Access to Engineering Education in the Province of Manitoba

ENGINEERS GEOSCIENTISTS MANITOBA | 870 Pembina Highway, Winnipeg, Manitoba   R3M 2M7

Engineering Education Task Group

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Executive Summary

Engineers Geoscientists Manitoba has appointed an Engineering Education Task Group to consider the future marketplace demand and current access to engineering education in the province. Research was done by considering a variety of sources including government, university and special interest group reports, academic journal articles, newspaper articles as well as presentations from Manitoban guest speakers involved with engineering education.

The findings suggest that around 10,000 additional engineers will be required to keep up with industry growth and retirement, and that a diverse engineering force would be a welcome addition to these ranks, both in terms of fulfilling the marketplace demand as well as broadening the engineering perspective to be more representative of the communities they serve.

Several barriers were identified as limiting the participation of under-represented or minority groups, including recognition of the engineering profession, current perception of engineers, a lack of social support for under-represented or minority groups, financial barriers to funding an engineering education, difficulties associated with relocation required for rural or northern students, educational inequalities and competitive entrance requirements, lack of representation in decision-making processes, and finally, difficulties with professional registration.

Ten main recommendations were proposed as solutions to these barriers, with practical sub-recommendations. These suggestions include revising the brand projected by Manitoban engineering institutions, supporting outreach groups and mentorship programs, promoting change to Manitoba's K-12 education system, reforming scholarship and bursary programs, expanding the University of Manitoba's Engineering Faculty as well as modifying the Faculty's admissions criteria, creating bridge or transfer programs to the University of Manitoba Faculty of Engineering from various other programs, establishing on-going monitoring programs, and supporting changes made to university and professional policies, procedures and curricula to promote inclusivity.

1 Introduction – Access to Engineering in Manitoba

The main objectives of the Engineering Education Task Group (hereby referred to as the Task Group) were to consider the future marketplace demand and present access to engineering education in the province of Manitoba, and given these findings, recommend possible initiatives for the future.

In order to achieve these goals, research was conducted over several months. The Task Group attempted to focus on information most applicable to engineering in Manitoba or Canada; however, research and investigations from similar countries (e.g., USA, Australia, UK) and/or on comparable programs (i.e., science, technology, mathematics or computer science) were also considered. The information was obtained from a variety of sources, including government, university and special interest group reports, academic journal articles, and newspaper articles. Guest speakers, representing various Manitoban engineering perspectives, also presented statistical data and anecdotal evidence to the Task Group. The guest speakers were:

- Randy Herrmann, Engineering Access Program (ENGAP) Director
- Doug Ruth, University of Manitoba Professor and Associate Dean
- Nusraat Masood, Women in Science and Engineering (WISE) Program Administrator
- Jonathan Beddoes, University of Manitoba Dean of Engineering

A summary of the Task Group's findings is presented in the following report, starting with a discussion of Manitoba's future engineering needs in Section 2. Section 3 highlights the major barriers identified by the Task Group that would potentially prevent someone from becoming a professional engineer in the province of Manitoba. Supporting evidence and possible methods for diminishing each barrier are also included in Section 3. The Task Group's recommendations are summarised in Section 4 and in Table 2.

2 Background – Manitoba's Future Engineering Needs

The 2015 Engineers Canada Labour Market Study (Engineers Canada, 2015c) anticipates a growing need for young engineers. More than 40,000 engineering jobs are expected to be available in Canada over the next four years due to an aging workforce and predicted growth in related industries (Engineers Canada, 2015). Considering that approximately 30,000 new engineers are expected to graduate during this four-year period (Engineers Canada, 2015), it is

clear that Canada would benefit from the recruitment and retention of more aspiring engineers. Manitoba has an especially high demand for engineers, as it is the province with the second tightest predicted engineering labour market in the next five years, and it is the province with a substantial demand for engineers across the most disciplines (Engineers Canada, 2015).

In the past, engineering recruitment focused primarily on Caucasian males. The effects of this biased recruitment are still felt by the profession, potentially discouraging over 63% of Manitobans who identify as First Nations (15%), a visible minority (10%), or as a Caucasian woman (~38%) from entering the engineering profession (Statistics Canada, 2006). The current demand for engineers in Manitoba suggests that there is a need to expand traditional recruitment techniques to focus on under-represented minorities. Barriers to engineering education, particularly those that under-represented populations continue to face, must be identified and addressed to increase diversity within engineering.

In addition to fulfilling the increased market demand for engineers in Manitoba, greater diversity in the profession will have several advantages, including a broadening of the engineering perspective and improving the ability for engineers to represent the communities they serve to protect (Engineers Canada, 2012). Furthermore, by improving access to engineering education for all, the University of Manitoba Faculty of Engineering will have greater success in attracting and retaining the brightest talents, regardless of background, which will likely have a positive influence on the province's engineering profession.

3 Barriers to Access – Evidence and Mitigation Measures

A review of research focused on access to engineering in Manitoba and Canada, revealed systemic inequalities or barriers inhibiting the participation of several underrepresented or minority groups. Women, visible minorities, Indigenous Peoples, people of low socio-economic backgrounds, rural residents, and people with disabilities, were identified as groups of people potentially facing one or more of the barriers discussed in the following sections. The Task Group initially organized the findings sequentially, to identify barriers at each stage of a potential engineer's development. However, upon further investigation, we found that individual barriers were often encountered at several steps during the engineering career track. The barrier matrix illustrated in Table 1 was established to identify the potential junctures of each barrier.

The Task Group aimed to include as many of the potential barriers as possible; however, we

recognize that the barriers discussed in the following sections are by no means a comprehensive list.

3.1   Recognition

Students need to recognize that engineering exists and what engineering education and employment encompass before they can select it as a career path. Choosing what type of post-secondary education to pursue may seem like a single eureka moment. In reality, it is often a compendium of events and factors, some deliberate and others not, that build upon themselves while charting a course for future growth. Exposure to engineering at all stages of childhood and young adulthood maximizes the possibility of engaging future engineers (Wolsky, 2012).

3.1.1   Contributing Information

"What do you want to do when you grow up?" This is the question often asked to early years school children by teachers and family. Classic responses are an astronaut or pop star, doctor or hockey player. It is easy to understand why these occupations are often chosen; students often select these careers because of the opportunities to explore, create, help others, have fun, and obtain a good income (Cook, Kelly et al, 2016). If this same question was rephrased to "what do you want to accomplish when you grow up?", the emphasis is placed on the actions rather than pre-defined societal job roles. Many of the same reasons why students choose the classic responses listed above, may also be associated with the engineering profession. Explore and investigate, apply and invent, help and sustain - all of these actions are available in an engineering career, and it is our role as a profession to ensure today's youth recognize their interests can be fulfilled in engineering. According to the National Academy of Engineering (NAE, 2008):

"No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their imaginations to help us meet the needs of the 21st century."

A systematic way of approaching problem solving and the ability to identify opportunity where others may find distress, are the fundamental ideas taught to engineering students within their early university years. Out of this common foundation, multiple disciplines provide increasingly specialized courses that allow engineering professionals to serve in all realms of society. The opportunity to serve society by applying specialized technical knowledge and problem-solving skills makes engineering an exciting and rewarding career. However, many young people might not recognize these opportunities and skills as being associated with the engineering profession.

Recognition of engineering as a worthwhile profession can occur at any point in life. Students are exposed to engineering methods beginning at a young age, as applied science is a key component of early and middle year school curriculum. High school offers students the opportunity to enrol in electives of their choice that are key to further pursuing an engineering education, with a variety of communication, science, and math courses potentially available. However, students may not recognize when they are exposed to tools fundamental to the engineering process. Outreach programs such as WISE endeavour to promote activities related to engineering methods or education. The WISE program has found that the optimum time for generating excitement about the field of engineering is between grades three to eight (Masood, 2016). Outreach activities aimed at students in elementary and middle schools also allows interested students to complete the high school courses required for admission to the Faculty of Engineering.

Self-motivated students may research post-secondary education options by seeking out information through a variety of digital and paper media platforms. Some will choose different means, relying on personal interactions and the influence of role models such as parents, friends, teachers and guidance counsellors. Thus, the public attitude towards engineering may influence a student's recognition and perception of engineering as a viable career choice. Perception of the engineering profession is discussed in Section 3.2.

3.1.2   Summary of Findings and Recommendations

In order to increase the recognition of engineering as a worthwhile profession, a focus on engineering promotion and branding is recommended. Future branding should consider who requires the information, what they are interested in, and how they access information. Any

outreach materials should promote the importance of engineering professionals to the general public by focusing on the people behind the profession and those engineers serve (rather than the engineered object/design). A campaign with aspiring engineering professionals (similar to the current University of Manitoba promotional campaign), particularly those from under-represented groups, would provide engineering role models and increase general recognition of the engineering profession. Engineers Geoscientists Manitoba Association members could act as brand ambassadors for this. Brand ambassadors should include people holding non-traditional engineering jobs where a seal isn't necessary in day-to-day activities, to increase the visible diversity of engineering as a career. This campaign could also encourage all engineers to act as brand ambassadors. This promotional campaign would likely be more successful if Engineers Geoscientists Manitoba collaborated with the Faculty of Engineering.

Current outreach groups (e.g., ENGAP, WISE) should receive continued support as they already act as ambassadors of the engineering profession and work to increase diversity within engineering education. Further mentorship programs should be established to allow for outreach on a personal level. This could include a multi-tiered mentorship program that learns from the success of outreach groups (such as WISE, Career Trek, Community Schools Investigator, Bright Futures and SUPERB), where new graduates provide mentorship to middle and high school students, and experienced professional provide guidance to new graduates. Another potential outreach program could support the organization of funded summer camps where elementary students learn and use skills applicable to the engineering profession. Engineering should be promoted as an education option for self-guided individuals.

Involvement in the development of school curricula should be considered, as this would allow for the expansion of engineering ideas taught in grade school, both in the natural and social sciences, as well as in formal sciences. Basic engineering concepts should be promoted, alongside the general fulfillment of a career in engineering and the ability for engineers to make a difference in people's lives.

Finally, position statements of Engineers Geoscientists Manitoba should be reviewed to ensure inclusivity of those outside the engineering profession (the public).

3.2   Perception

Once a student recognizes the potential of engineering as a career option and has a basic understanding of the requirements for entry into engineering education, the student's perception of engineering as a whole becomes a major consideration. In general, a student's perception of the Faculty of Engineering, the people who study engineering, and the course workload will have significant weight in dictating that student's decision to enter the Faculty. This section attempts to bring forth the general perception of engineering both as a field of study and as a career, compares these perceptions to reality, and provides some ideas for adjusting the current perceptions. Perception was observed to fall into three broad categories – how one views engineering students, the Faculty of Engineering, and engineering as a career. In general, previous research has indicated that a student's perception of engineering, particularly those who do not have a connection to the profession (e.g., through a relative or friend), is relatively consistent within most age groups and across demographics.

3.2.1   Contributing Information

Engineering Students

Engineering students are typically seen as people who excel in math and science, enjoy problem solving, and over-achieve in their classroom work (Wolsky, 2011). Often these students are considered awkward in social settings. Interest in athletics, arts, and the social sciences are not usually viewed as a necessity for an engineering student, and in some cases are considered antithetical to the typical engineering student and practitioner. Historically, this may have been true; however, the makeup of the Faculty of Engineering is slowly changing to one consisting of people with more diverse interests and skill sets. Those with interest in human sciences, for example, often find that fields such as transportation, biosystems, and environmental engineering (i.e., those fields that typically have the end-goal of assisting people's lives on a direct, day-to-day way) can be very rewarding. While it is indeed necessary to have a solid mathematical and natural science understanding to be successful in studying engineering, a supplementary understanding of social sciences is beneficial in many engineering fields. While this is but one example of many where skill sets outside of the formal and natural sciences are an asset to

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studying engineering, it does serve as an illustration of the variance between the perception of who an engineering student should be versus the reality.

Engineering Education

The Faculty of Engineering is generally viewed as being math and natural sciences focused, with a very demanding workload (Wolsky, 2011). Again, while true to an extent, this perception is often exaggerated, leading students to believe that the Faculty is only focused on mathematics and natural sciences, with no coursework related to sociological, psychological, or human-interactions, and that the heavy course load leaves no time for extra-curricular and social activities. In reality, most engineering students enjoy a variety of extra-curricular activities (there are many groups, societies, and social clubs for students to join), and have fulfilling social lives. In fact, many engineering students have indicated that their social and extra-curricular involvement increased during their time within the faculty of engineering.

Engineering Careers

Students interested in a career in engineering view the engineering profession in highly varying ways, many of which indicate a relatively poor understanding of the work that engineers actually do (Cunningham et. al., 2005). Those who have first-hand knowledge of the career (e.g., via relatives who are practicing engineers) generally understand the day-to-day life of an engineer relatively well; however, those without such knowledge may believe some of the perceptions listed in the following paragraphs.

Some feel that the life of an engineer is one of endless work hours, many of which are spent staring at computer screens or "crunching" numbers. This perception is particularly problematic given that recent research indicates that 80% of bachelor's degree holders feel that "personal interests" rank as "very important" in evaluating career choices, while only two-thirds placed a similar level of importance on "future career opportunities" (Dehaas, 2014). In this regard, while engineers are typically known to have relatively good career opportunities, the perceived lack of time for personal interests can turn away potential professional engineers. Others view the life of an engineer as one with significant time spent away from home, with little time for family, friends, and interests outside of the work environment. Others still view the life of an engineer as one spent in endless meetings, with little interaction with people outside of the

field in which they work. Though there may be an element of truth to these perceptions, they generally do not paint a full picture of the responsibilities and opportunities associated with an engineering career, and the quality of life of a practicing engineer.

3.2.2 Summary of Findings and Recommendations

In general, changing the perception of engineering likely requires an educational approach. Mentorship programs, in-school presentations, and other face-to-face methods for sharing information on engineering with potential students would likely be the most effective method for correcting the common misconceptions. Typical educational methods such as presentations can help eliminate misconceptions of engineering students; however, the ideal solution would likely involve a more one-on-one approach. Research conducted by the National Academy of Engineering (NAE, 2008) illustrated that the most effective method for changing perceptions was to create a "personal" connection to engineering. This could be accomplished via mentorship programs pairing high school students interested in engineering with current engineering students or practicing engineers. For example, the CIPWIE Mentorship Program already pairs female engineering students with practicing engineers. This Task Group suggests that a similar program is established to provide mentorship for a greater number and variety of potential engineering students. Mentorship programs pairing potential engineering students with current engineering students or practicing engineers from a variety of fields, would serve to alter and broaden a student's perception on engineering students, education, and the profession in general.

Another potential method for changing misconceptions associated with engineering, is to conduct surveys of practicing engineers, recent graduates, and engineering students to gain insight into their life outside of work/school, and life at work/school. A young person interested in a career in engineering could use this information to evaluate the life that they could expect while studying and practicing as an engineer. Repetition of these surveys over multiple years would also serve as an excellent indicator of the effectiveness of new programs, such as the mentorship program suggested above.

3.3 Social Support

Social support is the encouragement, assistance, or sense of personal belonging and value that originates from relationships with other people or the presence of a supportive network

(Wills, 1991). Social support can manifest itself in different forms, either tangible, e.g., financial assistance, material support; or intangible, e.g., companionship, emotional support (Wills, 1985). This support is seen as being important for decreasing stress levels and maintaining ones physical and psychological health (Ozbay et al., 2007). Thus, social support is important for individuals experiencing significant changes (e.g., youth transitioning to adulthood, moving, beginning university) or stressful situations (Makhoul et al., 2011). Conversely, a lack of social support can limit an individual. Therefore, a lack of social support was recognized as a barrier that a prospective engineer might experience.

Social support is a very broad term that we will use to represent any of the forms of support mentioned above – except for financial assistance, which is discussed in Section 3.4 Financial. This support may be received from individuals (e.g., family members, teachers, friends, role models) or by organizations (e.g., University of Manitoba Aboriginal Students Association, ENGAP, University of Manitoba Engineering Society). Additionally, social support may be provided at different times during a prospective engineer's lifetime. The common forms of social support that influence the probability of a prospective engineer becoming an engineer are discussed in the following section.

3.3.1   Contributing Information

Social support is important throughout a prospective engineer's entire lifetime. In their early years, parents provide a large part of the social support for a prospective engineering student. Both a parent's level of education and their attitude towards post-secondary education may significantly impact the probability that their child finishes high school and continues on to post-secondary education (Educational Policy Institute, 2008; Senate Canada, 2011; Shaienks and Gluszynski, 2009). A parent's attitude towards post-secondary education may vary based on personal or geographical factors; for example, rural parents are less likely to expect their children to attend a post-secondary institution (Junor and Usher, 2004). Other studies have shown that a supportive family (i.e., encouragement, concern, focus on work ethic), regardless of their level of education, increases a young person's education aspirations (Clarke, 1983; Ginsburg and Hanson, 1986). Overall, parental influence has been deemed significant in regards to the future career of a young person (Shadt, 1975; Sukovieff, 1990).

Teachers and guidance councillors also provide important social support for guiding a prospective engineer during their youth (Winfield, 1995). Research has shown that the support of guidance councillors is integral for assisting low-income, minority, and/or first-generation university hopefuls (Education Commission of the States, 2008). Thus, the quality of the guidance councillor, including how knowledgeable they are on university programs and requirements, can affect how prepared a student is (or feels) for their future (Education Commission of the States, 2008).

Role models or mentors also provide vital social support to prospective engineers. Girves et al. (2005) suggest that mentoring can be provided in many different forms but generally mentors and mentees should have a reciprocal relationship that is vocational (e.g., career-focused information-sharing or coaching) and/or psychosocial (e.g., encouragement and counselling). An important outcome of successful mentoring is "academic integration" (Tinto, 1992) or increased sense of belonging felt by a prospective engineer (Girves et al., 2005). Mentors can also have substantial influence over a mentee's career decisions, provide valuable assistance with personal and professional development, and expand the mentee's future aspirations (Girves et al., 2005). A university may see the following benefits from strong mentorship: increased retention rates, a better sense of community on campus, and greater student productivity and commitment.

Role models and mentors are particularly important for prospective engineers belonging to under-represented groups (Mason et al., 1992; Thomas et al., 2007). Under-represented groups in engineering include women (Zywno et al., 1999), Indigenous Peoples (Herrmann, 2016), those with disabilities (Cowan-Dewar, 2009) and those self-identifying as lesbian, gay, bisexual, transgender/transsexual, two-spirit or queer (LGBTTQ), to name a few. A lack of role models and mentors has been cited as a reason for low enrollment of these groups in engineering programs across Canada (Cowan-Dewar, 2009; Myers, 2010; Zywno et al., 1999). An increased presence of role models and higher mentorship rates geared towards under-represented groups could improve the academic integration or sense of belonging of these individuals.

Support organizations may be important throughout a prospective engineer's childhood and university years. In lower-income or lower-education households, social programs can offer the necessary encouragement and development allowing a student to move on to post-secondary education (Senate Canada, 2011). For example, the Council of Ontario Universities established the *Let's Take Our Future Further* campaign to provide Indigenous youth with both information

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on post-secondary institutions in Ontario and role models to show a snapshot of the success attained by Indigenous students (futurefurther.ca). WISE Kid-Netic Energy conducts outreach activities across Manitoba to promote engineering and science to children aged five to seventeen, to inspire youth (particularly under-represented groups), and to provide positive role models.

Social support programs are also linked to the retention of post-secondary students in university. Support programs may include mentoring or advising organizations, learning assistance centres, and summer bridge programs (Hanover Research Council, 2010). Social support is key to the success of an engineering student, as the degree of interaction between post-secondary students and academic or social communities is directly related to degree completion rates (Hanover Research Council, 2010) due to increased academic integration. In addition, these support organizations are integral to encouraging enrolment and providing timely information for those with disabilities (National Educational Association of Disabled Students, 2012).

When considering social support in the larger context of this report, it may be linked to both the recognition and perception barriers, as those providing support may teach a child about engineering as a career option and may also influence an individual's opinions or perceptions of engineers. For example, a guidance councillor with little knowledge of engineering or a negative opinion of the profession may dissuade students from applying. Social support may also help an individual overcome some of the other barriers discussed in this report. For example, support programs can assist a student with preparing and applying for university, or obtaining bursaries or scholarships, and role models can improve the perception of engineering so that it is seen as a worthy career option. Thus, a lack of social support could reinforce or compound the barriers acting against a prospective engineer.

3.3.2 Summary of Findings and Recommendations

Social support mechanisms provide a prospective engineering student with invaluable benefits both before and during university. Some of the most important social supports recognized by this committee are: (1) parents supporting work ethic and further education; (2) informed teachers and guidance councillors; (3) positive role models or mentors in the engineering profession; and (4) organizations that provide information, emotional or academic support, and access to role models. Based on these findings, the Task Group suggests that existing mentorship programs (e.g., CIPWIE, WISE, University of Manitoba Career Mentor

Program) are supported or expanded. Promotion and support of engineering societies should also continue, as they promote interaction between students, provide social and educational support, and consequently increase the probability of a student completing their engineering degree.

The Faculty of Engineering website should be updated to include role models of varying backgrounds, genders, abilities, etc. or include links to other websites that highlight positive engineering role models, such as the WISE Atlantic Region site (www.wiseatlantic.ca/Videos.asp). Finally, Engineers and Geoscientists Manitoba and the Faculty of Engineering should work together to develop an informational package for guidance councillors and teachers on engineering, particularly for rural and/or northern communities. This package should include information on academic requirements, application procedures, support organizations (e.g., ENGAP), role models, and career options. WISE could potentially assist with distribution of the informational package as they travel to many rural and northern communities in Manitoba.

3.4   Financial Resources

Surveys conducted by Stats Canada indicate that 26% of Canadian students who did not enrol in post-secondary education cite financial concerns as the main cause (Montreal Economic Institute, 2004), making it a major barrier to a post-secondary education. The cost of post-secondary education comes not only from tuition and related fees (books, supplies, etc.) but also from areas not directly related to education, like transportation, clothing, and, for students who do not have the opportunity to live at home, food and rent (Standing Senate Committee on Social Affairs, Science and Technology, 2011). Beyond even that is the lost-opportunity cost of attending a post-secondary institution – that is, the money that a student could be making if they were not in school (de Broucker, 2007). Two groups of prospective students generally face the largest financial barrier to obtaining a post-secondary education: (1) people from low-income families; and (2) those who would have to relocate in order to attend school.

3.4.1   Contributing Information

A study done by the Canadian Policy Research Network indicates that young people from high-income families are two to three times more likely to attend a post-secondary institution than students from low-income families (de Broucker, 2007). In a 2012 article, the Globe and

Mail defines the after-tax low-income threshold in Canada as, "less than half of the national median income". The median household income in Manitoba for 2010 (the latest year for which National Housing Survey income breakdown information is available) was $57 299, so the low-income threshold would have been $28 649. In that same year, there were 121 240 private households in Manitoba with an after-tax income of less than $30 000 (Statistics Canada, 2011a). This number corresponds to approximately 25% of the total number of households in the province (465 805); thus, low-income households represent a significant portion of Manitoba's population.

With a lower percentage of students from low-income families attending university than their higher-income counterparts, the financial demand of post-secondary education ceases to be the only barrier to overcome. There is likely to be fewer degree or diploma-holding role models in the low-income student's life than that of the student from the high-income family (see also Section 3.4 Social Support). Studies have found that Canadians tend to overestimate tuition costs, while underestimating the average university graduate's starting salary compared to that of someone with a high school diploma (de Broucker, 2007), which may increase the perceived size of the financial barrier. Student loans are available, however Manitoba Student Aid considers the student's own income in determining the amount of money to lend (Government of Manitoba, n.d.a), penalizing students who hold part or full-time jobs. These jobs are often a necessity for people from lower-income families. Further, the Canadian Policy Research Networks study points out that the student debt often incurred during the completion of a degree may especially discourage prospective students from low-income families as they may anticipate, "fac[ing] more inequity after graduation when they enter the labour market with a handicapping level of debt" (de Broucker, 2007).

Members of low-income families are not the only ones facing an increased post-secondary financial strain. Students who live in Winnipeg but far from the University of Manitoba or students originally not living in Winnipeg, incur increased transportation and/or relocation costs. Students originally living further than a reasonable commuting distance from the University of Manitoba can expect to pay between $6 500 and $16 000 for accommodation and utilities alone, over a single calendar year (University of Manitoba, 2015). This does not take into consideration the transportation cost for the student to go back home for holidays or family emergencies. Students choosing to commute a greater distance to university as opposed to relocating, pay for

the associated automotive fuel and maintenance costs (or public transportation costs), and the lost-opportunity cost, as the time spent commuting could be used for work or study.

Statistics Canada found that incomes in rural regions are lower than those in urban regions, which further compounds the problem (Singh, 2002). As a result, many rural students find ways to reduce their financial strain. For example, some students choose to enroll in school part-time so that they may also work and make money. Unfortunately, this may not be an option while doing an engineering degree since the programs at the University of Manitoba have a time limit (e.g., Civil Engineering has a seven-year limit; University of Manitoba, n.d.). Some students are forced to postpone or terminate their studies if they can no longer afford to attend school, and others opt for college programs that are shorter and/or closer to home (de Broucker, 2007). Currently, the Faculty of Engineering offers the Dr. Len Domaschuk Engineering Entrance Scholarship to students from select rural high schools (Erickson Collegiate, Rossburn Collegiate, or Strathclair Community School); as well as the Dr. Norman Stephansson Memorial Scholarship, for which first year students from northern Manitoba entering Science, Arts, Engineering, or Management are eligible (Beddoes, 2016).

3.4.2   Summary of Findings and Recommendations

The Montreal Economic Institute states in its 2004 Economic Note, *Would Higher Tuition Fees Restrict Access to University Students,* "Data from various Canadian provinces show no direct relationship between lower fees and greater university access." Rather, it is suggested that targeted financing via loans and grants would be a more effective way of ensuring increased accessibility (Montreal Economic Institute, 2004).

For Status Indians and Inuit people in pursuit of a post-secondary education, the Post Secondary Student Support Program (PSSSP) is funded by Indian and Northern Affairs Canada (INAC) to provide money to students enrolled in post-secondary education. Each year, $314M is put towards the PSSSP, but Macdonald-Laurier Institute for Public Policy claims that this money does not always make it to the students it's intended for. A lack of accountability means that the distribution of money is often affected by favouritism, nepotism, and regional variations (Helin & Snow, 2010). This mis-allocation of funds can be even more problematic for Status Indians living on reserves that incur tuition and relocation costs (see also Section 3.5). As the PSSSP is a federal program, recommending improvements for the PSSSP is beyond the scope of this report;

however, there are other approaches that may assist students in overcoming their financial hurdles.

Additional bursaries should be created that take into consideration commuting costs to relieve some of the cost burden incurred by commuting students living far from the university. These costs should consider not only the price of commuting (e.g., public transit or fuel and maintenance), but also the opportunity cost associated with the lost time, as this may affect a student's GPA and chances for grade-based scholarships.

Bursaries for students from low-income families should be established that disregard the students' own income. Students who work during university often have less time to study so maintaining a high GPA is likely more difficult. Thus, their chances of receiving scholarships decrease, and their income still may not be enough to cover expenses.

Current information on the cost of an engineering degree, average starting salaries, and the Manitoba companies that typically hire engineering graduates should be readily available (for example, in the informational package recommended in Section 3.3.2). Given this information, students from low-income families and rural areas can make an informed decision on whether obtaining an engineering degree will (or will not) fit into their lives.

3.5   Location

The place that a prospective student lives at the time of high school graduation may determine whether or not they apply to engineering. Only 11% of students with a home more than 80 km away from a university will enrol in post-secondary education (Senate Canada, 2011). Rural students must leave familiarity behind (e.g., culture and physical environment) as well as their support systems (friends and family) in order to attend university (Senate Canada, 2008). And as previously mentioned, rural students generally incur a greater financial burden, as they must move from their home and pay for travel back and forth to visit their families (Senate Canada, 2008). Therefore, distance was deemed a barrier that may prevent a prospective engineer from going to university.

3.5.1   Contributing Information

Moss et al. (2008) found that perceived "rural and northern advantages" exist, for example, better quality of life and sense of community, and greater safety. These benefits may influence a

young person's desire to remain in a rural or northern community. Therefore, the decision to leave a rural or northern community typically corresponds to a young person's ambitions for personal growth or to acquire the skills necessary for a particular job (Moss et al., 2008). Moss et al (2008) suggested that the personal development attained by the young person by moving must be seen as favourable – some examples include business training, enhancement of personal resourcefulness and creativity, and acquirement of diverse job opportunities and meaningful employment. Thus, recognition and perception of engineering as a valuable career option are inextricably linked to a prospective engineer's location.

Distance is a more significant barrier for those with limited financial resources (Frenette, 2003; Junor and Usher, 2008). Rural and northern students wishing to become an engineer may not be able to because of the greater personal costs incurred when they leave home (Frenette, 2003). As discussed in the financial barrier section, even the distance a student lives from the University of Manitoba within Winnipeg may negatively impact their education due to the time and cost of travelling to and from school, particularly when they rely on public transportation (Herrmann, 2016). In addition to the correlation of distance and financial resources, distance may also diminish the social support available to a young person when they leave their home community (Junor and Usher, 2008).

Distance has a disproportionate effect on certain groups. For example, the percentage of Indigenous Peoples living in rural or northern communities is greater than non-Indigenous (Holmes, 2005). This means that distance is a more likely barrier for a prospective Indigenous engineer than a prospective non-Indigenous engineer. Also, rural communities that have more resources, for example, stronger educational systems and greater job opportunities, as well as the presence of good role models, are more likely to have a positive effect on a prospective engineer's outlook (Educational Policy Institute, 2008).

Improved communications systems (e.g., internet accessibility) have begun to alleviate some of the issues associated with the distance barrier. Increased communications leads to better exchange of information on the benefits of attending post-secondary education, a greater probability that a rural/northern student will find the financial assistance they need, and higher access to role models and social programs that may positively impact a prospective engineer's future. Finding new and better ways to communicate with rural and northern communities will be an important consideration for improving access to engineering in Manitoba.

3.5.2 Summary of Findings and Recommendations

Distance may be regarded in two ways: (1) as a barrier for the university to overcome to gain a student that might not have observed a benefit to moving from their rural or northern community; or (2) as a compounding factor for other barriers. Together, these perspectives reinforce the importance of overcoming the other barriers discussed in this report, particularly recognition of engineering as a career, perception that engineering is associated with meaningful, valuable, and diverse job opportunities, financial resources, and social support. Therefore, the recommendations provided for addressing these other barriers may also alleviate issues impacting a prospective engineering from a rural or northern community.

The Australian Government recognized the financial burden placed on remote students wishing to attend post-secondary education and developed relocation scholarships to assist those in need (Australian Government, 2016). In addition to the two scholarships currently available for rural and northern students (Dr. Len Domaschuk Engineering Entrance Scholarship and Dr. Norman Stephansson Memorial Scholarship), relocation bursaries should be available for prospective engineering students from rural and/or northern communities that wish to attend the University of Manitoba but do not have the financial means to do so.

3.6   Qualification

All of the barriers discussed up to this point provide insight on the potential reasons for the under-representation of certain groups in Manitoba's engineering community. In order to obtain an engineering degree at the University of Manitoba, a prospective student must meet the required qualifications. Thus, under-preparedness may be a barrier encountered by a potential engineer. This barrier may be a significant reason why minority students who apply to the Faculty of Engineering are not accepted into the program, and may also contribute to unequal representation in engineering.

3.6.1 Contributing Information

It is estimated that while 17.0 % of Manitoba's population is of Indigenous identity, only 0.3% of engineers in Manitoba are Indigenous (Herrmann, 2016). Although there are no specific statistics on the ethnic, socio-economic or gender status of applicants, Herrmann (2016) collected information on the region-of-origin of accepted engineering students. This data confirmed a

disparity between students from rural, northern, and inner-city locations (areas of large minority populations), and those from the rest of Winnipeg.

Furthermore, entrance to the Faculty of Engineering at the University of Manitoba is competitive and rigorous. The official entrance requirement for engineering is a minimum 85% grade average in Grade 12 chemistry, pre-calculus, and physics, with no less than 60% in any one course (University of Manitoba, 2015a). The actual high school average required for acceptance to the first year engineering program is usually significantly higher (up to 91%; Ruth, 2016), as the current acceptance criteria is based solely on grades (University of Manitoba, 2015a). Students are ranked again after their first year of study (based on their grades within this first year) for acceptance to a discipline (University of Manitoba, 2015b). One reason acceptance to the Faculty of Engineering is so competitive may be because Manitoba has the second-lowest percentage of engineering students when compared to total university enrollment (0.04%, which is second to PEI with 0.03%; Ruth, 2016). Furthermore, the University of Manitoba is the only Canadian Engineering Accreditation Board (CEAB) accredited university in the province, making it the largest province (both geographically and population-wise) with only one engineering school.

These rigorous application requirements can limit the diversity of those who apply to engineering. For example, studies indicate that girls typically avoid physics classes at the high school level due to social pressures (i.e., negative stereotypes) and low self-efficacy. Instead, girls move toward biological sciences (Papadimitriou, 2004), which are not required for acceptance to engineering at the University of Manitoba (while physics is).

The competitive nature of the application process favours students who have high school teachers with more lenient grading practices. Conversely, the current application process may negatively affect students who have part-time jobs, are supporting a family, or are influenced by cultural biases that limit their academic support and interests. These difficulties disproportionately affect those with lower socio-economic status (Educational Policy Institute, 2008; Holmes, 2005), which has been correlated to "a mix of mutually-reinforcing low expectations and low academic achievement" (Educational Policy Institute, 2008). The adoption of a quality-based acceptance program, particularly for those students who are negatively affected by privilege, could result in a more equal application process.

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Furthermore, educational inequalities exist that amplify the difficulties of an over-competitive application process. Specifically, Manitoba's low education rankings in previous Pan-Canadian and International Student Assessments (O'Grady, 2013; Martin, 2014) are thought to be due to poverty and socio-economic inequalities (Martin, 2014) indicating that the quality of education among the underprivileged and minority groups has decreased. Indigenous Peoples and immigrants are more prevalent in rural, northern, and Winnipeg's inner-city schools, which generally have lower-quality science and math teachers, and limited laboratory resources (Martin, 2011; Sniderman, 2012). Some have argued that transparency with respect to individual school initiatives, progress, and successes may mitigate these problems (Botelho-Urbanski, 2014). This information may also be a valuable tool for data-driven decisions on educational policies and resource allocation. The collection of performance and demographic data on individual schools can quantify education or resource gaps between schools or school divisions, reveal differential grade inflation, or identify successful programs that can be implemented in other schools.

Students who are not accepted into the first year engineering program have limited options for a "second chance" entry. For example, professionals within engineering education indicated that transfers to the engineering faculty from University 1 (U1), technical colleges, or para-professional employment are poorly developed and underutilized. In U1, students who failed to secure a seat in the Faculty of Engineering should be presented with an alternative route based on their U1 results to apply for a seat in the following year's preliminary year of engineering admissions pool. This would be different than the current approach (which allows U1 students to apply for an engineering major provided they have managed to take the appropriate classes) because students are offered the opportunity to address holes in their skillsets and improve their academic performance before attempting to enter a specific engineering department.

Students in technical colleges studying as technologists should also be presented with a process for transferring to a comparable engineering major at U of M. This is especially relevant for the recruitment of Indigenous students, as they have been found to be more likely to attend a technical oriented college program over university (Holmes, 2005). Furthermore, facilitating transfers from the University College of the North will establish connections with northern students who may require or prefer to start their education closer to their home (Holmes, 2005). The University of Manitoba is currently developing *Engineering Hybrid Pathways*, a program

designed to support "engineering students from other Manitoba post-secondary institutions ... to engineering programs" at the University of Manitoba (Beddoes, 2016). The initiative aims to transfer maximum applicable credits to allow students to put the courses taken while acquiring their engineering technology diploma towards their engineering degree (University of Manitoba, n.d.b). The program's future goals include developing a pathway for Red River College's students to qualify for Advanced Entry, as well as working with University College of the North's in developing its equivalent courses to allow for its students to qualify for Advanced Entry to the engineering programs at the University of Manitoba (Beddoes, 2016).

The current application process may also dissuade potential mature students (e.g., working in para-professional engineering occupations) from applying to the Faculty of Engineering. Thus, identification and targeted recruitment of mature workers in para-professional engineering occupations should be considered. This would increase the diversity of perspectives in the engineering profession, and may potentially assist in bolstering the enrolment of minority groups. The establishment of university-industry partnership programs could alleviate the financial burden assumed by these mature students.

3.6.2 Summary of Findings and Recommendations

The competitive application process associated with engineering in Manitoba is connected to many of the issues discussed in the previous section. The obvious recommendation is to support the expansion of the University of Manitoba's Faculty of Engineering to accommodate more students. Increasing the capacity of students the Faculty can educate would be difficult to achieve, but with the initiatives already undertaken by the University of Manitoba and continued funding from the Manitoba Government, Manitoba has recently experienced the largest increase in enrolment in CEAB accredited engineering programs. Over the past decade, engineering enrolment increased 39% (between winter term 2010 and fall term 2016) and further growth is expected in the near future (Beddoes, 2016). Additional (smaller) measures may also be taken to increase the overall preparedness of all potential engineering students in the province. First of all, the gap between inner-city, rural and northern schools versus other Winnipeg schools must be assessed and reduced. Data should be collected on the ethno-socio-gender-economic demographics of schools across Manitoba to identify the situations and environments that lead to greater success rates for engineering applicants from all school divisions, particularly those with

a high percentage of minority groups (George et al. 2001). A monitoring body could be established to oversee data collection while also promoting transparency of the high school education system, controlling differential grade inflation, and recommending resources allocation.

The Faculty of Engineering should consider the implementation of a quality based selection process for students entering the Faculty of Engineering. This could be applied to underprivileged students (recognized by the monitoring body mentioned above) who may not be competitive with grades alone. The Faculty of Engineering could award a percentage of the first-year seats on a quality-based system (using tools such as questionnaires, interviews, Pathfinder-type assessments, or a combination thereof), while the rest are awarded according to the traditional grade-based system. This would limit the required resources but would provide greater opportunity for under-privileged students to qualify for the Faculty of Engineering. The University of Manitoba has already begun implementing a comparable solution with its supernumerary admission category. This category was established for advanced entry of qualified ENGAP students to disciplinary programs.

The University of Manitoba is currently establishing the *Engineering Hybrid Pathways* program designed to support STEM students transferring to the Faculty of Engineering from other post-secondary educational institutions. Specifically, bridges from Université de Saint-Boniface, the University of Winnipeg and the University of Brandon exist, and the expansion of this program to include the University College of the North and Red River College are in the works. Continuing support of the University of Manitoba's efforts on this front is recommended. In a similar vein, a second recommendation is to establish a 'second chance' option for U1 students whereby they are allowed to apply to the preliminary year of engineering. This would differ from the current system in which they must compete against first year engineering students when applying to one of the engineering departments.

The Faculty of Engineering may also consider recruiting mature students working in para-professional engineering occupations. Both of these initiatives would likely promote post-secondary education of under-privileged or under-represented groups and would increase the diversity of perspectives in the engineering profession.

Finally, additional support should be available to those accepted to the Faculty of Engineering in order to ensure that they are fully prepared to begin university. Specifically, the

development and implementation of pre-university programs or introductory summer courses may help address any knowledge or skill set gaps in education (particularly for under-represented groups), and may also be particularly useful in preparing students with other university-related skills (American Speech, Language and Hearing Association, u.d.). Information on course selection, communicating with teaching assistants and professors, study skills, obtaining financial aid and available social support groups may help facilitate the transition to post-secondary education, particularly for students who come from unconventional educational backgrounds (Marable, 1999). These programs may tie nicely into a mentorship program so that students' knowledge gaps can be filled as the first year of engineering unfolds. The ENGAP provides similar resources to Indigenous students; thus the Task Group suggests that this program receives continued support.

3.7   Representation

Related to the barriers of recognition and perception, representation (or the lack thereof) has been identified to address the lack of peers and role models a prospective student may encounter when considering a career in engineering. Furthermore, the lack of minority or under-represented groups among veterans of the profession identifies the chicken-and-egg scenario that can occur when those making decisions or relaying information are an un-diverse population that is inherently unaware of the minority perspective.

3.7.1 Contributing Information

The majority of institutions handle minority populations with an assimilative approach. This requires all students to fit into a 'normal' program schedule (Holmes, 2005). This in itself is not necessarily barrier but these fixed programs are often developed, imposed, and enforced by governing professional associations, university administrators, and faculty or educators that don't include a minority perspective and may include implicit biases (Hill et al. 2010). As such, it is difficult to address the manifestations of these biases in governing bodies, and academic or employment policies and environments.

Implicit biases exist – often unconsciously and in direct contradiction with explicit beliefs (Hill et al. 2010) – and can have a detrimental effect on the attraction and retention of minorities in engineering. For example, the majority of people (both men and women) implicitly believe

that science is masculine and liberal arts are feminine (Hill et al. 2010, Project Implicit 2011). This bias can negatively affect the results of peer reviewed acceptance, hiring and promotions, and even perceived self-efficacy in the context of science and engineering (Hill et al. 2010, Schwartz 2015, Kost-Smith 2005).

These implicit biases, among those governing or teaching engineering, can result in biases in curriculums, programs, policies, and work environments. This is significant, as these institutions themselves have been identified as sources potentially deterring minorities from even considering an engineering career track. Prospective students may be influenced by these biases at an early age. Many factors, from an instructor's teaching style (Hill et al. 2010) to the physical posters on the wall (Master et al. 2016), can affect middle and high school classroom environments, which can change interest and success in math and science within girls or any other minority group considered 'poor' students. Alternatively, during a career in industry or academia, re-entry procedures may restrict women or Indigenous Peoples who take time off to tend to family needs (e.g., raise children) from promotion or tenure (Schwartz, 2015).

At an individual level, those minority students who do decide to pursue engineering may experience a general sense of "lack of fit" in the tract, which may directly influence their motivation to consider or continue with engineering (Educational Policy Institute, 2008). Minority students, with differing socio-economic, cultural, or gender backgrounds or sexual orientation may have a more difficult time integrating among their engineering peers, which is essential for instilling a sense of belonging (Educational Policy Institute, 2008). Furthermore, being unable to identify with the typical (Caucasian male) engineering student may contribute to feelings of inadequacy or low self-efficacy, as found among female physics students in a 2005 study (Kost-Smith).

Furthermore, minority students who are alone amongst their peers can experience pressure related to feelings that they represent not only themselves but their group (gender, race, socio-economic background, etc). This 'stereotype threat' (Vogt, n.d.) can lead to decreasing classroom participation as well as declining test performance and interest in the field. Further studies on stereotype threat have confirmed its action among minority populations in the context of engineering (Spencer et al, 1999; Beasley & Fischer, 2012). This threat may also contribute to negative perceptions of engineering, particularly among women and girls who believe they won't

be taken as seriously as their male counterparts (Modi et al., 2012) due to the general stereotypical belief that females are not as good at math and science as males.

3.7.2 Summary of Findings and Recommendations

The impact of under-representation of minority populations in engineering is two-fold: it results in a system that puts pressure on minority students to succeed in an environment that was not constructed with their input. In order to address these concerns, the solution must also be two-fold. First, support must be offered to under-represented students at the individual level in order to eventually increase their ranks to that of a critical mass capable of asserting alternative perspectives. In the meantime, steps must be taken to consciously account for implicit bias and a lack of minority perspective among current policies, procedures, and environments at all levels of the career track. Many of the solutions identified to address the other barriers, such as mentorship, social support, and financial aid, can be employed to address the effect of under-representation at the individual level (Girves et al., 2005; Educational Policy Institute, 2008). Additional measures must be taken to limit implicit bias and to better represent minority populations.

On-going research and monitoring of various socio-ethnic-economic and gender groups and their connections to the University of Manitoba engineering department, along with explorations studying how various barriers might combine to limit individuals from pursuing engineering (like this document) can be used in the process of making decisions on behalf of an absent minority population (Educational Policy Institute, 2008). It may also be useful for administrators, educators, employers and policy makers to determine whether they harbor any implicit association biases by taking free, online tests (e.g., Project Implicit, 2011). Implicit biases do not always reflect explicit beliefs and have the potential to be even more powerful, so awareness of implicit biases can be a tool to help decision-makers take steps to compensate for them (Hill et al. 2010).

Further steps can be taken by implementing changes to engineering educational and professional environments and policies. Supporting paternity leave and refining re-entry procedures would allow more women to remain visible among the ranks (Schwartz, 2015). Transparency and clear, objective evaluation within science education and employment can help eliminate bias that can arise from vague or poorly defined criteria for success (Hill et al. 2010).

Teachers at the middle school level should foster learning environments that encourage 'growth-mindset' where success in math, literacy, and spatial skills are defined as a result of acquired skill as opposed to inherent talent. This shift in focus will limit the impact of stereotypes on students subjected to biases on scholastic performance (Hill et al. 2010; Vogt, n.d.). Educators can also make physical changes to classrooms to discourage the image of a subject's 'type'. For example, including art and nature pictures in a computer science class was found to increase the number of female students interested in the class, but had no effect on the number of interested males (Master et al. 2016). Changes can also be made to the university environment to increase inclusivity by broadening the topics of introductory courses to extend the range of relatable topics (Hill et al. 2010). In Manitoba especially, engineering communication, socio-technical or ethics courses can include aboriginal perspectives with case studies on what to consider when planning engineering projects on treaty land or their effects on local populations.

3.8   Professional Registration

The final component to becoming an engineer is to register with the provincial association, Engineers Geoscientists Manitoba. In order to practice engineering, each member must be registered unless covered under a Certificate of Authorization. While registering is still common practice in Manitoba, many engineering graduates are deciding against it. According to Engineers Canada, only about 50% of Canadian engineering graduates opted to register in 2015 (Engineers Canada, 2015b).

A national survey of final-year engineering students (Engineers Canada, 2015b) found that 46% of students definitely intended to apply for a license upon graduation in 2015. This number was lower than the 2014 and 2013 survey results (49% in 2014 and 55% in 2013). The most common reasons students provided for not obtaining a license to practice were that it was not required for their intended career path (29%), they planned to work in a different province or country, a general lack of interest (13%) or that it was a waste of time and money (4%; Engineers Canada, 2015a). Engineers Canada determined that older students and males who were permanent residents of the province were more likely to apply for a license through the provincial association. Students with a high knowledge of the licensing requirements were also more likely to apply for a license than those that had little or no knowledge (Engineers Canada, 2015a).

3.8.1   Contributing Information

Non-traditional Engineering Fields

As cited in the Engineers Canada study, the most common reason for not registering with an association is that registration is not required in their desired field of work. Compared to 100 years ago, engineers now work in a variety of fields, as the skills attained in an engineering degree are applicable to and valued in other sectors. In Manitoba, the engineering profession was first regulated by the Manitoba Civil Engineer's Act, passed in 1896. The title of the document shows how narrow the focus of engineering was at the turn of the 20th century. Before flight, cars, and home electricity, the requirements of engineering were very specific. As the century progressed and these inventions became commonplace, other engineering focuses were developed (mechanical and electrical engineering). In more recent decades, the engineering profession has expanded into many new areas of practice, for example, environmental, biomedical, and software engineering.

Jobs in these new engineering fields may not have the same requirements as those within the traditional engineering sectors. Therefore, young engineers in these non-traditional fields may not recognize the value in registering with the provincial association. A potential mechanism for responding to these young engineers is to promote the diversity of registered members and their associated fields of work. This endeavour may also benefit the overall perception of the association or engineering profession.

Professional registration is not required for those working in a position that may be filled by someone without an engineering degree. For example, a Biosystems engineer or a graduate with a biochemistry degree from the Faculty of Science may both be qualified for the same job. Similarly, a manager could have a business or engineering background. Engineers in non-traditional positions may not work with many other engineers, limiting the potential support for professional registration. On the other hand, companies that hire engineers from a traditional discipline often reimburse annual professional registration costs, as well as the costs associated with the Professional Practice Examination.

Registration Costs

Compared to other professional organizations, the annual Engineers Geoscientists Manitoba registration fee is relatively low. Chartered Professional Accountants Manitoba (CPA) has a base annual fee of $985, Manitoba Association of Architects charges $900 annually, and registration with The Law Society of Manitoba is $2 730. These fees are all well above the $380 annual renewal fee for registration as a professional with Engineers Geoscientists Manitoba.

One difference in these other professional organizations is the variety of payment plans available to each registered individual. For example, The Law Society of Manitoba has the option to pay in two installments, six months apart. At an annual fee of $2 730, two payments is an easy way to reduce upfront costs for an individual.

Alternatively, CPA Manitoba's fees are assessed based on annual income and years of registration. CPA Manitoba registered members collect 'points' based on the member's age plus their years of registration. For example, a 40 year old member who registered at age 25 would have a total of 55 points. If a member has 80 points, and their CPA related income is less than 10 times the annual fee, their annual fee is waived. If annual income is over 35 times the annual fee, that member pays 100% of the annual fee. Different methods to reduce the cost to an individual are important for membership retention.

3.8.2   Summary of Findings and Recommendations

In order to increase professional registration, Engineers Geoscientists Manitoba should promote the importance of engineering skills in non-traditional fields of work. The Association could also recruit high-profile individuals working in non-traditional fields to register as professional engineers. These individuals could act as role models for engineering graduates looking to work in non-traditional fields, and would greatly help the perception of engineering across the province.

Engineers Geoscientists Manitoba could also increase their presence at the University of Manitoba. Currently, students are taught about the Association, professionalism, and ethics in a first year design course. There is limited Association presence again until the final year, when graduates are encouraged to register as a Member-In-Training (MIT). Potential ways to increase the presence of Engineers Geoscientists Manitoba include joint events with the Faculty of Engineering, more presentations by members of Council (e.g., during design projects or

professional networking events), and an updated website with a student-specific area providing information on joint events and the benefits of professional registration. The registration process for a MIT could be done through this portal, with helpful tips on how to register. For example, some students may not know that they have to wait until they receive their transcript to register as a MIT. The website could also be updated so that the engineering graduate could submit their transcript electronically as opposed to sending it to the Association in the mail.

Registration is important for meeting future marketplace demand for professional engineers and the dynamics of registration requirements by industry are changing. The Task Group recommends that a specific group is formed to evaluate professional registration with Engineers Geoscientists Manitoba, using the information summarized in this report as a starting point.

4   Recommendations for Improving Access to Engineering

Given the six major barriers discussed in the previous section, the Task Group came up with ten overarching recommendations to improve access to engineering education in the province of Manitoba, thereby meeting the increasing demand for professional engineers in the future. Each recommendation includes a list of additional suggestions or methods for achieving that recommendation. Many of the suggestions respond to multiple barriers. The recommendations are summarized in Table 2, and are listed below. Various stakeholders have already initiated some of the suggestions. Rather than eliminate these from the list, they have been identified with a double asterisk in order to encourage the ongoing support of these endeavours.

1) Update the engineering "brand" projected by Engineers Geoscientists Manitoba and University of Manitoba Faculty of Engineering.

    i.   Focus on the people representing engineering, over the things engineers design or build.

    ii.   Review position statements of the Association and ensure that they are inclusive of those outside of engineering, allowing full access into the engineering realm.

iii. The Association should work with the Faculty of Engineering on any branding changes to ensure consistency of the "new brand".

iv. Develop a campaign to attract future engineers by highlighting engineering role models on the Faculty of Engineering and the Association's websites and in print materials – similar to the campaign currently being used by the University of Manitoba. This could be a collaborative effort between Engineers Geoscientists Manitoba and the University of Manitoba focusing on aspiring individuals, particularly those from underrepresented groups. Similar campaigns have been used to increase the recognized value of an engineering education, including: www.engineeryourlife.org, and http://www.tryengineering.org/become-an-engineer, which include biographies of engineers, career experiences, explanations about the profession, and links about extra-curricular engineering competitions.

v. Conduct a survey of practicing engineers with questions related to their life outside of work, time spent at work, time spent away from home, etc. to provide insight on all aspects of life as a professional engineer.

vi. Develop an informational package for guidance councillors and teachers on engineering, particularly for rural and northern communities. This package should include information on the academic requirements, application procedures, cost of degree, cost of application, support organizations (e.g. ENGAP), role models, career options, companies across Manitoba that typically hire engineers, and starting salaries. If people are given cost, salary, and potential employment information, they will be able to make a more informed decision on how getting an engineering degree will (or will not) fit into their lives. WISE could potentially assist with distribution of the informational package as they travel to many rural and northern communities in Manitoba.

vii. **The University of Manitoba is currently doing much to restructure the engineering "brand" in Manitoba. Specifically, the Faculty vision has been revised to address diversity, and art installations celebrating women in engineering and ENGAP programs are prominently featured as "welcoming beacons" (Beddoes, 2016). They have also committed to scholarships supporting students who are

female, LGBT, involved in ENGAP, and originally from a rural community. Consequently, women engineering students have doubled and there are over 100 self-identified Indigenous engineering students (Beddoes, 2016).

2) Promote and support current outreach groups.

i. **Manitoba has several outreach groups acting as ambassadors and working with youth to establish diversity within engineering education (i.e., ENGAP, WISE). Other existing groups within the University of Manitoba include UMES and their Outreach Days program, (umes.mb.ca/page/get-involved/events/outreach), and the University of Manitoba's Let's Talk Science program (outreach.letstalkscience.ca/umanitoba.html). The University of Manitoba also supports "Make Your Move" and "Go ENG Girl" programs to support women in engineering as well as the CIPWIE mentorship program.

3) Promote and develop personal mentorship programs.

i. Establish a mentorship program pairing prospective engineering students (in middle and high school) with either a current student or a recent graduate. Programs such as ENGAP and WISE should be looked at as models, as well as Career Trek, CIPWIE, Community Schools Investigator, Bright Futures and SUPERB. Potential for funded summer camp programming should also be considered.

ii. **Support, and promote existing mentorship programs (e.g., CIPWIE, WISE, University of Manitoba Career Mentor Program).

4) Call for changes to education and education management in Manitoba.

i. Develop a scholastic monitoring program to increase the transparency between schools and school divisions, with the goal of identifying and sharing successful programs and distributing resources equitably.

ii. Help encourage teachers at the middle school level to foster learning environments that encourage 'growth-mindset' where success in math, literacy and spatial skills are defined as a result of acquired skill as opposed to inherent talent, as this will teach students subjected to biases on scholastic performance to be less affected by stereotypes (Hill et al. 2010; Vogt, n.d.).

iii. Help encourage educators to make physical changes to classrooms to discourage the image of a subject's 'type'.

iv. Help develop or inspire changes in grade school curricula to promote engineering processes and concepts in both the natural science and social science realms.

5) Reform scholarship and bursary programs.

i. Establish a relocation bursary program to provide resources for rural and northern students who must relocate to study engineering.

ii. Create bursaries that take into consideration commuting costs to relieve some of the cost burden incurred by rural students. These costs should consider not only the price of commuting (public transit; and automotive fuel and maintenance most notably), but also the opportunity cost in terms of both potential working time lost, and study time as this affects a student's GPA and therefore scholarship chances.

iii. Create bursaries for students from low-income families that disregard the students' own income. Often students who work during school have less time to study and maintain a high GPA, lowering their chances of receiving scholarships while their income may not be enough to cover expenses.

iv. **Continue to support scholarships given by the University of Manitoba such as the Dr. Len Domaschuk Engineering Entrance Scholarship and the Dr. Norman Stephansson Memorial Scholarship for rural and northern students.

6) Continue to expand the University of Manitoba Faculty of Engineering to accommodate more students and review the current admissions criteria.

i. **Continue to support the current expansion strategies lead by the University of Manitoba, which have resulted in a 39% increase in undergraduate students between the winter 2010 and fall 2016. Further funding commitments by the Manitoba Government are anticipated to promote an additional growth of 8%. The University of Manitoba is also investing in teaching and laboratory facilities to eventually increase the physical infrastructure available.

ii. Allow for students to take a 40S physics course in the first year of university, to avoid preventing female students who chose to take Biology over Physics in high school from applying to the Faculty.

iii. Implement a quality-based selection process for students entering the Faculty of Engineering; this can be applied to a limited number of seats if it is not feasible for the entire selection process.

7) Continue to support programs that provide financial and/or social assistance, particularly to minority students.

i. **Maintain and enhance the University of Manitoba ENGAP program (the best of its kind in Canada) so that it can continue to assist Indigenous engineering students.

ii. **Continue to support programs promoting women in engineering. For example, the University of Manitoba already financially supports CIPWIE and other women in engineering programs (such as Make your Move and Go ENG Girl).

iii. Support engineering student and technical societies such as the University of Manitoba Engineering Society, University of Manitoba Student Chapter of SAE International, University of Manitoba IEEE Student Branch, and the University of Manitoba Biomedical Engineering Society, to name a few. These groups promote interaction between students and provide social support to their members, which increase the probability of a student completing their engineering degree.

8) Establish bridge or transfer programs to the University of Manitoba Faculty of Engineering from various other programs.

i. **Establish a bridging program between the Faculty of Engineering and accredited Engineering Technology Programs in Manitoba, particularly those in rural and Northern areas. For example, the *Engineering Hybrid Pathways* program is currently being developed at the University of Manitoba to develop academic pathways between University College of the North (e.g., to offer preliminary engineering courses), and Red River College (e.g., assist students in qualifying for advanced entry to a disciplinary program) – in addition to the continued support of transfers from Université de Saint-Boniface.

ii. Create a "second chance" option for University 1 students to apply for the preliminary year of Engineering, rather than forcing them to compete with engineering students for class spaces in order to apply to a second year department

9) Establish on-going research and monitoring plans.

    i. Ongoing research can provide feedback on the success of new initiatives aimed at improving access to engineering in Manitoba.

   ii. Monitoring of various socio-ethnic-economic and gender groups and their connections to the University of Manitoba Faculty of Engineering, can be used with the information summarized in this report to inform future decisions and initiatives.

10) Support changes made to educational, university, and professional policies, procedures and curricula to promote inclusivity and diversity.

    i. Encourage administrators, educators, employers, and policy makers to determine whether they harbour any implicit association biases by taking free, online tests developed by a Harvard University not-for-profit (Project Implicit, 2011).

   ii. Support paternity leave, improved maternity leave, and refined re-entry procedures to allow more women to remain visible among the ranks (Schwartz, 2015).

  iii. Increase inclusivity in the university environment by broadening the topics of introductory courses to extend the range of relatable topics (Hill et al. 2010) – for example, courses including Indigenous perspectives with case studies considering projects on treaty land or the effects of development on the local population.

  iv. Address differing socio-economic, cultural, and educational backgrounds with pre-university summer camp programs to help fill skill or knowledge gaps and further enhance student's soft skills.

   v. Target educational or employment recruitment efforts towards groups underrepresented in the engineering profession.

5   Conclusions

The main objectives of the Engineering Education Task Group were to consider the future marketplace demand and present access to engineering education in the province of Manitoba, and given these findings, recommend possible initiatives for the future. The Task Group considered previous studies and reports, knowledge gained through personal experience, and presentations from key individuals working to address current issues with access to engineering education in the province. Manitoba will likely face a shortfall of qualified engineers in the coming years, due to the retirement of a large percentage of current engineers and growth of engineering-related industries. In order to meet the future demand, barriers to engineering education must be recognized and diminished. The Task Group found that the existing barriers fell into several broad categories:

- Recognition: Awareness from prospective students that engineering is a potential profession to pursue.
- Perception: The general perception of the type of person that would be suited to engineering, the schooling and work required to achieve an engineering degree, and the work that a practicing engineer ultimately does.
- Social Support: The assistance provided by individuals or groups to a prospective engineer.
- Financial Resources: The actual monetary resources available to prospective engineer to fund their engineering education.
- Location: The proximity of a prospective student to a place where engineering education can be obtained.
- Qualification: The preparedness of a prospective student for education in the Faculty of Engineering at the University of Manitoba.
- Professional Registration: The requirement for engineering graduates to become registered professional engineers.

Professional registration with the Association was also seen as an important consideration for meeting the future engineering marketplace demand, though it is not technically related to access to engineering education. The above categories were individually evaluated to determine

potential solutions for assisting prospective engineering students overcome each barrier. The solutions were combined to generate ten main recommendations:

- Revise the engineering "brand" projected by Engineers Geoscientists Manitoba and University of Manitoba's Faculty of Engineering.
- Support changes made to educational, university, and professional policies, procedures, and curricula to promote inclusivity and diversity.
- Promote and support current outreach groups.
- Promote and develop personal mentorship programs.
- Call for changes to education and education management in Manitoba.
- Reform scholarship and bursary programs offered by the Faculty of Engineering.
- Expand the University of Manitoba Faculty of Engineering to accommodate more students and modify the Faculty's admissions criteria.
- Continue to promote and fund social and/or financial programs that provide support to minority students.
- Create bridge or transfer programs to the University of Manitoba Faculty of Engineering from various other programs (e.g., U1, technical colleges).
- Establish on-going research and monitoring plans to evaluate the progress of these measured.

In general, the research conducted by the Task Group indicated that the implementation of these recommendations would allow for an increase in the overall size as well as the diversity of engineering education, and ultimately the engineering field within the Province of Manitoba, thereby reducing the risk of encountering a shortfall of engineers in the future.

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Tables

Table 1. Barriers matrix illustrating the time a prospective engineering student may encounter a given barrier

Timeline / Barriers	Elementary / Middle School	High School	Application and Acceptance to Program	University Studies	Post Graduation
Recognition	●	●			
Perception	●	●	●		●
Social Support	●	●	●	●	●
Financial Resources	●	●	●	●	
Location	●	●	●	●	
Qualification			●	●	
Representation			●	●	●
Professional Registration					●

Table 2. Barriers with corresponding solutions recommended by the Task Group

Barriers → / Solution	Professional Registration	Representation	Qualification	Location	Financial Resources	Social Support	Recognition	Perception
Revise the engineering "brand"	●				●		●	●
Support current outreach groups		●				●	●	●
Develop personal mentorship programs	●		●		●	●	●	●
Call for improvement to K-12 education in Manitoba			●			●		
Reform scholarship and bursary programs				●	●			
Expand the Faculty of Engineering		●			●			
Support social programs benefitting minority students		●	●	●		●		
Create bridging programs to the Faculty of Engineering		●	●	●	●			
Establish on-going research and monitoring plans	●	●	●	●	●	●	●	●
Change policies to promote inclusivity and diversity		●				●		●

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