiving posters in the mail. At the time of this Scan, posters had been returned to the Association by 15 schools with a total of nearly 5000 signatures on the posters in a petition-like style. An outreach plan delivered posters to engineer-employing companies in Manitoba and invited them to declare support for 30 by 30, as well as share their own plan for helping to reach this goal.

The second phase of the initiative continues at this time. The creation of an Environmental Scan has been part of the second phase, with the creation of a strategic plan also underway for Engineers Geoscientists Manitoba to reach 30 by 30. Execution of the strategic plan will comprise the third phase of the initiative.

Alongside the Engineering Changes Lives Provincial Steering Committee, Engineers Geoscientists Manitoba’s Committee for Increasing the Participation of Women in Engineering (CIPWIE) has long been active in working to increase women’s recruitment, retention and equity in the engineering profession. Engineers Geoscientists Manitoba additionally partners with a number of leaders, organizations, and operating bodies that share a focus on increasing girls and women’s participation and retention in STEM, such as Engineers Canada’s 30 by 30 Champions group, WISE Kid-Netic Energy, Technical Women in Consulting Engineering (TWICE), ACEC Manitoba, The NSERC CWSE Prairie Chair, and Go Eng Girl.

Manitoba 30 by 30 timeline for targeting student recruitment

Table 1. Manitoba 30 by 30 target group by timeline for high school direct entry and ENGAP route to U of M Engineering

	Direct Entry Route													
Year		Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022	Fall 2023	Fall 2024	Fall 2025	Fall 2026	Fall 2027	Fall 2028	Fall 2029	Fall 2030
		High school			Engineering	Engineering Faculty - specialized								
Route to Prelim Year	Track	Grade 10	Grade 11	Grade 12	Preliminary Year	Year 2	Year 3	Year 4	Year 5	Year 6				
Direct Entry Route	Track 1		30S chem, 30S precal, 30S physics	40S chem, 40S precal, 40S physics	8 required courses				Graduate (after 5 years)	Intern 1	Intern 2	Intern 3	Intern 4	Apply for licensure
	Track 2		30S chem, 30S precal, 30S physics	40S chem, 40S precal, 40S physics	8 required courses					Graduate (after 6 years) with 1 yr pre-grad work exp	Intern 1	Intern 2	Intern 3	Apply for licensure
	Track 3		30S chem, 30S precal, 30S physics	40S chem, 40S precal, 40S physics	8 required courses					Graduate (after 6 years)	Intern 1	Intern 2	Intern 3	Intern 4
	Track 4		30S chem, 30S precal, 30S physics	40S chem, 40S precal, 40S physics	8 required courses				Graduate (after 5 years) with 1 yr pre-grad work exp	Intern 1	Intern 2	Intern 3	Apply for licensure	

Key:	(yellow)	Year of interest
	(pink)	Educational/licensure track of interest

Other Canadian Association 30 by 30 Initiatives and Actions

Below is a brief overview of some of the actions that other Canadian Associations have taken toward reaching 30 by 30.

Engineers Yukon

Based on Engineers Canada's 30 by 30 numbers collected as of December 31, 2016, women made up 44.4% of newly licensed engineers at Engineers Yukon (Engineers Canada, 2018a). This was above the national average of that time which was 17.0% (Engineers Canada, 2018a).

Engineers Yukon has a number of initiatives begun as part of their 30 by 30 goal. Some of these include:

- Youth events aimed at expanding understanding of what it means to be an engineer
- Community and networking events for female members

- Continuing professional development events for all members focusing on gender-related workplace issues

Engineers Yukon has additionally partnered with Westcoast Women in Engineering, Science and Technology (WWEST) to address students, community members, and industry regarding increasing diversity in STEM fields.

(Engineers Yukon, 2017)

Engineers and Geoscientists British Columbia

As of December 31, 2016, women made up 17.2% of newly licensed engineers at Engineers and Geoscientists BC (Engineers Canada, 2018a). This was above the national average of that time which was 17.0% (Engineers Canada, 2018a).

In 2013, Engineers and Geoscientists BC's Women in Engineering and Geoscience Task Force presented a list of eighteen recommendations for the Association to focus on in support of their 30 by 30 goal. Engineers and Geoscientists BC has been focusing on fulfilling the recommendations of the Task Force as part of their 30 by 30 initiative. Recommendations which have been completed include:

- Development of a professional standards of practice guideline for Engineers and Geoscientists BC members (The Human Rights and Diversity Professional Practice Guidelines), like the ones produced by APEGA and PEO
- Presenting a recommendation to the Canadian Engineering Accreditation Board for adoption of a competency-based approach for undergraduate engineering programs

Some recommendations which are ongoing or in process include:

- Helping to train teachers to be more aware of careers in engineering and geoscience by holding an annual event targeted at teachers
- Supporting employers in creating a gender diverse workplace and workforce by providing access to existing guidelines and workshops which are posted on a dedicated page of Engineers and Geoscientists BC's website, as well as offering seminars on material listed such as for the national Managing Transitions guide
- Continuing to conduct a compensation survey and reporting findings based on gender
- Continuing research into improving diversity in the professions by providing support to a seven-year research project focused on determining best-practices for increasing the recruitment and retention of girls and women in STEM (conducted by UBC and three other Canadian Universities with funding from the Social Sciences and Humanities Research Council of Canada)

(Engineers and Geoscientists British Columbia, 2018a; Engineers and Geoscientists British Columbia, 2018b)

Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Women made up 18.7 percent of APEGA's newly licensed engineers as of December 31, 2016, above the national average of 17 per cent (Engineers Canada, 2018a).

Incorporating recommendations from a Women in APEGA Advisory Group which was established in 2011, APEGA has implemented a number of initiatives and actions directed at reaching its 30 by 30 goal. These included:

- Creation and publicizing of a formal APEGA statement on diversity
- Endeavoring for a 1:1 female:male APEGA member representation at events using diversity best practice methods in volunteer selection
- Development of a document for employees and employers in an engineering and/or geoscience workplace to provide support for and insight into best practices for taking a leave of absence. The document was used by Engineers Canada and Geoscientists Canada to create a national document in 2015 titled "Managing Transitions: Before, During and After Leave"

In the spring of 2018, APEGA was awarded a three-year, $350,000 grant from the federal government's Status of Women Canada agency to promote and further develop means for improved women's equality. APEGA announced that it would use the grant to study workplace barriers that may affect female engineering and/or geoscience professionals. Actions in support of the study which have already taken place include adding diversity and gender questions to APEGA's annual salary survey.

(APEGA, 2018a; APEGA, 2018b)

Association of Professional Engineers and Geoscientists of Saskatchewan (APEGS)

Women made up 16.7% of newly licensed engineers at APEGS as of December 31, 2016 (Engineers Canada, 2018a).

The APEGS 30 by 30 Task Group has taken a number of additional actions toward reaching 30 by 30, including:

- Having a 30 by 30 focused article in every issue of APEGS' newsletter, *The Professional Edge*

- Title sponsorship of the screening of “Dream Big: Engineering Our World” showing at the Saskatchewan Science Centre Kramer IMAX
- APEGS 30 by 30 participation in “Driving WinTech”, a research initiative aimed at increasing the number of women involved in the technology sector in Canada
- APEGS 30 by 30 sponsorship of “Full STEAM Ahead!”, a two-day professional development opportunity focusing on increasing diversity in the workplace

(APEGS, 2018)

Ontario Society of Professional Engineers (OSPE)

As of December 31, 2016, women comprised 14.7% of OSPE’s newly licensed engineers (Engineers Canada, 2018a).

OSPE received a 3-year Status of Women Canada grant of $385,000 in 2017 (Engineers Canada, 2017). OSPE announced that the grant would be used to fund their 36-month long Canada 150 – STEM Challenge: Overcoming Systemic Barriers for Women Choosing STEM Careers project (Engineers Canada, 2017). As part of the project, OSPE will work to collect information, develop strategies and promote policy recommendations with various stakeholders such as students, industry professionals, and government (Engineers Canada, 2017). Some of the major barriers OSPE has identified include cultural bias and discrimination, pay equity and lack of mentorship in early career stages (Society Notes, 2017).

Some findings and actions OSPE have made toward 30 by 30 to date include:

- OSPE’s “Let’s Break Barriers in STEM” initiative
- Partnership with the University of Western Ontario and the University of Toronto to conduct an online survey of Ontario engineers in 2016-2017 to better understand the gendered engineering workplace environment and workplace discrimination
- Partnership with the Ontario Network of Women in Engineering (ONWIE), Professional Engineers Ontario (PEO), the Canadian Centre for Women in Science, Engineering, Trades and Technology (WinSETT), and PEO York Chapter to carry out a needs assessment survey in 2015 of the province’s engineering students, engineering interns (EITs) and engineering professionals in preparation for creation of a pilot mentorship program
- Creation of a 2015 published report titled ‘Crisis in Ontario’s Engineering Labour Market: Underemployment Among Ontario’s Engineering-Degree Holders’, which examines pay equity between men and women mechanical, civil, chemical and electrical engineers using Canada’s 2011 census data

(Society Notes, 2017)

Ordre des ingénieurs du Québec (OIQ)

As of December 31, 2016, women accounted for 17.3% of newly licensed engineers for the OIQ, above the 17.0% national average (Engineers Canada, 2018a).

The OIQ is working toward the 30 by 30 goal in various ways, such as:

- Participating in career days at secondary schools and CEGEPs
- Providing support to "Les filles et les sciences", a program which focuses on inspiring interest in science among young girls
- Conducting workplace surveys examining career satisfaction among women and men professional engineers
- Raising awareness of the engineering profession through presentations to girls and young women across the province by regional volunteer committees

(OIQ, 2016)

Engineers and Geoscientists New Brunswick

As of December 31, 2016, women made up 15% of Engineers and Geoscientists NB's newly licensed engineers (Engineers Canada, 2018a).

Engineers and Geoscientists NB has taken action in a number of ways toward reaching 30 by 30, including:

- Holding networking events for students and professionals
- Partnerships with the University of New Brunswick (UNB) and the Université de Moncton (U de M) on 30 by 30 related outreach and events such as UNB Women in Engineering Society events
- Tracking of APEGNB members by member category (EITs, newly registered members, etc.) and further by gender, and tracking of the number of entry and graduating engineering university students from UNB and U de M

(Engineers Canada, 2018b)

- Awarding Inspirational STEM teacher Awards to educators at the K-12 level who inspire students to continue studying STEM (Engineers Canada, 2018a)

Engineers Nova Scotia

Women made up 18.5% of newly licensed engineers for Engineers Nova Scotia as of December 31, 2016, above the 17.0% national average (Engineers Canada, 2018a).

Officially established in 2014, Engineers Nova Scotia's Women in Engineering Committee was created to assist Engineers Nova Scotia in reaching their 30 by 30 goal and to support its female membership with outreach and networking opportunities (Engineers Nova Scotia, 2018). A number of Women in Engineering Committee sub-committees were also created, which included: a youth engagement sub-committee; an improving work conditions sub-committee; a general public awareness sub-committee; and a supporting women in engineering sub-committee (Engineers Nova Scotia, 2018).

Engineers Nova Scotia has taken a number of additional actions for reaching 30 by 30. These include:

- Visits by an outreach officer to all Nova Scotia high schools
- Partnering Engineers Nova Scotia Council meetings with university student held meetings and sessions, and holding Council meetings at universities
- Hosting an annual dinner ceremony "Spotlight on Innovation" event which features the work of a number of female members

(Engineers Canada, 2018b)

Engineers Prince Edward Island

Based on Engineers Canada's 30 by 30 data, women made up 17.4% of newly licensed engineers at Engineers PEI as of December 31, 2016 (Engineers Canada, 2018a). This is above the national average at that time which was 17.0% (Engineers Canada, 2018a).

Engineers PEI formed the Women in Engineering Committee in 2013, and this Committee supports Engineers PEI in reaching its 30 by 30 goal (Engineers PEI, 2018). Some actions taken by Engineers PEI to address reaching 30 by 30 include:

- Providing support and funding to Girls Get WISE Science Retreat
- Providing support to Girls Get WISE Science Summer Camp
- Hosting networking and social events for members, particularly for women in engineering, such as a movie night showing "Hidden Figures", a networking lunch, and an after-work social at a local brewery
- Sponsoring a university open house for high school girls to attend university engineering classes and to attend a networking lunch with female engineering students and professionals

(Engineers PEI, 2018b)

Professional Engineers and Geoscientists Newfoundland and Labrador (PEGNL)

As of December 31, 2016, women accounted for 11.8% of newly licensed engineers at Professional Engineers and Geoscientists Newfoundland and Labrador (PEGNL) (Engineers Canada, 2018a).

Women in Science and Engineering Newfoundland and Labrador (WISE NL) has been in existence since 1988 and continues to work to increase the participation of women in STEM (WISE NL, 2018). The organization has undertaken a number of actions, such as:

- Creation of the WISE NL Mentorship Program in 2015 for women in post-secondary education and professional women in their career
- Hosting a regular speaker series for the public aimed at highlighting women's achievements and work in science and engineering
- Hosting a WISE NL Aboriginal Youth Conference for female and male high school students, with selection preference for self-identifying Indigenous students, aimed at providing an understanding of science and engineering career options (WISE NL, 2018)

Association of Professional Engineers and Geoscientists of Northwest Territories and Nunavut (NAPEG)

As of December 31, 2016, women accounted for 14.3% of newly licensed engineers at NAPEG (Engineers Canada, 2018a).

NAPEG has appointed a dedicated 30 by 30 champion to oversee and instigate progress toward reaching 30 by 30 and to act as NAPEG's liaison to Engineers Canada's 30 by 30 Champion group (Engineers Canada, 2018a).

II. Trends throughout the Life course

The Role of Media and Stereotypes

Media are one of the wealthiest establishments in society (Raboy, 1990). The media tend to hold significant power through their ability to select and alter information that is presented to the public and through their ability to reach mass and varied audiences in society (Cheryan *et al. 2013;* Raboy, 1990). As such, the media play a critical role in the shaping of social identities and understanding of social realities within a culture (Harper & Thompson, 2017; Raboy, 1990).

Unfortunately, media portrayals of individuals involved in STEM frequently appear to proliferate traditional STEM stereotypes, such as seen in the popular show *The Big Bang Theory* (Cheryan *et al.,* 2011; Steinke, 2017). The mass media is not objective in nature, and STEM areas have been recognized as having a stereotyped image problem, with engineering identified as having a particularly challenging masculine image (Schäfer, 2006). At a time in development when children tend to be at heightened susceptibility to stereotyping, research suggests that mass media gains increased influence as children enter adolescence and attempt to gain independence from parental influence (Cheryan *et al.,* 2013; Steinke *et al.,* 2007). Notably, it is also around this age that research suggests girls tend to lose interest in STEM fields more than boys (Steinke, 2017). Studies demonstrate that gendered media stereotypes of STEM professionals affect young people's understandings of STEM and can influence ideas of their own sense of belonging to or wish to pursue STEM fields, particularly when an identity, such as that of gender, ethnicity, Indigeneity, or socioeconomic status is absent from a mass media representation or is represented as being unsuccessful within it (Cheryan *et al.,* 2013; McDaniel, 2015; Raboy, 1990; Steinke, 2017).

Examples of approaches to combat STEM stereotypes in the media include:

- Media campaigns geared toward challenging STEM stereotypes such as the television series *ScieGirls,* or a campaign called "Picture Me in Computing" offer alternative versions of social cultural realities to the public, challenging the dominant representation as being the reality (Cheryan *et al.,* 2013). The Technical University of Munich (Technische Universität München) (TUM) in Germany recently filmed a web series called "Technically Single" which is a fictional story featuring a young woman beginning studies in Electrical Engineering at a technical university (filmed at TUM), in an effort to make engineering more relatable and inviting in the media to a wider range of potential students. Financially supported by TUM, Filmföderfond Bayern, Hochschule für Fernsehen und Film, and two production companies, the TUM series will be broadcast on a streaming video service similar to Netflix in Germany later this year
- Highlighting alternative media representations to those which are the norm or are stereotypical of STEM may help to challenge or reduce the impact stereotypical media content has for individuals interested in pursuing STEM careers (Cheryan *et al.,* 2013)
- Studies suggest that learning to critically evaluate media content, such as by means of a media literacy program, can successfully lead to a change in understandings and attitudes learned from media content, such as stereotypical perceptions related to STEM fields (Cheryan *et al.,* 2013)

Learned role schemas form the basis for understanding and using stereotypes which are determined by a dominating representation, such as one encountered frequently in the mass media (Council of Canadian Academies, 2012). Family and social cues can also influence gender stereotypical behavior among children as young as three years of age, at which age researchers have found children demonstrating gender stereotypical choice in toys (Steinke *et al.,* 2007). Understanding of social norms using stereotypes can prepare young people to accept stereotypes as realities. Research demonstrates that the stereotype of STEM fields being masculine, such as viewing science as a primarily masculine domain, significantly impacts attitudes toward that field by young girls in grades seven to eight (Steinke *et al.,* 2007). Students in the later years of elementary school and in high school have been found to exhibit greater science stereotyping than younger students, suggesting that adoption of stereotyping is learned over time, and studies suggest that they are done so by both women and men to an equal extent (Cheryan *et al.,* 2013).

Studies have found stereotypes related to gender and perceived brilliance emerge at an even earlier age than those related to science, such as in six-year olds (Chestnut *et al.,* 2018). One study found for instance that five-year-old children tend to identify brilliance in equal numbers of men and women, often identifying an individual of their own gender when asked to point out a smart person, but that by age six, girls tended to identify men more often than women (Chestnut *et al.,* 2018). A similar finding was made in a study of children's behavior toward a game explained as being for brilliant children, where no significant difference was found between five-year-old girls' and boys' interest in the game, but a significant difference was found in six and seven-year olds at which age girls were notably less interested in taking part in the game than boys (Chestnut *et al.,* 2018). As children develop, internal and external stereotype pressures can accumulate as they continue to be encountered in personal, media, and institutional exchanges to create powerful understandings that are not always easily identifiable or easy to escape (Council of Canadian Academies, 2012).

Stereotypes are recognized as having influence on the career choices of individuals (Nassar-Mcmillan *et al.,* 2011). Being aware of negative gender stereotypes of women in STEM has been found to correlate with lower perceptions of ability among girls and women pursuing STEM areas, even when they demonstrate great potential for success (Steinke *et al.,* 2007). When an individual joins a group with which they may not stereotypically be imagined part of by society, social identity or stereotype threat is a well-documented experience that can occur (Murphy *et al.,* 2007; Walton & Spencer, 2009). Understood as a fear that one will be treated differently in a negative way based on their social identity relationship to a stereotype, stereotype threat has been found to challenge performance ability of those experiencing it (Murphy *et al.,* 2007; Walton & Spencer, 2009). Similarly, studies suggest that being outnumbered in a setting where stereotypes may be felt can contribute to reduced expectation of performance ability and reduced performance of a stereotyped minority (Murphy *et al.,* 2007). Literature findings suggest that stereotype threat may pave the way for stereotypes to become self-fulfilling for those stigmatized by them as individuals may conform to stereotype pressures, which is a particularly concerning occurrence for increasing the recruitment and retention of women in STEM since traditional gender stereotypes undermine such efforts (Steinke *et al.,* 2007).

Encouragingly, studies suggest that negative effects of stereotype awareness can be combated by raising awareness that stereotypes can be overcome (Williams *et al.,* 2014). Further, research has found that exposure to role models and peers in STEM fields who contradict stereotypes can reduce the influence such stereotypes have. For instance, female role models in STEM who challenge stereotypes have been found to strengthen other young women's identification with STEM (Riegle-Crumb & Morton, 2017). Increased interaction among members of groups within which stereotypes may exist is well documented to correlate with reductions in prejudice, stereotyping and stereotype threat (Pettigrew & Tropp, 2008).

Examples of approaches to combat STEM stereotypes in general include:

- Simply informing an individual of the existence of a stereotype can contribute to the use of the stereotype, whereas including explaining that people can overcome stereotype preconceptions helped to control and lessen stereotyping (Williams *et al.,* 2014)
- Studies suggest that personal experience which challenges stereotyped perceptions can combat prejudice and inaccurate beliefs learned from stereotypes (Cheryan *et al.,* 2013; Pettigrew & Tropp, 2008). For instance, one study found that young girls who had initially drawn scientists as male in school when asked to draw a scientist, drew scientists as female after meeting a female engineer (Steinke *et al.,* 2007)
- Not framing boys and men as the standard in STEM with sayings such as "girls are as good as boys at math". Research has found that both children and adults infer that a gender framed as the standard is innately better at the action than that framed as the non-standard, even when a topic has no gender stereotype associated with it (Chestnut *et al.,* 2018). Using boys and men as the standard reference of comparison for girls and women in this manner may thus be enforcing the idea of a gendered innate giftedness or ability in STEM, an idea that is not supported by research (Chestnut *et al.,* 2018; Holman *et al.,* 2018)

Believed by some scholars to be the most influential on one's idea of gender and societal gender norms, the local environment includes interpersonal encounters of everyday life, such as those experienced from early age with family and friends (Riegle-Crumb & Morton, 2017).

Family and Friends

Research has found parental education and family-related social determinants such as socioeconomic status (SES) and family environment to be significant in predicting a child's educational attainment and career choice (Buchmann & DiPrete, 2006; Harper & Thompson, 2017; Kolmos *et al.,* 2013; McDaniel, 2015). For example, numerous literature findings recognize family SES as a powerful forecaster of academic success in a positive correlation, where students from families of a lower SES tend to demonstrate lower academic success and those from higher SES tend to demonstrate greater success (Fahle & Reardon, 2018). Studies have repeatedly confirmed that family-based resources such as social, cultural and financial supports are key to a child's educational achievement, contributing not only to success in studies particularly by means of attendance rate, but significantly also to the likelihood that a child will continue in their education past secondary school (Buchmann & DiPrete, 2006).

A survey of graduate engineering students conducted by Engineers Canada found family and friends to also be the most important source of support for engineering students during their undergraduate university studies, as cited by 87 per cent of student respondents (Engineers Canada, 2017). Interestingly, studies have found the effects of variations in family-related social determinants to differ considerably by gender (Chetty *et al.,* 2016). For instance, one study found that the traditional gender gap in employment rates where women tend to be less employed than men is reversed for children growing in poor families in which girls are more likely to work than boys when they are adults (Chetty *et al.,* 2016). Research has also found girls to be more likely to outperform boys in mathematical ability in lower income neighbourhoods, while boys have been found to more likely outperform girls in higher income neighbourhoods, particularly when the neighbourhoods are predominantly white and suburban (Miller & Quealy, 2018). Examples such as these complement research which suggests that social forces begin to contribute to gender gaps from early childhood onward (Calnan & Valiquette, 2010; Chetty *et al.,* 2016; McDaniel, 2015; Steinke *et al.,* 2007).

Early childhood is a time when gender schemas, or gender beliefs and understandings, begin to be secured (Steinke *et al.,* 2007). Family members tend to be the first individuals with which children learn gender-role socialization and parents in particular are understood to have the deepest influence on a child's gender-role maturity (Witt, 1997). Research has also found parents to have a weighty effect on their children's decisions related to tertiary education (Kolmos *et al.,* 2013). For example, in a UK study examining influences on university choice, 26.8 per cent of respondents identified their parents as having influenced their choice to study engineering at university, and over half of university student respondents had one or more parents with either a math, science or engineering background (Kolmos *et al.,* 2013). Further, studies have found that young children are more likely to identify science as a field they would like to pursue when they know a scientist they want to be like either personally or through the media. Research indicates that ideas surrounding scientists are most powerfully shaped by influences such as these, outside of formal educational settings (Steinke *et al.,* 2007). Family and influential adults in the lives of children can lead to an understanding of gender roles which may be stereotypical or lend support to biases through this powerful influence, especially considering literature findings that girls look to their mothers or to adult women in their lives and boys to their fathers or adult men for guidance on understanding gender norms from an early age (McDaniel, 2015; Witt, 1997). Studies also find such gender explicit role modeling to contribute to a child's future career aspirations and associated educational goals (Buchmann & DiPrete, 2006).

Another factor in the development of gendered career aspirations is the geographical location in which a person grows up (Chetty *et al.,* 2016). The built environment and location one lives in relative to others in a shared society can have an impact not only on one's identity and resource accessibility, but also on the range and types of social interactions a person may grow up encountering (Chetty *et al.,* 2016). When children enter adolescence and begin to consider their future career or occupations, knowledge about and resultant aspirations toward jobs is limited by degree of exposure where children generally want a career they have learned about as opposed to one they have never heard of (McDaniel, 2015). Living in a less densely populated area as opposed to a zone with greater population density may limit the range of careers a child becomes aware of. Research has found gender gaps to vary by geographical location, including within urban locations such as between neighbourhoods (Chetty *et al.,* 2016). Larger variations between neighbourhood poverty level or average SES has been discovered to correlate with greater variation in gender gaps between those neighbourhoods (Chetty *et al.,* 2016). Even when a family is an outlier to the general make up of their neighbourhood or their community, experiences specific to that area such as lower-quality school options, difficulty finding skilled teachers, or increased expectation on the part of a parent to be actively involved in their children's schooling, can have an impact on a child's educational achievement and career choice (Fahle & Reardon, 2018).

Friend and peer behaviour have also been recognized as a powerful influence on academic and career pursuits of individuals, particularly in adolescence (Riegle-Crumb & Morton, 2017). Research has found adolescence to be a period in development at which peers gain influence, lessening the influences of parents (Riegle-Crum & Morton, 2017). For example, research has found girls' likelihood of deciding to study advanced mathematics in secondary school increases if they have female friends who pursue and are successful in STEM studies (Riegle-Crum & Morton, 2017). Research has also found that a significant presence of confident female peers in a science classroom improves confidence in girls to pursue STEM and combats negative biases. It is believed female peers help to legitimize the choice to pursue STEM and help to provide a sense of belonging for girls in STEM (Riegle-Crumb & Morton, 2017). However, the confidence and positive effects gained from such peers can be overridden by opposing attitudes of a larger peer group in a classroom (Riegle-Crumb & Morton, 2017). Literature findings highlight the importance of working on changing attitudes and biases of boys in addition to doing so for girls, who tend to be the primary focus of initiatives on increasing the participation of girls and women in STEM (Riegle-Crum & Morton, 2017). While confident female STEM peers help to combat negative biases, research has demonstrated that when such biases are significantly reduced or nearly eliminated in male peers in a classroom, there is a substantial increase in the number of girls interested in pursuing a male-dominated career, such as engineering (Riegle-Crum & Morton, 2017).

Recommendations

- Parents and family members can work toward addressing gender biases by recognizing whether they harbor and perpetuate biases themselves. This can be done using a variety of measures, such as Harvard University's Implicit Association Test (https://implicit.harvard.edu/implicit/canada/takeatest.html).
- Since it is well documented in research literature that having a parent with a background in STEM is significantly correlated to a child pursuing a STEM career, offering a bursary for students who have no direct relation to an engineer and who would be the first in their immediate family to pursue engineering may better support diversity recruitment efforts (McDaniel, 2015).
- It is important to recognize the average disproportionately lower income and SES level of Manitoba's Indigenous population when carrying out initiatives and offering services aimed at increasing diversity and participation of Indigenous Peoples (Harper & Thompson, 2017). Initiatives such as WISE Kid-Netic Energy's Adopt-a-Class program that provides workshops to schools in low-income neighbourhoods in Winnipeg at no cost should be supported and other such programs considered.

- It is also recognized that there exist additional challenges for recruitment of individuals into STEM fields from remote communities such as in northern Manitoba. Programs such as WISE Kid-Netic Energy's week-long science and engineering camps, which take place in communities throughout Manitoba including Churchill and First Nations communities such as in Brokenhead Ojibway First Nation, should be supported and furthered. The Verna Kirkness Science and Engineering Education Program that exists to increase the number of First Nations, Métis and Inuit students graduating from science and engineering programs in Canada brings Indigenous students to campuses, including the University of Manitoba, to introduce them to science and engineering classes and laboratory work for a week. Many of the students describe the experience as very valuable and influential.
- Research has found that girls can experience an increase in sense of belonging and confidence to pursue STEM fields when around other girls who are confident in their interest in and abilities to succeed in STEM fields (Leaper *et al.,* 2012). Based on this, findings suggest that parents and family can help to encourage girls' interest and confidence in STEM by enrolling them in STEM-related extracurricular activities that expose them to other STEM-confident female peers (Leaper *et al.,* 2012).
- Research findings underline the importance and significant positive impacts of exposing boys and men to initiatives and goals aimed at increasing gender diversity in male-dominated fields such as STEM (Riegle-Crumb & Morton, 2017).

Indigenous Peoples and Minority Groups

An important consideration when examining inequalities in Canada's educational institution is of its colonial nature and history, and how this affects Indigenous Peoples, which include First Nations, Métis, Inuit Peoples, Treaty Indians, Registered Indians, and those with membership to an Indian band or a First Nation (Battiste et al., 2002; Bourassa *et al.,* 2004; Statistics Canada, 2017). Inequalities between non-Indigenous and Indigenous Peoples in Canada's educational system are widely recognized as continuing to exist, as in 2016 when high school diplomas had been earned by 91 per cent of non-Indigenous women within the age range of 25 to 64 years as compared to 64 per cent of Indigenous women in the same age range (Manitoba Women's Advisory Council, 2018). Indigenous Peoples are disproportionately positioned among the poorest in Canada, and Indigenous women face the greatest poverty and violence rates in the country (Bourassa *et al.,* 2004; Harper & Thompson, 2017). As legacies of oppression and intellectual colonialism continue to be felt over generations from residential schools operating from circa1831 to 1996, the negative attitudes of some Indigenous Peoples towards schooling in Canada are deserving of understanding (Battiste et al., 2002; Pidgeon, 2016; Truth and Reconciliation Commission of Canada, 2015).

According to Engineers Canada, individuals identifying as Indigenous Peoples accounted for only one per cent of Canadian undergraduate engineering students in 2016, disproportionate to their representation in the country's population in which Indigenous Peoples accounted for 4.9 per cent that year (Ricci, 2016; Statistics Canada, 2017). As the fastest growing population in Canada, growing at roughly four times the rate of non-Indigenous peoples since 2006, and as one of the youngest in average age with nearly 44 per cent being less than 25 years old in 2016, Indigenous Peoples constitute a significant and unique population in Canada and Manitoba's demographic landscape (Government of Canada, 2017; Statistics Canada, 2017). The University of Manitoba's Engineering Access Program (ENGAP) is recognized as one of the leading programs in Canada for Indigenous applicants wanting to study engineering (University of Manitoba, 2018). Growth of ENGAP is highly recommended to increase the number of Indigenous professional engineers in Manitoba.

Due to the scope of this Scan, the focus in most of the document is on women primarily as a whole using dichotomous terms such as male and female or man and woman. However, it is critical to recognize while reading this document and considering its recommendations that girls and women are not one homogenous group, and instead represent numerous identities based on identity associations such as of class, race, family-status, Indigeneity, ethnicity, age, (dis)ability, sexual orientation, and more, which can further intersect with one another to create another multiplicity of identities which can moreover be fluid and changing (Adams, 2017).

K-12 Education

Just as family and friends and their related social determinants can contribute significantly to a young person's choice to pursue an engineering career, so too can elementary and secondary school education (Pearson *et al.,* 2015, p. 27). Elementary and secondary schooling is required by law for children in Canada by means of publicly funded public school, paid private school, or at-home schooling (Government of Canada, 2017). Typically spanning from early childhood to adolescence and early adulthood, elementary and secondary education take place at crucial points in development. It is during elementary and secondary school education when math achievement gender gaps tend to appear and when future career aspirations are determined, and when pre-university educational choices to achieve them are made (Kolmos *et al.,* 2013; Riegle-Crumb & Morton, 2017; Robinson-Cimpain *et al.,* 2014). Understanding gender inequalities and their determinants in pre-university educational success is important to increasing diversity and gender balance further downstream in STEM university studies and careers (Council of Canadian Academies, 2012; Pearson *et al.,* 2015).

Referred to by some as the "queen of sciences" or as the essential ingredient for STEM subjects, aptitude in mathematics (math) is commonly used to predict a child's future success in STEM (Council of Canadian Academies, 2012; Guba & Lincoln, 2003; OECD PISA, 2015; Statistics Canada, 2017). Beginning in kindergarten at the age of five or six years old, elementary schools begin to teach children various core subjects such as language-of-instruction arts (language arts) and math. It is in this learning period that gender gaps in math achievement tend to first appear (Government of Canada, 2017; Robinson-Cimpain *et al.,* 2014). Unlike race- or SES-based gaps in math success or gender-based gaps favouring girls in reading at the start of kindergarten, studies have found no evidence of gender-based gaps in math ability at that time (Robinson-

Cimpain *et al.,* 2014). Instead, research has found that gender-based gaps in math performance emerge by third grade favouring boys (Robinson-Cimpain *et al.,* 2014). The finding that math-based gender gaps tend not to appear in kindergarten concurrently with other socially constructed gaps from pre-elementary school childhood, and instead appear later in elementary school, suggests that elementary schooling might play a significant role in creating gender-based gaps in mathematical achievement (Robinson-Cimpain *et al.,* 2014).

One theory as to why math-based gender gaps may emerge after a few years of schooling is that math is commonly taught as a subject that someone can have an innate ability and 'brilliance' in (Chestnut *et al.,* 2018; Pearson *et al.,* 2015). Since brilliance tends to be associated with some groups more than with others in our society, such as with white men more than with women of colour, this teaching can predispose certain individuals to perceive a greater sense of confidence and natural ability in math than others (Chestnut *et al.,* 2018). Gender stereotyping has been recognized in schools across Canada and the United States at the elementary school level and above, and teachers have been found to influence students' future educational achievement (Council of Canadian Academies, 2012; Miller & Quealy, 2018; Robinson-Cimpain *et al.,* 2014). For instance, a U.S. study surveying first grade teachers from various schools found teachers to regularly attribute girls' math success to hard work and boys' math success to giftedness (Chestnut *et al.,* 2018; Fennema *et al.,* 1990). Researchers have noted that a similar association tends to be made for ethnic or racial minorities where their educational successes are commonly assumed to be the result of persistent hard work and/or institutional supports more so than of brilliance or innate talent (Chestnut *et al.,* 2018). Continual exposure to gendered beliefs about ability and giftedness in math from socializing agents like teachers, impacts self-confidence in math. Studies have found self-beliefs relating to ability to be formed based partly on comparisons to other classmates (Chestnut *et al.,* 2018; OECD PISA, 2015; Robinson-Cimpain *et al.,* 2014). Lack of self-confidence and anxiety toward math has been proposed as a substantial contributor to the lack of women in STEM fields (OECD PISA, 2015).

Gendered differences in attitudes toward science continue to be noted at the secondary school level (Wasburn & Miller, 2004). For instance, an international educational survey of 15-year olds conducted by the Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA), found girls to be more likely to experience math anxiety than boys (OECD PISA, 2015). Reported feelings of math anxiety led to future avoidance of math if given the option (OECD PISA, 2015). Even young women who demonstrated greater success in math than their peers were still less likely to pursue STEM studies at university than young men who demonstrated lesser success in math (Ferguson, 2016). This underlines the strength that misconceptions about gendered innate giftedness in math can have on an individuals' desire to pursue math or math-related subjects in the future (OECD PISA, 2015). Alternatively, success in language arts is also commonly attributed to giftedness rather than to practice, and this misconception favours girls (OECD PISA, 2015; Ferguson, 2016). Research has found perceptions of self-belief to develop from comparing success between subjects. It has been theorized that since girls tend to perform better at language arts and particularly reading than in math, they may interpret their math performance as lacking, even when they are at the top of their class (OECD PISA, 2015). This can further contribute to a lack of confidence in math ability and to math anxiety (OECD PISA, 2015). Adolescence is a crucial point in the pipeline of pursuing a career in engineering as it is a time when young people make significant choices relating to future educational and job possibilities, but also a time when social pressure to conform is at its greatest, (Buchmann & DiPrete, 2006; Van Langen & Dekkers, 2005; Watt *et al.,* 2012).

Studies have found a significant positive correlation between adolescents aspiring to have STEM careers and majoring in a STEM subject in university (McDaniel, 2015). Further, women and men have been found to be equally likely to complete an engineering or science degree if they aspired to it during their last year of high school (Legewie & DiPrete, 2014; McDaniel, 2015). However, the last years of high school remain a source of ‘leakage’ in the life course pipeline toward becoming a professional engineer as high-level math and science courses become optional (Buchmann & DiPrete, 2006; Robinson-Cimpain *et al.,* 2014). Greater freedom to choose elective courses in the last years of high school compared to limited curricular choice has been found to coincide with stronger peer influence on a young person’s curricular and career choice, and to coincide with less women in STEM studies (Buchmann & DiPrete, 2006). Literature findings suggest that there exists a disconnect between the options students choose in their last years of high school and the tertiary and career paths they expect to be able to pursue thereafter (Council of Canadian Academies, 2012).

Other research posits that the main problem for recruiting women to pursue a pathway to STEM careers from high school is that there is insufficient awareness surrounding what an engineering career involves, particularly in a way that challenges negative stereotypes about engineering (DeBartolo & Bailey, 2017; Calnan & Valiquette, 2015; Cantrell & Ewing-Taylor, 2009; Council of Canadian Academies, 2012). Study findings by Engineers Canada and the Canadian Council of Technicians and Technologists indicate that it is not a lack of interest or participation of girls and young women in math and science that is an impediment to increasing the numbers of women in engineering and technical careers, but instead a lack of understanding of what such careers can entail combined with the negative stereotypes of these careers held by women such as that they are not as ‘people-oriented’ or as social as other disciplines (Calnan & Valiquette, 2010). These findings are supported by research from a number of American engineering associations as well (Calnan & Valiquette, 2010). However, solely increasing student awareness of what careers in engineering and technical disciplines generally offer has been found to have little impact towards pursuing them (Calnan & Valiquette, 2010).

One approach researchers suggest is to present the public with an entirely new or rejuvenated idea of what engineering and technical disciplines are, in order to open the public mindset to what these careers can offer (Cantrell & Ewing-Taylor, 2009). Instead of showing engineers as builders or operators, engineers should be portrayed as creators and designers (Cantrell & Ewing-Taylor, 2009). A recent campaign video by the United Kingdom’s Royal Academy of Engineering entitled, “This is Engineering” (http://www.thisisengineering.org.uk) (portrayed engineers as socially focused individuals who work on global issues and help to make the world a better place Royal Academy of Engineering, 2018). It is widely acknowledged that certain engineering disciplines such as Mechanical or Electrical engineering tend to be perceived by the public as being less directly related to societal welfare and helping people than others, such as Biosystems or Biomedical engineering. Girls and women tend to apply to and make up representation within the latter disciplines (Calnan & Valiquette, 2010). By showcasing engineering as a profession that works toward solving global issues and directly helping people in various multidisciplinary ways, not only might more girls and women consider engineering as a career, but a more diverse array of individuals overall may be interested in learning more about engineering and pursuing its study (Calnan & Valiquette, 2010; Cantrell & Ewing-Taylor, 2009).

Role models and mentors are extensively referenced as being significant in the recruitment and retention of women in STEM (Council of Canadian Academies, 2012; Fox, 2010; Ingram *et al.,* 2009; Ronene & Pines, 2008; Schäfer, 2005; Wasburn & Miller, 2004). Women role models and mentors can contribute a sense of 'belongingness' and self-identification to STEM students and professionals, by challenging gender norms and helping to lessen feelings of anomie or loneliness associated with being a minority (Gaucher *et al.,* 2011; Harper & Thompson, 2017). However, research suggests that the most effective types of role models and mentors for recruitment are not necessarily the most effective for retention, where a role model's gender has been found to be less important (Drury *et al.,* 2011). For example, studies have found that when women in STEM fields reflected on who first inspired them to pursue STEM, they were equally likely to indicate a man or a woman (Drury *et al.,* 2011). The fact that women in STEM were equally recruited by men as women suggests that male role models and mentors are successful in recruitment (Drury *et al.,* 2011). Understanding this can help to alleviate pressures put on women in STEM to be visible in increasing the number of women in their respective discipline. Over-reliance on a few women can contribute to burnout, a state of exhaustion recognized as occurring more in professional engineering women than men (Ronene & Pines, 2008; Schäfer, 2005). Utilizing men in efforts to increase the participation of women in STEM such as in recruitment is an inclusive approach that can shift diversification efforts from being perceived as a woman's issue to being understood as a shared societal issue (Schäfer, 2005).

Even more important than the gender of a role model or mentor is the degree to which that individual challenges stereotypes. (Drury *et al.,* 2011; Riegle-Crumb & Morton, 2017; Schäfer, 2005). Referred to as 'stereotype-inoculation', STEM role models who challenge traditional stereotypes associated with their STEM identity can provide significant confidence and sense of belonging to those in STEM who do not fit the stereotypes, thereby increasing the likelihood of these individuals pursuing the respective discipline (Riegle-Crumb & Morton, 2017). For instance, a male computer science professor at Harvard University is cited as being responsible for one of the most significant increases in the number of women in a computer science class at the University as a result of his non-stereotypical character and his teaching approach which emphasizes the context within which computer science can be of benefit and use in society, which has been found to appeal to women (Schäfer, 2005). Even including non-stereotypical displays in STEM or STEM-related elementary school classrooms such as nature posters instead of Star Trek posters has been found to correlate with a greater sense of belonging and interest in these subjects by girls (Cheryan *et al.,* 2013).

Some discussed ideas related to increasing girls' interest in STEM fields at the kindergarten to high school levels include sex-segregated schooling and school choice between private and public. While the private school sector has gained greater presence in Canada over the years and tends to be widely highly regarded, as of 2004 only about five per cent of Canadian elementary and secondary school students attended private schools (Davies, 2004). With those attending private school tending to be children of parents from some of the highest levels of SES, and thus likely already exposed to the field of engineering, it makes sense to focus the majority of recruitment and retention efforts in the public school sector. (Davies, 2004; Fahle & Reardon, 2018; Kolmos *et al.,* 2013; Steinke *et al.,* 2007). As Söderström & Urusitalo note, choosing which public school to attend is a more common decision for parents and children than choosing between attending a private or a public school (2010).

Regarding sex-segregated schooling, one of the most common arguments against its use is the idea that it goes against the 'natural atmosphere' or creates a 'artificial world' (Brutsaert & Van Houtte, 2002; Sagebiel & Dahmen, 2006). Yet, studies suggest that girls and boys naturally create gender segregated school environments for themselves from preschool onward by generally preferring to be around peers of the same gender (Brutsaert & Van Houtte, 2002). Research has found that girls-only secondary schools provide adolescent girls with an increased sense of belonging and less feelings of stress than adolescent girls in co-ed school environments. Research has also found that girls who attend a girls-only high school are more likely than those who attend a co-ed high school to pursue non-traditionally female careers such as engineering afterward (Brutsaert & Van Houtte, 2002; Thompson, 2003). One theory as to why this may be is that these schools that direct learning specifically to girls may spend more time and resources and be more effective than co-ed schools on teaching topics such as feminism and sexism, which has been correlated to greater pursuit of girls in male-dominated fields later on (Leaper *et al.,*2012; Thompson, 2003). These findings lend support to theories that school environment is more influential and important for girls' sense of belonging and future likelihood to pursue non-stereotypical career paths than for boys. This has also been demonstrated in studies where boys' feelings of belonging are not significantly changed with the presence of girls in secondary schools while girls' feelings of belonging decline with the presence of boys (Brutsaert & Van Houtte, 2002). There is still much opposition to the idea of gender-segregated education, particularly among young people, as being discriminatory, old-fashioned, furthering ideas of gendered innate abilities, and as a poor policy approach to take (Bradley & Cooper, 2009; Sagebiel & Dahmen, 2006; Thaler & Wächter, 2005). While sex-segregated schooling to increase participation of women in male-dominated careers may still be a contentious idea, it is worth noting the significance that a same-gender learning environment has for girls and women, more so than for boys and men (Brutsaert & Van Houtte, 2002).

Recommendations

- Learning about feminism and gender equality has been found to positively correlate with increases in inspiration to study science and math (Leaper *et al.,* 2012).
- Research suggests that more inquiry-based learning, teacher involvement, hands-on learning, and role-model engagement and interaction are teaching methods which appeal to girls and women (Cantrell & Ewing-Taylor, 2009).
- Research suggests that teaching and presenting math as a subject in which success is earned with learned skill and practice and avoiding mention of ideas about innate math ability or brilliance is correlated to smaller gender-based gaps in math achievement (Miller & Quealy, 2018).

- It is important to consider that some teachers and guidance counselors at certain high schools may be more aware of what is required to pursue university education in fields such as engineering or medicine than others. Teachers and school staff may express their own biases by only sharing information about these careers to certain students who fit their biases and by communicating how accessible they feel certain careers are (Robinson-Cimpain *et al.,* 2014). Educating school staff at all levels across the province in kindergarten to grade twelve on becoming aware of the biases they harbor and on the benefits of combating such biases, as well as on how best to prepare students for direct entry university programs such as engineering when in high school, may help to lessen discrepancies in proportional application and representation of students between schools in Manitoba.

University and College

Researchers have noted a significant rise in the number of people expecting to attend university and to pursue a university undergraduate degree in Canada in recent decades (Davies, 2004). In most industrialized countries including in Canada, many have acknowledged the presence of what is perceived to be a demonstrated ‘female advantage’ in this increase as women seem to be pursuing and earning more university degrees than men (Buschmann & DiPrete, 2006). This can be seen in Manitoba where in 2016, 61 per cent of women age 25 to 64 held a postsecondary certificate, degree or diploma compared to 54 percent of men within the same age range (Manitoba Women’s Advisory Council, 2018). In Canada, the proportion of women having fulfilled postsecondary education requirements increased by more than double from 1991 to 2015, more than it did for men in that time span (Ferguson, 2016). Klassen notes that there has been a momentous increase in university undergraduate engineering enrollment in Canada as well, as in 1990 there were roughly 38,000 engineering undergraduates compared to approximately 80,000 in 2015 (2017). However, women still tend to be found more concentrated in university studies of education, health and the humanities than in engineering (Holman *et al.,* 2018). Even within engineering, women tend to be concentrated in disciplines more directly associated with social welfare and living systems such as Biosystems; approximately 71 per cent of the University of Manitoba’s graduates in Biosystems engineering in 2015 were women, compared to nine per cent of graduates in Mechanical engineering that same year (Engineers Canada, 2015).

One explanation as to why more women than men are earning tertiary level education is that the return value of doing so has increased more for women than it has for men over time (Buchmann & DiPrete, 2006; Moyser, 2017). For example, marriage and parenthood effects in Canada have been found to impact labour market earnings differently for men and women, where men tend to receive what has been referred to as a ‘fatherhood premium’ and women a ‘motherhood penalty’, as men’s earnings increase both with marriage and fathering young children, while women’s earnings show no correlation to marriage status and lower earnings are associated with being a mother (Waite, 2017; Zhang, 2015). In addition to offering benefits such as increasing the likelihood for a high standard of living and protecting against unemployment, higher levels of educational attainment are also traditionally associated with greater earnings in the labour market and a narrowing of the gender wage gap. However, research by Waite suggests that this is only the case for those with post-secondary education up to the master's level (Waite, 2017). Returns associated with postgraduate education and wage premiums for master's and doctoral degrees are greater for women than men in Canada, supporting the idea that there are greater incentives for women to attain a higher level of education (Waite, 2017). Findings suggest that the return value on level of educational attainment is domain specific, as women have been found to earn smaller postgraduate wage premiums than men in engineering compared to more traditionally female dominated areas such as education (Waite, 2017).

Engineering culture has been raised as another barrier women face in becoming professional engineers. While the professional engineering culture might be less pronounced in university than in work settings, university engineering provides an introduction to the culture of the profession and is a period of professional socialization (Cech, 2013). The culture of engineering can be understood as a socially created force which can unify social actors by means of a shared set of norms and expectations held by engineers and also as a force which can be divisive based on the same set of communicated norms and expectations. The culture of engineering is well established in the literature as being associated with the white, heterosexual male gender role and this is acknowledged to negatively impact women pursuing engineering (Council of Canadian Academies, 2012; Robinson & McIlwee, 1991; Simon et al., 2017; Williams et al. 2014; Cech, 2013). This culture is found throughout engineering in various conscious and unconscious ways of being a part of or of understanding the profession, such as in "engineering jokes" (Cech, 2013). Another example is the expressed belief that being good at 'tinkering' means that a person has an innate giftedness for engineering (Ingram & Parker, 2002). As Ingram & Parker point out, this alone can be a barrier to women's participation in engineering as it is a behavior traditionally socialized and deemed more appropriate for boys and men than for girls and women (Ingram & Parker, 2002). Failing to assimilate to the heteronormative male-biased normative culture and behaving in feminine ways has repeatedly been found to result in experiences of a what is commonly referred to as a 'chilly climate' (Simon et al., 2017; Cech, 2013). Rejection of such norms and ideologies associated with engineering culture, including traditionally stereotypical ideas of how women should behave, can result in the real or perceived risk of isolation and further marginalization. This can provide a strong incentive to conform or to hesitate before rejecting such a culture or ideologies (Cech, 2013; Mlambo & Mabokela, 2017). The conflict between societally socialized gender expectations and those experienced in engineering results in tension between gendered roles and it is understandable that this could cause stress to those having to navigate multiple identities (Mlambo & Mabokela, 2017). Even if an individual does not agree with certain beliefs and aspects of engineering culture concerning gender equity but chooses not to voice this disagreement, this further reinforces these gendered understandings of engineering culture and its patriarchal nature (Cech, 2013; Mlambo & Mabokela, 2017).

It is important to note that ideologies within engineering culture which hinder women's recruitment and retention in engineering may be supported and defended by women as well as by men, as demonstrated by beliefs in depoliticization and meritocracy (Cech, 2013; Faulkner, 2009). Depoliticization, or the belief that political and social issues are not applicable to engineering, and meritocracy, the belief that society is structured fairly and that each individual earns the outcomes in life they deserve, are recognized as being rooted within engineering culture and as helping to justify social inequalities (Cech, 2013; Faulkner, 2009). These ideologies assume that engineering is an explicitly technical domain and that the opportunity to pursue engineering is equally available to all, that the society we live in is structured in a way that is fair, and that individuals choose their position in the social hierarchy, all of which has been disproven by social research (Cech, 2013). These ideologies also foster neglect of social issues such as of social inequalities and social justice within engineering, which tend to be areas of interest for women particularly (Calnan & Valiquette, 2010; Cech, 2013).

Although studies have identified women as having greater academic success in engineering than men, their success has often been attributed by other students to external systematic factors that advantage women such as a gender quota or gendered treatment by a professor, rather than the individual's hard work (Schäfer, 2005). Being a part of a social network of other women or minorities in engineering may counter negative attitudes from a majority-group so that feelings of imposter syndrome do not prevail (Sagebiel & Dahmen, 2006). Research indicates that university students consider how similar they are to individuals already in the areas they are considering specializing in, and that greater similarities result in a greater belief that the individual will do well and belong, and a greater likelihood that they will choose to pursue the area (Cheryan et al., 2013). As Cheryan et al. point out, perceptions of how similar a student feels to those they see within a particular discipline matter. Changes in how similar representatives of a specialty are viewed by prospective students could change the types of students who apply to that discipline (Cheryan et al., 2013).

Recommendations

- As the literature acknowledges that the engineering culture is not gender neutral, improving recruitment and retention of women to engineering requires positively changing engineering culture to lessen biases which favour men. The approach of having women change to more easily assimilate has not demonstrated a significant improvement in the recruitment or retention rates to date (Male et al., 2009).
- Studies suggest that social welcoming events are particularly appreciated by women in male-dominated fields, as an opportunity for establishing social networks with other minorities (Sagebiel & Dahmen, 2006).
- Although incorporating social welfare topics into engineering studies such as by an additional lecture or an extra assignment, it is not an effective way to challenge ideologies central to the culture of engineering' (Cech, 2013). It is recommended that meritocracy and depoliticization be explained and the topics which they devalue be further discussed in relation to their importance to engineering (Cech, 2013). Cech suggests that engineering educators partner with social science educators to better teach students the structural, cultural, and institutional societal origins of social welfare and social inequalities and to highlight commonplace uses of such knowledge in engineering work (Cech, 2013). As social engagement and social welfare are recognized as areas that

women tend to be interested in, efforts to increase the presence and role these focuses have in engineering offer potential to increase the number of women in engineering (Calnan & Valiquette, 2010).

Employment

Alongside women's increasing labour force participation since the mid-20th century, research has found an accompanying reduction in differences between men and women's educational majors, occupational choices, hours worked, time spent in the labour force, and wages earned (Ellingsaeter, 2013; Goldin, 2014; Moyser, 2017). Employment rates positively correlate with increases in levels of education earned. As women are earning a greater proportion of tertiary degrees than men, they are also an increasing proportion of the labour market. The gender wage gap appears to be shrinking for those with university education (Buchmann & DiPrete, 2006; Ferguson, 2016; Moyser, 2017; Waite, 2017). Despite these advances and despite expansion of Canada's knowledge-based economy including STEM professions, women continue to be underrepresented in STEM fields and particularly in engineering (Ferguson, 2016; Manitoba Women's Advisory Council, 2018; Riegle-Crumb & Morton, 2017; Simon et al., 2017). Differences in women's labour force participation and membership in the engineering profession compared to that of men are significant and manifold. These include noteworthy distinctions are women's sector preference (public vs private), lower level of representation in top management and executive levels, a tendency to work part-time, as well as subtle distinctions such as gendered language use and use of social support networks (Chestnut et al., 2018; Council of Canadian Academies, 2012; Holman et al., 2018; Ingram et al., 2009; Moyser, 2017). In 2016 in Manitoba more women worked part-time than men, accounting for 64.6 per cent of all part-time employees in the province, and this pattern is seen internationally (Manitoba Women's Advisory Council, 2018; Moyser, 2017). Differences between women and men professional engineers vary by intra-professional factors as well as by firm size, firm location, wages and more (Adams, 2017; Marshall, 2015; Van Langen & Dekkers, 2005).

Recognizing the complexity of labour market trends, segregation is commonly understood in terms of horizontal segregation which can be understood as segregation across a field, vertical segregation which can be understood as segregation between hierarchical levels of a discipline, and in terms of 'gliding gender segregation' which can be understood as gendered differences employees experience at the workplace in allocation of job duties, team tasks, opportunities and wages, etc. (Mandel & Semyonov, 2006). These differences are acknowledged to occur as a result of social influences at multiple levels such as at the individual or institutional level, and which may be consciously or unconsciously communicated (Pearson et al., 2015, p. 54). Research literature stresses the importance of becoming aware of divides in professional engineering employment, to avoid underuse of women's talents (Faulkner, 2009).

Research examining engineering workplaces has found a negative correlation between the degree of engineering culture present which values 'tinkering' know-how and masculine interactions and displays, and women's success in that environment (Faulkner, 2009). Ingram et al., discusses styles of interaction fostered by engineers which are traditionally masculine and are not the communicative styles women tend to be practiced at or be inclined to adopt, which research has found consequently diminishes their career success (Ingram et al., 2009).

Studies have found that managers tend to hire individuals who are similar to themselves. In a male-dominated profession, women are less likely to be chosen for management positions compared to men (Bygren, 2013; Ellingsaeter, 2013).

Literature highlights that engineering competence and excellence is often synonymous with male competence and excellence based on traditionally masculine characteristics such as the ability to work long hours (Pesonen, 2009). Tendencies to use masculine norms for establishing measures of excellence can hinder those who behave differently, such as by reducing work hours to part-time to look after family needs (Pearson et al., 2015, p. 65; Roberts & Ayre, 2002). While some women may succeed in such environments or in what is commonly referred to as a ‘chilly climate’ in engineering, these women engineers represent a small and unique minority of women (Ronene & Pines, 2008; Simon et al., 2017). Even wording for engineering job advertisements has been found to recruit for predominantly masculine attributes, such as competitiveness or strong leadership, as opposed to interpersonal skills, which are more commonly found in advertisements for occupations which are more gender balanced (Gaucher et al., 2011). Such masculine gendered language in job advertisements is associated with reduced numbers of women applicants (Williams et al., 2014). Likewise, tacit interactions and unspoken cues, such as greeting a woman engineer with a nod and a man engineer with a handshake, particularly when repeated over time, can have powerful negative effects on even the most academically successful women, as Dinovitzer et al. note (Dinovitzer et al., 2009).

Valuing assertive self-promotion is another example of engineering culture which poses conflict for women who are not generally socialized to express aggressiveness, putting them at risk of being disliked or of experiencing negative consequences if they act in contradiction to prescribed gender norms, or of not being able to compete to the same degree as men for promotion (Faulkner, 2009; Ingram et al., 2009; Williams et al., 2014). Research has found that successful women who violate gender expectations tend to be viewed as ‘less likeable’ and less deserving of high-performance ratings and rewards than male colleagues who act in the same manner (Dinovitzer et al., 2009). Other studies have found administrators and management to respond to women differently based on their fitting to gender prescriptive biases, where a woman being demanding, has been found to trigger negative reactions (Pearson et al., 2016, p. 66). While women reliably oppose sexist behaviours and beliefs more than men, both women and men can express gender prescriptive biases such as that women are friendlier and more collectively-oriented than men. Women respond negatively or even more negatively than men to women who break this ‘niceness’ expectation (Rudman & Glick, 2001). Similarly, salary negotiation is understood to benefit men more than women where women experience costs when acting in masculine ways that men don’t experience. Research has found that when people were made aware that an individual negotiated a greater salary, they were 5.5 times less keen on working with that individual if it was a woman than if it was a man (Dinovitzer et al., 2009).

Upon entering professional engineering employment after university, scholars noted different impacts on women and for men during the family formation period (Nimmesgern, 2016). Literature suggests that one of, if not the most, harmful of gender biases is the ‘maternal wall bias' generated by motherhood (Williams et al., 2014). This bias presumes that women's commitment to work and capabilities to succeed in the profession significantly decline after they have children, and punishes women who act differently than this assumption, such as by prioritizing work over family commitments. This bias was shown to vary based on the woman's race due to the specificities of racial stereotypes (Williams et al., 2014). While there is a fluidity and complexity of ways of performing motherhood alongside professional work, motherhood is also socially constructed and mothers tend to face substantial conflict in having to meet the demands of motherhood while at the same time behaving in prescribed masculine ways to be deemed competent and committed in the engineering culture (Herman et al., 2012).

This change in identity is noted as differentiating women from highly-masculine peer groups (Herman et al., 2012). Women's minority status in engineering can add further tension through the 'in/visibility paradox', whereby women professional engineers come to feel invisible as engineers and visible only as women (Faulkner, 2009; Herman et al., 2012; Seron et al., 2018). Research indicates that these family and career balance issues tend to result women's attrition from the engineering profession approximately ten years after graduation (Calnan & Valiquette, 2010). While not all women have children, studies have identified a tendency for people to see all women as possible mothers and by extension even women without children tend to be hindered to some degree by a 'maternal wall bias'. (Faulkner, 2009; Zhang, 2015). While men also have children and have child-rearing responsibilities and roles, according to stereotype and in actuality, women more often look after children and family members and dedicate more time to doing so than men in Canada (Statistics Canada, 2016). Consequently, women are more likely than men to experience difficulties balancing work and family responsibilities and women professional engineers are more likely to agree that this balance is hard to achieve. (Adams, 2017; Ronene & Pines, 2008). Flexible work arrangements can help to mitigate stress and barriers encountered in balancing work and family life and in so can help to prevent loss of individuals, of all identities, from the engineering profession (Council of Canadian Academies, 2012; Goldin, 2014; Nimmesgern, 2016). Furthermore, research suggests that promotion of flexible work arrangements and of work-life balance is inviting to and supportive of women and that there is a positive correlation between organizations who offer flexible work arrangements and their greater gender balance (Bebbington, 2002; Council of Canadian Academies, 2012).

Flexible work arrangements are recognized as contributing to increased performance and productivity in work (Council of Canadian Academies, 2012). While most women engineers surveyed in a Canadian 2002 report identified their employer as offering a degree of flexibility for balancing work and family, availability of such flexibility tends to be limited for individuals working in firms of less than 100 employees or working on a contract basis. (Ingram, 2007; Van Langen & Dekkers, 2005). A survey by the Association of Consulting Engineering Companies (ACEC) identified flexible working hours as being an appealing benefit to most who responded to the survey, yet also as being one which few identified as being comfortable using due to the risk of negative consequences (ACEC, 2015). Only changing working hours to accommodate more flexible work arrangements has not been found to be sufficient to significantly increase the representation of women in a profession. Instead, it is believed that a multiplicity of changes is needed to impact gender representation (Hold & Lewis, 2011).

Lack of national childcare policies, as is the case in Canada, have potential to further strain the work-life balance of professional engineers with children as compared to those living in countries with greater institutional supports for childcare (Council of Canadian Academies, 2012; Pearson et al, 2015, p. 67). Differences in benefits and supports exist between public and private professional engineering sectors within Canada as well (Waite, 2017). Women tend to be more greatly represented in the public sector than in the private sector of the workforce (Dinovitzer et al., 2009). The public sector is characterized by factors which contribute to greater equality and smaller wage gaps for women and minorities, including greater unionization rates, greater coverage by equality legislation, and more rigid and less open-to-negotiation wage setting practices (Waite, 2017). Public sector employers are also more likely to offer the Supplemental Unemployment Benefit (SUB), also referred to as a 'top up', to individuals on maternity and parental leave to top up their employment insurance remuneration. In 2010, 48 per cent of public sector employed new mothers received top ups compared to only eight percent of new mothers employed in the private sector (Paterson, 2017). Some of the supports which the public sector provides seem to be more highly desired by women . Working in a larger firm with 500 or more employees also tends to increase the likelihood of receiving top ups which are beneficial not only for employees in helping to increase earnings during leave, but also for employers since SUB agreements typically require the employee to return to employment at the firm within a set amount of time, helping employers retain employees in the process (Marshall, 2015). Engineers Canada and Geoscientists Canada estimated in 2012 that replacement of entry level employees costs roughly 40 per cent of their annual salary, replacement of mid-level employees costs approximately 150 percent of their annual salary and replacement of a top-level employee costs roughly 400 percent of their annual salary. These costs reinforce the value in retaining professional engineering employees, particularly those with a specialty (Engineers Canada, Geoscientists Canada, 2012).

While public sector employment for professional engineers offers supports which the private sector does not, it also tends to pay less than jobs in private industry (Dinovitzer et al., 2009). It is theorized that this difference in sectors contributes to the gender pay gap between men and women in all countries (Pearson et al., 2015, p. 66). In Canada, women continue to be paid less than men with the same credentials and experience working the same number of hours at roughly 74 cents on the dollar (Maclean's, 2018; Moyser, 2017; Statistics Canada, 2016; Waite, 2017). Increased uptake by men of paternity and parental leave options could help to dismantle gender stereotypes by challenging views of women as the sole or primary caregiver of children, allowing greater opportunity for women to take on other roles and greater long-term family involvement by fathers (Ellingsaeter, 2013; Marshall, 2014).

Literature suggests that women tend to be socialized to understand a sense of self identity through connecting with others and thus place a greater value on interacting with people and working in a social environment than men do (Holman et al., 2018). Studies suggest that women receive less career and collegial support in the workplace than their male engineering peers (Ronene & Pines, 2008). Women experience greater risk of burnout in engineering than men, and social supports through interpersonal relationships in the profession help insulate and protect women against burnout (Ronene & Pines, 2008). Mentorship and networking initiatives should provide women with role models and peers who challenge gender norms (Council of Canadian Academies, 2012). A prevalence of hierarchical work arrangements and impersonal or technical interactions is considered negative by women while more cooperative environments are seen as more inviting (Roberts & Ayre, 2002). An increasing demand for managerial and soft skills in engineering might mean that the creation of environments and more interactive management styles might help Canada's engineering professionals be more diverse and remain competitive (Kolmos et al., 2013; Roberts & Ayre, 2002).

The representation of women decreases the higher up in the professional and workplace hierarchy one moves (Rees, 2010). Gender quotas are one means of combating disproportionate representation of women or minorities in positions of power and influence. In 2004, Norway introduced a law requiring that 40 per cent of public board members be of the lesser represented gender on the board. Research has found that the discussion of introducing gender quotas can positively influence the recruitment of the underrepresented gender (Ellingsaeter, 2013; Virtanen, 2010). Implementation of gender quotas remains debated; however, they are worth considering to achieve equality of outcome that challenges popular ideas of depoliticization in engineering culture which are recognized as helping to maintain gender inequalities in the profession (Cech, 2013; Pesonen et al., 2009).

Recommendations

- Employers can offer flexible work arrangements to mitigate stress associated with balancing work and family, such as by allowing flexibility in work start and end times and in work locations.such as working from home. Work arrangements where employees can cover or substitute for one another, such as job sharing, also allow for greater flexibility in work scheduling and correlate with reductions in gendered wage gaps (Engineers Geoscientists Manitoba, Goldin, 2014; Statistics Canada, 2016).
- Governments can encourage fathers to participate in paid parental leave by making parental/maternity/paternity program rules more flexible, offering fathers bonus weeks as incentives, and by creating non-transferable paternity leave opportunities (Marshall, 2014). An initiative which has been effective in Canada is the Québec Parental Insurance Plan (QPIP), whereby five weeks of non-transferable paternity leave is paid at 70 per cent income replacement has significantly increased the number of fathers taking paternity leave (Marshall, 2015). Beginning in March 2019, Canada will be offering five additional weeks of parental leave to those taking 12 months parental leave, and eight additional weeks of parental leave to those taking 18 months, only in cases where both spouses share the leave.
- Employers and associations can lessen work-family conflict by providing flexible schedules, onsite daycare, and options to take leaves to care for children or family members or for personal reasons (Fox, 2010; Statistics Canada, 2016).
- Recommended industry policies that promote the recruitment and retention of minorities and women and support work/family balance include mainstreaming gender equality,

bias and bias interuptor training and, promotion of networks (Council of Canadian Academies, 2012).

- Recognizing that women who have children tend to encounter a significant career hurdle around ten years into a career, research suggests providing supports to help relieve any difficulties with balancing work and family and pressures associated with career advancements and prescribed gender roles to prevent attrition, particularly five to ten years into an individual's career (Calnan & Valiquette, 2010).
- There is substantial evidence that women expect less pay than men and are less likely to negotiate their salary than men are (Dinovitzer et al., 2009). Studies suggest that employers provide employees with an option to ask for more money as opposed to negotiating for it (Dinovitzer et al., 2009). Asking has been found to be deemed less aggressive and more appropriate to feminine prescribed gender norms which make it more socially acceptable according to prescriptive gender bias and research has found it to be preferred by women to negotiating (Dinovitzer et al., 2009).
- Use and provision of APEGA's "Managing Transitions" Guide (https://engineerscanada.ca/sites/default/files/Managing-Transitions-en.pdf) which is nationally endorsed by Engineers Canada and helps professional engineering employees and employers to plan for leave (APEGA, 2018a).
- Use and provision of the "Guide to Screening and Selection in Employment" by the Canadian Human Rights Commission (https://www.chrc-ccdp.gc.ca/eng/content/guide-screening-and-selection-employment) (Canadian Human Rights Commission, 2018).
- Creation of a breastfeeding friendly workplace has been found to be associated with less absenteeism from the workplace, increased worker productivity, loyalty and morale, reduced staff turnover, and recognition as being a more progressive employer who supports families (OPHA, 2018). Under The Human Rights Code of the Manitoba Human Rights Commission, employees have the right to receive support from employers to breastfeed upon returning to work from a maternity leave, at minimum the essential requirements outlined by resources such as Ontario Public Health Association's (OPHA) "Creating a Breastfeeding Friendly Workplace" (http://opha.on.ca/OPHA/media/Resources/Resource%20Documents/BreastfeedingFriendlyWorkplace-Sep08.pdf?ext=.pdf) (OPHA, 2018; The Manitoba Human Rights Commission, 2018).

Professional Licensure

In many western industrialized countries, including Canada, rates of professional engineering licensure have been noted as falling behind rates of undergraduate engineering student enrollment (Klassen, 2018). Market projections by both Engineers Canada and Prism Economics Analysis have posited that it may be a new norm for engineering graduates to find work without acquiring professional licensure (Klassen, 2018). One theory for this is that employers are increasingly recognizing engineers as valuable and adaptable workers regardless of whether they hold a professional designation (Klassen, 2018). One occupation that has become commonly adopted by engineering graduates is that of project manager, a process of professional work merging referred to as 'hybrid professionalism' (Adams, 2017; Klassen, 2018). As of 2009, one of the most common non-technical Continuing Professional Development courses Canadian engineers chose to take was project management and approximately 50 per cent of engineers have classified project management as one of the most central elements of their job (O'Grady, 2009). Hybrid professionalism as well as the flexibility of engineering graduates to work in a variety of areas not overseen by a Professional Engineering Act, gives graduates the opportunity to apply professional principles and have status in their work without needing to pay dues to the engineering regulatory body (Adams, 2017; Klassen, 2017). These work options undermine professional regulation and licensure (Klassen, 2017). In response, OSPE has introduced an 'Associated Membership' category for graduates of an accredited engineering program who do not require a license for the work they do (Klassen, 2017).

An alternative approach is to increase the value of being a member of a professional association. Engineers Canada has noted a decline in the proportions of engineering graduates who demonstrate certainty that they will apply to their provincial regulatory association for membership and has found that roughly one in three engineering graduates who do not plan to become professionally licensed identify not needing a license for their work as a reason (Engineers Canada, 2017).

Recommendations

Some examples of supports professional engineering associations could offer engineering graduates which could additionally promote the participation of women and other underrepresented groups in the profession might be:

- Hosting networking events for engineering graduates at which potential employers are in attendance and job-matching is a focus
- Offering members a re-skilling program such as MIT's Midcareer Acceleration Professional Development Program, aimed at those wanting to return to professional practice after taking time out
- Including information on the Association website about flexible work arrangements for members, similar to that presented in the Women in Engineering Advisory Committee's 'Flexible Working Arrangements' document prepared for Engineers Geoscientists

Manitoba previously overviewing flexible agreement options such as flex-time, job sharing, telecommuting, permanent part/time understandings, and more (http://www.apegm.mb.ca/pdf/Guidelines/flexwork2.pdf). Access to such information might also help to support improved work-life

- Providing information to members on resources and rights for maternity, paternity and family leave, such as the "Policy on Pregnancy & Human Rights in the Workplace" by the Canadian Human Rights Commission, and Engineers Canada's 'Managing Transitions guideline' (https://engineerscanada.ca/sites/default/files/Managing-Transitions-en.pdf), on an association website
- Providing information to members on resources and rights for breastfeeding in the workplace, such as the document "Creating a Breastfeeding Friendly Workplace" by the Ontario Public Health Association, or the document "Breastfeeding and the Human Rights Code" by the Manitoba Human Rights Commission
- Providing members with a list of employers who provide onsite childcare;
- Providing members with a list of employers who provide a designated prayer room for religious practice, such as Wardrop Engineering Inc.
- Providing members with a list of: employers who have established plans and policies for accessibility and LGBTTQ+ employees, such as Manitoba Hydro; employers who have established a strategy for increasing the participation of women in engineering; and employers who have committed to the Truth and Reconciliation Commission's Calls to Action
- Continuing to carry out an annual salary survey, monitoring not only variations in salary and wage to contribute to understandings of wage-gaps
- Providing other formal and informal workplace supports and resources that might help to increase recruitment and retention of diversity in engineering
- Continuing to monitor trends and changes in the diversity of membership using segregated data collection, such as that used for an association's salary survey or member registration, expanded to include a broader spectrum of identities for Indigenous self-identification and gender self-identification choice beyond binary understandings, and in addition to providing the option to not declare. Considering documented past and ongoing negative consequences experienced as a result of self-identifying as a woman, Indigenous, having a disability, or as non-gender conforming, it may be of value to include why such information is being collected.

III. Comparing Professions

Like law and medicine, engineering is a traditionally male-dominated profession. Yet, compared to engineering, law and medicine have made more significant strides forward in increasing the representation of women and minorities interested in and practicing in their fields, for which women now account for approximately 50 per cent of student admissions and over 30 per cent of full and active status licensure for medicine and law respectively in Manitoba (Menkel-Meadow, 1986; Sullivan, 1990; The College of Physicians and Surgeons of Manitoba, 2017; The Law Society of Manitoba, 2017). As 2030 approaches and Manitoba and Canada as a whole focus on increasing the percentage of newly licensed engineers who are women to 30 per cent by 2030, examining the history and current approaches these other well recognized professions have promoted to surpass women making up 30 per cent of their university graduates and licensed professionals on both a provincial and national level, offers an insightful and worthwhile comparison for considering changes which might help the engineering profession follow suit.

Some Facts:

- In Canada, women began accounting for over 30 per cent of new entrants to the law profession in the 1980s.
  (Menkel-Meadow, C. (1986). The Comparative Sociology of Women Lawyers: The “Feminization” of the Legal Profession. Osgoode Hall Law Journal, 24(4):897-918.)
- In Canada, women began accounting for over 30 per cent of admitted medical students in the 1980s, and have accounted for nearly 50 per cent since the 1990s.
  (Sullivan, P. (1990). Women close in on 50% share of places in Canada’s medical schools. CMAJ: Canadian Medical Association Journal, 143(8):781-783.)
- From May 1, 2016 to April 30, 2017, women comprised 36% of fully licensed physicians in Manitoba (as per The College of Physicians and Surgeons of Manitoba 2017 Registrar’s Report (http://cpsm.mb.ca/cjj39alckF30a/wp-content/uploads/Registrars%20Report/RegistrarsReport2017.pdf)
- From December 31, 2016 to March 31, 2017, women comprised 37.25% of active status lawyers in Manitoba (as per The Law Society of Manitoba 2017 Annual Report (http://www.lawsociety.mb.ca/publications/annual-reports/2017_Annual_Report.pdf/view)
- As of June 30, 2018, women comprised 10.5% of practicing professional engineering members in Manitoba (women = 589, total = 5625), 9.5% of combined practicing, retired and life member engineers in Manitoba (women = 615, total = 6444), and 11.1% of combined practicing, retired, life member, and MIT engineers in Manitoba (women = 889, total = 7990). (As per Engineers Geoscientists Manitoba statistics http://www.apegm.mb.ca/pdf/MemberStats.pdf)

IV. Other Case Studies

University of Waterloo, Canada

Launched in Fall 2017, the University of Waterloo's Women in Engineering Living-Learning Community (LLC) pilot was put in place as an optional women-only residence to offer participating students a sense of belonging in engineering with a space where women engineers are not a minority but a norm (M. Wells, personal communication, May 23, 2018). A significant amount of work and consideration had led to the idea of introducing a women-only engineering residence as part of the University's LLC, including research conducted by social psychologists which found a sense of belonging made a significant positive difference for retention and success in a program such as engineering (M. Wells, personal communication, May 23, 2018). The Faculty expected roughly 30% of its first-year students to be female upon the LLC's pilot launch and the pilot filled up quickly with about 50 women who signed up and lived in the Women in Engineering residence in its first year (M. Wells, personal communication, May 23, 2018). The program has been regarded as a success at increasing women's retention, sense of belonging and enjoyment in engineering at the University, and is now in its second year (M. Wells, personal communication, May 23, 2018).

Ryerson University, and University of Manitoba, Canada

In accordance with Section 11 titled 'Equal Wages' of The *Canadian Human Rights Act,* Ryerson University adopted a Salary Anomalies fund in 2008 to remedy inequities found to exist in salaries for its Faculty, Counsellors and Librarians (Canadian Human Rights Act, 1985; Council of Canadian Academies, 2012). Considering only institutional hierarchy or rank, experience, and number of years affiliated with Ryerson, the anomalies fund helps to provide adjustments to base salary, and in 2012 a Gender Anomalies Fund specifically focusing on women's salary adjustments was established (Council of Canadian Academies, 2012).

The University of Manitoba Faculty Association (UMFA) Collective Agreement includes the creation of an annual anomalies fund as well for members of the UMFA (University of Manitoba Faculty Association, 2018). Each academic year the fund is overseen by a joint University of Manitoba and UMFA Committee to correct salary inequities determined as not being within a normal salary range for a member's level of qualifications, rank and experience (University of Manitoba Faculty Association, 2018). The affected base salary is increased to correct for an inequity recognized by the Committee and the higher salary is adopted from then onwards (University of Manitoba Faculty Association, 2018).

Carnegie Mellon, United States

Despite its recognition as one of the top computer science universities in the United States, female enrollment in Carnegie Mellon's undergraduate computer science program had been below 10 per cent for years before it changed significantly (Fisher & Margolis, 2002). In 1995, women made up 7 per cent of new entrants to the University's undergraduate computer science program (Fisher & Margolis, 2002), rising to 42 per cent in 2000 (Fisher & Margolis, 2002). Data collected by the University included student enrollment, continuance, attrition and graduation rates as well personal experiences. (Fisher & Margolis, 2002). Carnegie Mellon noted its efforts to increase the number of women in its computer science program were influenced by recognizing that:

- The context of a problem presented to a class to solve held greater importance to women than men
- Individuals associated with hard sciences such as engineering or computer science believed that learnings from soft sciences such as of cultural or gender studies were common knowledge and did not need to be studied
- Women transferred out of undergraduate computer science in the first two years of the program at a greater rate than men and tend to express a loss of interest as a primary reason for doing so, though loss of confidence was posited by researchers to be the real catalyst for such attrition
- Loss of confidence for women in the program was not commonly correlated with poor academic success but rather with lower relatability to the qualities and lifestyle choices understood as the norm or as deterministic of success in the field
- Courses that many students did poorly in affected minority and female students to a greater extent, as their confidence level, desire to continue studies, and sense of belonging were more susceptible to threat than for students who were the norm

(Fisher & Margolis, 2002)

Carnegie Mellon changed its computer science program curriculum, level and means of support for women, and culture (Fisher & Margolis, 2002). Changes that initiated a significant increase in the number of women in the program included:

- Inclusion of interdisciplinary courses in the program, open to students from a range of backgrounds
- Inclusion of an option to concentrate on human-computer interaction in undergraduate studies
- Inclusion of an opportunity to support and interact with non-profit and community-based organizations within courses
- Increasing awareness among faculty of stereotypes and unconscious biases, and educating on methods to prevent or reduce them

- Emphasizing to potential and new students that previous experience beyond academic prerequisites was not required and by showing appreciation for students with multiple interests, particularly those interests outside of the majority student cohort
- Continued monitoring and tracking of application, acceptance, drop-out, continuance, returning and graduation numbers of students by gender and other trait variables
- Addressing the idea of innate ability with facts to dispel misconceptions such as that math is a talent and not a learned skill
- Addressing comments targeted at women and/or minorities that undermine their success using gender or minority status as reasoning such as ‘you got that job because they had to fill a quota’. This included educating students about admissions and hiring policies and enforcing consequences for making such inappropriate comments to other students

(Fisher & Margolis, 2002)

Harvey Mudd College, United States

Harvey Mudd College is recognized for its recent success in recruitment and retention of women in its computer science undergraduate program (Coger *et al.,* 2012). Actions the College took to increase the number of women enrolled included:

- Creation of smaller introductory class sizes, found to significantly increase confidence among women compared with levels in larger class sizes
- Changing presentation and teaching style of classes so as to be more problem-solving based
- Offering research opportunities to early year women undergraduate students instead of only later year students, which increased the confidence and sense of belonging of women in the program during some of the most difficult years for retention
- College participation in and college supported opportunities for students to attend conferences focusing on women in computer science

(Coger *et al.,* 2012)

(TUM) Technical University Munich, Germany

The Technisches Universität Munchen (TUM), one of the top universities in Germany and a university recognized for its engineering programs, has taken significant steps toward becoming the most desired technical university for women in Germany (Ihsen *et al.,* 2008). Beginning with the election of a women’s representative for the University in 1989, the university also increased gender balance and diversity through the creation of TUM Equal Opportunity Offices, a TUM Diversity Centre, as well as a Gender Studies in Science and Engineering department within the Electrical Engineering and Information Technology department. Alongside monitoring progress including the proportion of women at different academic levels and involved in research at the University, and implementing gender mainstreaming and diversity management planning, some of the changes and initiatives TUM has taken to become more diverse included:

- Offering a 'mentorING' program for female engineering and science students
- Funding from the University's Gender Consulting Office for a "Vocational Training Fund" to assist with financing refresher courses and re-skilling after periods of parental leave, as well as of a "Gender Issues Incentive Fund" to help fund institutional and departmental changes for improved support of gender diversity
- Providing coaching services from the Gender Centre for support with academic and professional career planning and networking
- In cooperation with Student Services, providing a Family Service offering advice, financial assistance, access to childcare facilities, childcare during academic holidays, support for teleworking, as well as a "studying with children" discussion group
- Offering engineering courses that include gender and diversity studies
- Supporting the creation of a Web Series called "Technically Single" which features a young woman engineering student as the lead character in a fictional drama as she goes through studies of Electrical Engineering at university (based and filmed at TUM). The Series will be broadcast to the public on a streaming service similar to Netflix in Germany later this Fall
- Regularly offering TUM colloquiums on gender and diversity coordinated in partnership with various TUM diversity initiatives and supports

As discussed with TUM Faculty member Univ.-Prof. Dr.-Ing. Klaus Diepold, TUM has noted an increase in the number of female students in its Engineering programs over the past five years and a high representation of international students in its female student population.

(Ihsen *et al.,* 2008; K. Diepold, personal communication, August 25, 2018)

University of Wollongong, Australia

As part of its efforts to increase female participation in its engineering programs, the University of Wollongong in Australia introduced a diversity lecture into its fourth-year compulsory engineering management course (Schäfer, 2006). Aiming to increase awareness of the benefits of diversity and of the difficulties associated with being a minority in engineering, presentations by a variety of speakers such as the Pro-Vice Chancellor of the Faculty of Engineering, engineering professionals from differing career points, and post graduate students demonstrated the magnitude of the issue and made it relevant to a wide range of students (Schäfer, 2006).

- One finding of the university was that it was important to have men present and be part of the lecture and initiative alongside women and minorities, so as to make the issue of increasing diversity relevant and accessible to them as well (Schäfer, 2006).

The University of Wollongong also found that there was a desire for the diversity lecture to be offered at earlier points in engineering education than fourth year (Schäfer, 2006).

MIT Midcareer Acceleration Professional Development Program

In 2006, the Massachusetts Institute of Technology (MIT) Professional Education Programs office introduced a Midcareer Acceleration Program (MAP) to assist alumni and other recognized professionals in their return to science, engineering and technology fields after leaving jobs for personal reasons or for reasons such as company closure (Massachusetts Institute of Technology, 2006). The MAP is offered part-time for 10-months and provides professional participants with personal and professional guidance, technical re-skilling, a MIT course, and with a company internship or research opportunity with MIT faculty (Massachusetts Institute of Technology, 2006). The program was created based on recognition that:

- Professional science, engineering and technology (SET) fields are constantly evolving and such rapidly changing areas can be particularly difficult to reenter after time out
- Continuous learning throughout the professional and life course result in the greater success of professionals in SET fields and to MIT’s mission to provide education needed for the entirety of a professional career

(Massachusetts Institute of Technology, 2006)

Wardrop Engineering Inc.

In response to a requirement for a certain level of representation of women and visible minorities within a company in order to be eligible to bid and work on Government of Canada contracts, Wardrop Engineering Inc. (Wardrop) began taking proactive steps toward increasing diversity years ago and has been recognized a number of times as one of Canada’s Top 100 Employers (Calnan & Valiquette, 2010). In 2005 an Employment Equity Committee was established at the company to oversee efforts toward increasing diversity and after three years, visible minorities representation increased to account for approximately 24 per cent of all staff, and for approximately 30 per cent of core design and engineering employees (Calnan & Valiquette, 2010; Engineers Canada & Canadian Council of Technicians and Technologists, 2008). Actions taken by Wardrop to increase diversity within the company included:

- Posting advertisements for jobs on international job boards in addition to local and national sites
- Partnering with organizations such as Maytree Foundation and the Toronto Region Immigrant Employment Council (TRIEC) to help new immigrants integrate into the workforce
- Offering prayer rooms for individuals to use for religious practice
- Sponsoring internationally-educated technical graduates and engineers to come to Canada and providing assistance in becoming licensed
- Partnering with upgrading initiatives and re-skilling programs such as with Alberta's Engineering and Technology Upgrading Program (ETUP) for engineering professionals searching for employment

(Engineers Canada & Canadian Council of Technicians and Technologists, 2008)

Manitoba Hydro

Also recognized as one of Canada's Top 100 Employers, Manitoba Hydro has clearly established diversity goals on its website which recognize four designated diversity groups with the aim of guiding the company toward having a workforce which reflects Manitoba's population demographic (Manitoba Hydro, 2018a). Manitoba Hydro's four designated diversity groups followed in brackets by the respective percent representation goal for each are: Indigenous peoples (18 per cent);persons with disabilities (6 per cent); visible minorities (9 per cent); and women (26 per cent) (Manitoba Hydro, 2018a). Manitoba Hydro is working to increase diversity by:

- Partnering with the University of Manitoba's Internationally-educated Engineers Qualification Program (IEEQ) to support internationally-educated engineers in their pursuit of provincial licensure by offering bursary awards, a Career Development Program, and co-op placements (Manitoba Hydro, 2018b)
- Offering two monetary awards specifically for Indigenous students called the Manitoba Aboriginal Youth Achievement Awards (Frank Wesley Awards) (Manitoba Hydro, 2018c)
- Offering pre-placement programs for Indigenous applicants of its trades programs who do not meet the academic qualifications in which candidates can obtain the required qualifications while gaining training and pay on the job (Leung & Yerema, 2018)
- Participating in Project Search, a program for high school students with intellectual disabilities which offers work placements at participating companies such as Manitoba Hydro (Leung & Yerema, 2018)

- Offering a DisAbility Access Program which aims to reintegrate individuals who have experienced a serious brain injury back into the workforce, as well as aiming to integrate other individuals with intellectual disabilities into the workforce (Leung & Yerema, 2018)
- Offering flexible working hours, telecommuting, and transit subsidy options (Mediacorp Canada Inc., 2018)
- Establishing an accessibility plan and policy, and a formal strategy for lesbian, gay, bisexual, transgender and two-spirit (LGBTT) employees (Leung & Yerema, 2018)
- Offering educational training on Indigenous culture awareness, LGBTT awareness, disability awareness, and multicultural communication (Leung & Yerema, 2018)
- Supporting an Indigenous Sharing Circle employee group (Leung & Yerema, 2018)

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