ISSUES AND CHALLENGES FACED BY UNDERREPRESENTED GROUPS IN ENGINEERING AND COMPUTER SCIENCE INDUSTRIES

A Literature Review created as part of the Building Capacity Through Competency Development Project: a partnership between the University of Victoria and Canada’s Digital Technology Supercluster, funded by the BC Ministry of Advanced Education and Skills Training

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About the Project

This literature review was conducted as a part of the Building Capacity through Competency Development: A Partnership between the University of Victoria (UVic) and Canada’s Digital Technology Supercluster (“the Supercluster”) project. In partnership, UVic and the Supercluster aim to build capacity in the digital technology ecosystem by exploring innovations in work-integrated learning (WIL) that will develop a diverse talent pipeline and ensure a workforce prepared for the jobs of tomorrow. The purpose of the Building Capacity through Competency Development (BCCD) project is to three-fold:

1) To create an inclusive industry-based competency framework that integrates core competencies developed in a student’s discipline or field of study with job-specific competencies. This comprehensive framework will include the digital literacy and dexterity required to help the student be job ready in the emerging digital economy.

2) To build capacity, diversity and inclusiveness in the digital workforce by increasing participation of underrepresented groups in WIL opportunities.

3) To identify initiatives and tools post-secondary institutions can provide to help employers with recruitment and retention of talent.
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Executive Summary
Diversity is an important strategic consideration for organizations in the 21st century. The purpose of this literature review is to develop a better understanding of the issues and challenges faced by Black, Indigenous, and People of Colour (BIPOC), women, immigrants\textsuperscript{1}, LGBTQ2SAI+, and people living with disabilities in engineering and computer science industry. A recent study by the Trudeau Foundation, that surveyed nearly 8,000 workplaces across Canada, found that an increase of as little as 1% in ethnocultural diversity contributed to a 0.5% increase in workplace productivity.\textsuperscript{1} Including diverse peoples and perspectives in post-secondary engineering and computing science education, as well as respective industries, fosters the capacity to solve problems, to think critically, to be creative, and to embrace cognitive complexity.

Key Findings

- Members of underrepresented groups often reported experiencing an unwelcoming climate in STEM programs which negated a positive educational experience and fostering a supportive learning environment. Nondominant groups were more likely to have a lower sense of belonging in STEM fields compared to White male counterparts.\textsuperscript{75}

- Students of colours faced structural and social barriers to learning computing science and pursuing engineering degrees. Students tended to leave STEM program and workplace due to feeling unwelcomed, marginalized and pushed out.\textsuperscript{10,12}

- A study showed that women of colour experienced higher rates of harassment, assault, and felt unsafe in workplaces because of their gender and race.\textsuperscript{13} Research also showed that women of colour experienced different patterns of bias women faced in workplaces. \textsuperscript{13,14}

- Key issues facing Indigenous job candidates and employees included social and economic challenges associated with colonial legacy, the historic and systemic discrimination toward Indigenous Peoples in the labour force, family relationships and community obligations and social and geographic isolation.\textsuperscript{28,35,36,37}

- Studies showed that cultural messages, stereotypes, lack of role models, poor working conditions and environment stopped women from pursuing STEM degrees.\textsuperscript{6,45,46,48,49}

- Although ageism was a concern of many in the tech industry (76%) and was especially prevalent among younger people (18-24) and older people (50+), age discrimination was perceived to be less harmful compared to other forms of inequities taking place in workplaces today. \textsuperscript{70}

\textsuperscript{1 Limited to students enrolled in engineering or computing science programs.}
The LGBTQ2SAI+ workplace inequalities were pervasive within STEM-related agencies, extend across age cohorts and supervisory status, and exist for both LGBTQ2SAI+-identifying women and men.\(^{80}\)

LGBTQ2SAI+ professionals of colour and LGBTQ2SAI+-identifying women were more likely to experience professional devaluation and harassment at work.\(^{83}\)

In a 2018 report, Information and Communications Technology Council (ICTC) stated that people with disabilities were a key source of underutilized talent that can be critical to filling employment demand in ICT sector.\(^{84}\) Nevertheless, employers were still unsure on how to employ people with disabilities and how to adequately source, train, and enable their inclusion in their organizations.\(^{84}\)

To date, there is a limited number of resources on intersection of multiple marginalized identities in STEM, however, there is a clear indication of strong interest and attention to this approach in academia and industries.

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“If we in engineering profession do not acknowledge that—if we don’t diversify our understanding of diversity—we aren’t preparing students for the real world, and we are not living in it either.”\(^{67}\)

Dr. Thomas Duever

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Search Approach

This analysis took an intersectional approach that acknowledges that people’s overlapping identities and experiences are affected by a number of discriminations and disadvantages. Furthermore, when the intersection of race, age and gender are considered, employment gaps are compounded. Researchers posited that people holding two or more identities do not fit the prototypes of either of the identities and, as a result, experience unique consequences, often falling under intersectional invisibility.\(^2\) One researcher defined intersectional invisibility as “the general failure to fully recognize people with intersecting identities as members of their constituent groups”.\(^3\) Consequently, those holding multiple identities (e.g., ethnic minority women) face challenges associated with misrepresentation, marginalization, and disempowerment.

It is also important to acknowledge that some of the barriers faced by underrepresented groups begin even before students apply to pursue engineering and computing science degrees. Where possible, the analysis speaks to challenges experienced by these groups before entering post-secondary system and industry to provide better insight into people’s experiences with engineering and computing science programming and careers.
Introduction
The purpose of this literature review is to develop a better understanding of the issues and challenges faced by ethnic minority people and those from socio-economically disadvantaged backgrounds in engineering and computer science industry. The repercussions of COVID-19 pandemic and associated system disruptions revealed deep disparities in people’s access to education and barriers to employment. Many researchers and academics expect that the response to the pandemic threatened gains and progress in diversity, inclusion, and belonging achieved in the past. \(^{45}\) While the full impact of the pandemic on the lives of underrepresented groups remains yet to be determined, to date, there is a limited number of resources on intersection of multiple marginalized identities in STEM. What remains clear is that these barriers have far-reaching implications for underrepresented groups and to continue working on inclusive practices to remove these barriers, we need to have a better understanding of people’s experiences.

People of Colour
One study conducted by Google on diversity gaps in computer science of 12\(^{th}\)-grade-students’ parents and teachers revealed structural and social barriers to learning computing science that created disparities in opportunities to learn. \(^{6}\) The study results showed that Black and Hispanic students were less likely to use a computer at home compared to White students. \(^{2,6}\) Forty-nine percent of Hispanic students said that an adult in their life worked with computers or technology compared to 65% of Black students and 68% of White students. \(^{6}\) Student’s experiences with technology coupled with the lack of pre-university academic preparation does not help to cultivate talent among minorities in STEM fields. \(^{7}\)

National studies indicated that Black and Latino college students declared STEM majors at the same rate as their White peers. \(^{8}\) however, left the major at nearly twice the rate of White students. \(^{9}\) The researchers posited that because Black and Latino students were more likely to come from low-income families, they might not have access to the academic resources that traditionally helped support students. \(^{9}\) However, the researchers also suggested that discrimination and bias in STEM could be pushing minority students away from the field. \(^{9}\) Another study confirmed these findings: students of colour left STEM majors as a consequence of feeling marginalized and pushed out. \(^{10}\) When researchers compared the drop-out rates to other competitive majors, such as business, Black and Latino students did not leave other majors at the same high rates. \(^{9}\) Another study found a potential explanation to that: the pressure to prove wrong negative stereotypes that

\(^{2}\) Frequent computer usage is related to interest in computing science. While this difference was identified among different ethnicities, there was no difference between males and females. This may be attributable to the fact that students use computers at home for different purposes (e.g., males to play videogames, and females to check social media).
White peers have about them placed enormous pressure and racial battle fatigue on students of colour.\textsuperscript{11}

Similar trends persevered in workplaces. McKinsey’s study\textsuperscript{3} found that Black people experienced representation gaps at each step of their career.\textsuperscript{12} Black employees were more likely to leave a job compared to their White counterparts.\textsuperscript{12} While the disparity in attrition at the entry level may seem insignificant, it has a compounding effect, with Black employees who are promising candidates for higher-level position choosing to leave and not progressing to management position.\textsuperscript{12}

Percentages of Black employees who felt valued, respected, and appreciated were significantly lower when compared to White colleagues.\textsuperscript{12} Over half of Black employees said that their company did not recognize their traditions and habits, with 42\% stating that their employers did not raise awareness on topics related to diversity.\textsuperscript{12} Black employees were 1.7 times more likely than Hispanic, Latino and Asian employees to believe their race would make it harder to achieve their goals.\textsuperscript{12} Black employees were twice less likely to share about themselves compared to White employees, with 31\% feeling discouraged to speak up.\textsuperscript{12}

Women of colour experience inequities based on their skin colour and gender, with some researchers calling this characterization a “double jeopardy” (see Figure 1).\textsuperscript{13,14} A study showed that women of colour experienced higher rates of harassment, assault, and felt unsafe in the workplaces because of their gender and race.\textsuperscript{13} Among some other harmful stereotypes and behavior patterns were:\textsuperscript{13}

- **Prove-it-again:** women having to prove themselves despite having all the necessary credentials and experience.

  One report showed over sixty percent of the women reported having their successes and expertise questioned.\textsuperscript{15} Indigenous\textsuperscript{35} and Black women were

\textsuperscript{3} The study sample included the following industries: consumer packaged goods, energy, utilities, basic materials, engineering and industrial manufacturing, food and beverage, healthcare systems and services, IT services and telecom, media and entertainment, oil and gas, pharmaceutical and medical products, professional and information services, retail, technology, transportation, logistics, and infrastructure.
considerably more likely than other women to report having to deal with this type of bias.

- **Tug of War**: women distancing from women who just started in the profession.
  A fifth of the scientists surveyed reported “I feel like I am competing with my female colleagues for the ‘woman’s spot’”.¹³
- **The Maternal Wall**: after becoming a parent, women’s commitment to profession being questioned.
  Nearly two-thirds of the scientists with children reported running into this form of bias, across all races and ethnic groups.
- **The Tightrope**: women behaving in masculine ways to be seen as competent and recognized on par with male colleagues (“walking a tightrope between being seen as too feminine to be competent, and too masculine to be likable”).¹³
  Black and Latina women were more likely to be seen as angry for “masculine” behaviors such as being direct and decisive.
- **Isolation**: after socially engaging with colleagues, women having negative perceptions about their competence. This bias was mostly mentioned by Black women (42%), followed by Latina (38%), Asian-American (37%), and White women (32%).

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*Race and racism create specific, unique challenges for women of colour that are too easily ignored with broad platitudes that seek to advance women’s representation without questioning which women are most likely to benefit.*¹⁶

*Brookings Institution*

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**Indigenous People**

Indigenous learners typically move through many transitions and obstacles as they navigated their learning journey. Among these barriers that restricted access to post-secondary engineering education for Indigenous learners were: ¹⁷,¹⁸,¹⁹,⁴³

- intergenerational impact of residential schools,
- socio-economic challenges,
- sparse information on career options,
- lack of access to engineering prerequisites (e.g., math and science),
- structure and focus of provincial school curricula,
- low expectations of teachers,
- being in care or in the justice system,
- or attending a remote or rural school.

The International Adult Literacy and Skills Survey (IALSS) indicated that the majority of First Nations adults and youth were at or below the level in using computer, writing, and
mathematics needed to take full advantage of post-secondary education and to compete in Canadian labour market. While secondary and post-secondary education may help to a certain degree in raising these percentages, thirty-five per cent of Indigenous peoples in British Columbia have not completed high school (according to 2016 Census). For First Nations this number grows to thirty-nine percent and remains slight lower for Inuit (34%) and Métis peoples (28%). If students are not graduating high school, attaining advanced degrees in post-secondary environment becomes especially difficult for Indigenous learners.

While Indigenous peoples make up 4.9 per cent of the population in Canada, Indigenous students only account for 0.6 per cent of total undergraduate enrolment in engineering programs and 0.7 per cent of undergraduate degrees awarded. According to the Information and Communications Technology Council (ICTC) report Indigenous peoples comprise approximately 1.2% of information and communication technology (ICT) professionals nationwide. Among those that pursued post-secondary education, approximately 3% went into ICT and 3.7% went into STEM. While the education level of Indigenous peoples is increasing, challenges remain surrounding the on- and off-reserve transition for education and employment. A 2016 Aboriginal Peoples Survey supported this notion. Respondents shared that the biggest barriers to attaining further education and training were “courses not matching needs, the cost, personal and family responsibilities and a lack of personal priority.”

Ways of learning, achieving and succeeding in post-secondary educational setting were understood differently in Indigenous and Western worldviews. Indigenous learners typically were raised with the idea of collective success rather than individualism that is dominant in Western cultures. Moreover, STEM education rarely includes Indigenous knowledge or methodologies and tended to focus on White scholar’s knowledge. While Western science takes a quantitative, compartmentalized approach to understanding natures, Indigenous science uses qualitative, interrelated approach. Indigenous peoples also viewed humankind inseparable from the land, whereas STEM majors had historically been subscribed to a Western scientific paradigm which aimed to understand forces of nature and manipulate them for the benefit of humankind. Indigenous people had a profound spiritual connection to land and idea of viewing the world as fundamentally interrelated—air, animals, plants, and forces of nature—which introduced an evident misalignment in the ways of knowing and being. Some Indigenous engineers reconciled this contradiction by taking responsibility to balance the need to respect the Earth and the need to improve life through engineering work.

“The fundamental differences between Western science and the way Aboriginal people view the world…[contribute to] the reason Aboriginal people are underrepresented in science and engineering.”

"
Developing a greater sense of belonging was particularly difficult for Indigenous learners when a dominant ideology reflected discordant ways of knowing. Coupled with lack of opportunities available to students in remote areas, socio-economic challenges, and low expectations of teachers, Indigenous learners tended to leave STEM courses and degrees. Figure 2 visually depicts how the educational pipeline of Indigenous learners shrunk as they progressed through their education. As Indigenous learners opted out of STEM subjects, the pool of Indigenous candidates shrunk starting as early as Grade 3.

In 2016, Engineers Canada identified seven consensus practices that some Canadian post-secondary engineering programs have used to improve access to engineering education for Indigenous peoples. These practices are available in Appendix A.

One of the most common reason why Indigenous employees left an organization was a lack of awareness of Indigenous culture in the place of work. Eleven Truth and

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4 Activities and outputs generally agreed upon and frequently deployed in access programming.
Reconciliation Commission Calls to Action dealt directly with education, including calls to improve educational outcomes for Indigenous people as well as to develop a better understanding of Indigenous people, their cultures, the barriers they have faced as a result of colonization, and the need for reconciliation in the general population (#s 62, 64, 65, and 66). Progress on the Calls to Action seemed to be slow. In a 2017 study, public servant employees expressed a need to constantly defend or explain Indigenous histories and cultures. Many spoke about challenges advancing their careers and processes being neither transparent nor inclusive of Indigenous cultural values.

Key issues facing Indigenous job candidates and employees included social and economic challenges associated with colonial legacy, family relationships and community obligations and social and geographic isolation. The history of residential schools and other colonial practices left a traumatic imprint on Indigenous peoples of Canada. Depression, low self-esteem, mental health challenges were among few examples of associated challenges Indigenous people experienced daily. Infrastructure issues were more pronounced for Indigenous peoples, especially in remote communities. Nineteen percent of Indigenous population in Canada lived in homes needing major repairs: plumbing, electrical, walls, or flooring (according to 2016 Census). This not only posed challenges to successful employment, but made it difficult to do homework, vocational training or work from home. One report stated that jobs that could provide housing were very appealing. Other examples of underlying barriers included various forms of difficulties surrounding community infrastructure and services: lack of recreation and sports centers, good educational and health facilities, effective water treatment facilities, and basic telecommunications infrastructure. For example, only thirty-eight percent of Indigenous communities in BC met the basic Internet service criteria in 2020.

Family and community responsibilities were of significant importance to Indigenous peoples. Important community cultural events, traditional seasonal activities (e.g., hunting, fishing, and harvesting) funerals, natural disaster, social crisis could take several days and weeks. If employers were unable or unwilling to adjust work schedules to allow employees to meet family or cultural obligations, it created significant challenges for Indigenous employees. Such events allowed Indigenous peoples to reconnect with their heritage, identity, and communities. Hunting and fishing activities may be of a special importance to remote communities that struggle with food insecurity. The Canadian Community Health Survey found that household food insecurity in Nunavut was three times higher than Canada overall.

If employees were required to travel for work or were refused time off to visit community and family events, it might reinforce the feeling of social and cultural isolation. Understanding and accommodating these cultural practices of Indigenous workers could help employers strengthen their workforce. These practices might include a worker's
community obligations or need to participate in traditional practices such as hunting, and fishing.\textsuperscript{34} In this context, standard work schedules might not allow Indigenous workers to participate in these vital cultural activities.\textsuperscript{33}

Canada has prevalent infrastructure problems in Indigenous communities\textsuperscript{17,42} Since people in STEM occupations have political as well as economic influence, and can play strong leadership roles, Indigenous communities want to see more of their members in these decision-making positions.\textsuperscript{43,44}

**Women**

There are wide gaps between men and women working in STEM jobs, with women being more likely to experience unfair treatment and workplace discrimination. These gaps begin since a young age. One study showed that the percentage of 12\textsuperscript{th}-grade female students (16\%) that were interested in learning computer science was half of the male students percentage (34\%).\textsuperscript{6} Female students tended to be less aware of computing science learning opportunities and less confident about their ability to learn computing science.\textsuperscript{2,45} Female students' confidence in their science and math skills was considerably lower when compared to male students (male: science – 48\%, math – 48\%; female: science – 33\%, math – 37\%).\textsuperscript{6} Parents of female students were more likely to say that their child was 'very skilled' in English, music, and working with other people which may have encouraged children to take classes in those areas.\textsuperscript{6}

Female students were less likely to report seeing people like themselves doing computing science, hence it was more difficult for them to picture themselves doing computer science.\textsuperscript{6,46} Role models have been identified as being important for women pursuing career in computer science and engineering.\textsuperscript{6,45,46} Statistics Canada numbers dating back to 2010-11 showed just 12\% of engineering professors in Canada were women.\textsuperscript{57} Unsurprisingly, another study showed that female students offered more stereotype-consistent ratings and were less likely to express interest in computer science and engineering degrees.\textsuperscript{46,47} In general, parents and educators were more likely to say external reasons—such as a lack of exposure, a lack of opportunity to learn and a lack of role models—are major reasons why women and certain racial and ethnic groups are underrepresented in CS careers.\textsuperscript{6,46,48} One survey also reported that 47\% of females said that they "have felt judged or micro-aggressed" because of their choice to study computer science or engineering, compared to only 6\% of males.\textsuperscript{49}

\textit{"The lesser awareness, exposure, interest, and confidence could be keeping female students from considering learning CS."} \textsuperscript{2}

Google, Gallup

As the profession moves toward achieving Engineers Canada’s 30 by 30 goal, Engineers Canada annual survey 2019 showed an increasing representation of women at the
engineering undergraduate programs (23.4% were enrolled in undergraduate programs and 22.1% graduated with engineering degrees). The disciplines that experienced the highest proportion of female undergraduate enrolment in 2019 were biosystems engineering (50.2%), chemical engineering (41.4%), and geological engineering (38.8%). The disciplines with the lowest percentages of female undergraduate enrolment were software engineering (15.6%), mechanical engineering (16.1%), computer engineering (16.6%), and electrical engineering (16.6%). While these four disciplines account for 50.1% the total number of undergraduate students, women were underrepresented in these disciplines and account for 35% of the total number of female undergraduate students. Materials or metallurgical engineering and geological engineering programs observed the largest increase in the proportion female graduates (9.9% increase and 7.3% increase respectively).

Dr. Mary Wells, Dean of the Faculty of Engineering at the University of Waterloo and former Chair of the Ontario Network of Women in Engineering (ONWiE), summarized the 'leaking pipeline' of females in engineering in Figure 3. Wells's study showed that targeted outreach to high school female students, coupled with showcasing professional female engineers, made a substantive impact on the engineering application numbers in Ontario.

analyzed over 30,000 undergraduate applications and found that female students tended to refer to a career that enabled them to impact and improve society in their applications. Male students were more likely to describe how their technical skills and experience matched the engineering profession.

Women’s underrepresentation was not always the case. The computing science industry observed a 19% decrease in females graduating with computing science credentials since 1984 in the U.S.. When asked about potential reasons as to why the numbers dropped dramatically, one study found that personal computers and computer games were catered more towards boys. The social image and advertisements have only boosted this image that “computers are for boys.” To negate that perception, one study suggested eliminating “gatekeepers” by having at least one computer science class with no prerequisites, hosting face-to-face recruitment events that have female students as recruiters, reaching out to students at a young age, encouraging faculty and administrative staff to promote computer science courses to increase registration for computing science courses, and sharing information about future careers in computer science with parents. Another study found that having support groups for women, role models and mentors from the community, alumni and guest speaker interactions and to have the students themselves reach out and act as mentors, encouraging to attend conferences and tech summits help students address their imposter syndrome.

The study conducted by the Professional Institute of the Public Service Canada found that forty-two percent of women surveyed saw a gender as a barrier to their career progress. One study found that computing departments that sought to address structural barriers to students’ self-recognition as computer scientists were successful in increasing females enrolment in computing science programs. Researchers suggested applying intersectional identity theory to expand equity and support female students in developing computing identity. The authors defined computing identity as the extent to which “the student sees themselves as a computer scientist” and found that it had the strongest correlation with students’ intention to continue in a computing science major. This review identified a lack of research on intersectional identity theory in this area. Failing to understand their unique, intersectional experiences may mean that colleges and universities subject students to contexts and experiences that force students out of computing programs and careers.

Research emphasized the importance of computing students first-year experiences to shaping their ability to see themselves as computing scientists as well as their continued interest in the field. The study also identified that student’s persistence could be threatened when they had experiences in computing that they could not integrate into

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5 Harvey Mudd College, for instance, redesigned introductory computer science courses to be more welcoming to students without previous coding experience, raising the share of women computer science graduates from 10% in 2010 to 56% in 2018.
their personal identities (e.g., the hacker/geek stereotype, video games posters in classroom). Research on sense of belonging within computer science has found that a strong sense of belonging in the field can help students overcome concerns about their abilities to succeed in computer science and allow students to persist in the major.  

“…Women aren’t underrepresented in STEM because they dislike math or science. They’re underrepresented because they don’t like to be discriminated against.”

Joseph Cimpian

Among the top reasons cited among women who worked in engineering and left the field for a non-STEM career included:  

- poor and/or inequitable compensation,
- poor working conditions,
- challenges of work-life integration (heavy workload and travel expectations),
- lack of recognition,
- ‘boys club’ mentality,
- dissatisfaction with the work and organizational climate (HR violations, discrimination from colleagues, bullying, harassment, etc.).

Another study found that demographic and family characteristics of women in STEM jobs were not so different from women in non-STEM professional jobs. The authors argued that one possible reason that women in STEM occupations often move to non-STEM jobs and occupations is the unwelcoming climate that they experienced in their working environment. One study that followed 700 engineering students for almost ten years found that many first encounters with collaboration that were treated in gender stereotypical ways were first experienced in school projects. Another report noted that trends differ among women of different racial/ethnic backgrounds because they may experience exclusion at multiple intersecting axes. For example, women degree earners were more racially diverse than men degree earners, however, even with the most recent increase in ICT degree enrollments women are still underrepresented in the ICT field.

**Immigrants (limited to international students who are enrolled in ECS degree programs)**

Canadian immigrants were highly educated and were likely to specialize in engineering and sciences. Immigrants knowledge of other languages was considered be helpful in communicating with clients and understanding foreign cultures. Since 2015 the percentage of international students enrolled in engineering increased by twenty-five percent, with the largest increase in 2019 (10% when compared to 2018). While there was limited research about experiences on International students in engineering, some institutions have taken steps to address diversity and inclusion at a programmatic level.
Ryerson’s Faculty of Engineering and Architectural Science established “Identity Dialogues” to encourage students to share their experiences with bias. One international student shared that because of their accent other students were interrupting and dismissing their comments.

**Age**
The growth rate in ICT employment among those aged 35 and older (76%) was nearly four times the growth rate among that age group in the overall labour market (20%). While the increase in the number of youth employed in ICT was promising, the transition of younger workers into the ICT workforce was not happening at the desired rate. While expertise did not diminish with age, the perception that those skills did not increase enough to justify higher salaries was prompting some employers to hire younger people than retaining older employees. Ageism was especially prevalent among young and older individuals in tech industry. One survey showed that 27% of employees between 25 to 39-years old reported being in the ‘sweet spot’ (most desirable tech candidates) and said their organization was helping by paying for courses or providing training. This figure drops to 22% for the 18-24-year-old age group and falls even further to 19% by the time people hit 50. Another survey in the U.K. showed 41% of IT and tech workers experiencing ageism at work, with the majority experiencing it at an average age of 29.

One survey reported 76% of participants stating ageism was an issue in tech industry globally. Sixty-eight percent of Baby Boomers reported feeling discouraged from applying for jobs due to age. Forty percent of those who belonged to Generation X felt ageism was affecting their ability to earn a living. Overall, 29% of all respondents said they have “experienced or witnessed” ageism in their current workplace or most recent employer. This is especially important given that Canada has an aging population.

Much remains to be unknown about ageism as age discrimination is perceived to be less harmful compared to other forms of inequities taking place in workplaces today. However, one thing remains clear: ageism is an issue in ICT and engineering industries.

**Lesbian, Gay, Bisexual, Trans, Queer, 2S (Two-Spirit), Asexual/Aromantic and Intersex (LGBTQ2SAI+)**

One survey found that LGBTQ2SAI+ students faced greater marginalization, devaluation, and health and wellness issues relative to their peers in engineering programs. LGBTQ2SAI+ students were less likely than their peers to feel that their work as engineering students was respected. The findings suggested that these difficulties affected LGBTQ2SAI+ students personally: compared to their peers, LGBTQ2SAI+ students were significantly more likely to report emotional, sleep, stress, and anxiety difficulties and were more likely than their classmates to feel exhausted by efforts to compartmentalize their lives.
Intersection of different identities added a new dimension of experiences. LGBTQ2SAI+-identifying students with disabilities in STEM majors experienced unwelcoming learning environment, described faculty as dismissive and unwilling to support and understand students’ needs, feeling isolated and tokenized within learning environments, and reported instances of harassment and invisibility based on their identities (gender, race, ethnicity, disability). Another study explored the experiences of Black gay and bisexual men and found that these students faced challenges when navigating the complexities of their racial and sexual identities from a position of a double minority. Asian students were also more likely than White students to avoid social events and to stay at home from school because they did not feel welcome, and less likely to feel accepted by other students. Black students were significantly less likely than White students to feel accepted by other students, and Native American/Pacific Islander respondents were more likely than White students to report that they feel the need to be discrete about their personal lives at school. Unsurprisingly, a study by researchers at the University of Exeter and Vanderbilt University in Nashville discovered that gay men were 12% less likely to have completed a bachelor’s degree in STEM than men in heterosexual relationships.

Some researchers acknowledged a shift in social acceptance of LGBTQ2SAI+ students on campus among younger people. The presence of well-regarded faculty, staff, and famous people in academic world and beyond also had been a catalyst for change.

While there had been a shift in social acceptances, there were still challenges experienced by LGBTQ2SAI+ in workplaces. The LGBTQ2SAI+ workplace experience inequalities were pervasive within STEM-related agencies, extended across age cohorts and supervisory status, and existed for both LGBTQ2SAI+-identifying women and men. One study estimated that only about one third of LGBTQ2SAI+ survey respondents below the senior manager reported being out in their workplaces. Some respondents indicated that they had to come out several times, with some coming out a couple of times a week. Forty percent of LGBTQ2SAI+ women felt they needed to provide extra evidence of their competence. In addition, trans and nonbinary respondents were far more likely than cisgender people to be in entry-level positions.

Many LGBTQ2SAI+ respondents, especially women, indicated navigating a series of microaggressions, hearing derogatory comments or jokes, and feeling isolated. LGBTQ2SAI+-identifying employees reported more negative workplace experiences along a variety of different measures: they were less likely than their non-LGBTQ2SAI+ colleagues to report that their success is fostered, that they had adequate resources, that their organization supported diverse workers, and that they had transparent evaluations in their workplace. Transgender and gender nonbinary respondents reported experiencing minor health problems, stress, and depressive symptoms more frequently.
than their cisgender sexual minority peers and non-LGBTQ2SAI+ respondents and were more likely to have considered leaving their STEM jobs.\textsuperscript{83}

Other disadvantages were also amplified for LGBTQ2SAI+ professionals of colour and LGBTQ2SAI+-identifying women. LGBTQ2SAI+-identifying women and racial/ethnic minorities were more likely than White and men LGBTQ2SAI+ STEM professionals to experience professional devaluation and harassment at work.\textsuperscript{83} It is important to note that the study did not attribute these disadvantages to any particular STEM discipline. The study also found substantial differences in job satisfaction: LGBTQ2SAI+ employees reported significantly lower satisfaction with employee empowerment and organizational procedures in their agency, and lower overall job satisfaction than their non-LGBTQ2SAI+ colleagues.\textsuperscript{80,83}

**People Living with Disabilities**

In 2018 report, ICTC stated that people with disabilities were a key source of underutilized talent that can be critical to filling employment demand in ICT sector.\textsuperscript{84} According to the Statistics Canada Survey on Disability there were 140,000 people working in ICT sectors who identified as having a disability.\textsuperscript{85} Among the main barriers experienced by people with disabilities were:\textsuperscript{86,87}

- lack of awareness about supports available to students, including assistive technology and academic accommodations,
- lack of awareness of successful role models,
- lack of student support systems who can advocate on student’s behalf,
- lack of accessible spaces (e.g., students with mobility issues experienced difficulties accessing lab equipment),
- low expectations from faculty,
- expectancy effect of students with disabilities not doing well in advanced classes as perpetuated by social media and societal expectations.

One report identified that one of the key challenges was the lack of clarity on employer’s part when it comes to how to adequately source, train, and enable the inclusion of persons with disabilities; some employers were not sure where to look for candidates with disabilities.\textsuperscript{84} Among the most significant barriers the majority of employers noted architectural (e.g., building not wheelchair accessible) and technological (e.g., purchasing braille keyboards, adjustable desks, screen-reading software, joysticks, etc.).\textsuperscript{84} If financing these changes were not an issue, the employers were unsure where to source accessible software, the best and most appropriate type of software, and how to implement it in the workplace.\textsuperscript{84} In order to create and foster an inclusive workplace culture, some employers invested in training staff on removing stigmas and stereotypes about people with disabilities and redesigned company policies and positions to be more accommodating of the employee’s needs.\textsuperscript{84} The majority of employers were interested in
providing employment opportunities for students, new grads and non-conventional (e.g., not full-time) work via co-ops, summer projects and internships.84

Conclusion
Technological and engineering innovations touch nearly every aspect of human life. Many studies have shown that diversity in workplaces unlocks innovation.1,88,89 In order to continue building on these successes, companies will require a far more diverse pool in engineering and computing science. This literature review revealed many barriers and challenges faced by underrepresented groups. It is also important to acknowledge that the recent events of the pandemic continue exacerbating the effects of structural barriers that underrepresented groups experience and face in Canada. Now more than ever educators and employers need to embrace equity-minded approaches and policies in their classrooms, campuses and workplaces.

A review of literature in relation to Issues and Challenged Faced by Underrepresented Groups in Engineering and Computer Science Industries has provided a foundation for further discussion between post-secondary institutes and industry leaders. The Building Capacity Through Competency Development Project will use this literature review as a basis for:

1. Developing a framework for ongoing conversations between post-secondary institutions and industry to examine how best to collaborate to address the digital technology gap; and

2. Creating capacity for co-operative learning opportunities to develop competencies needed for the digital economy.

3. To identify initiatives and tools post-secondary institutions can provide to help employers with recruitment and retention of talent.
Appendix A: Engineers Canada – Consensus Practices

In 2016 Engineers Canada identified seven consensus practices\(^6\) that some Canadian post-secondary engineering programs have used to improve access to engineering education for Indigenous peoples.\(^90\) These practices are:

1. Improving and promote evaluation capacity founded on Indigenous epistemology and publication
2. Consulting, developing, and maintaining relationship with Indigenous people and communities the program serves
3. Systematic approach to evaluating target student population and assessing student needs
4. Creating an alternative applications stream for Indigenous learners
5. Providing financial assistance to cover costs of tuition textbooks, living expenses, transportation, childcare, and other expenses
6. Establishing support services that provide an opportunity to frequently check in on students
7. Developing bridge program and alternative orientation programs (e.g., orientation programs at students Indigenous communities)

Appendix B: Most Effective Recruitment and Retention Strategies


<table>
<thead>
<tr>
<th>Most-Effective Recruitment and Retention Strategies</th>
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<tbody>
<tr>
<td><strong>Strategy</strong></td>
</tr>
<tr>
<td>1. Training and development programs</td>
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<td>2. Working with Indigenous communities and groups</td>
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<tr>
<td>3. Inclusion and diversity policies and strategies</td>
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<td>4. Attending job fairs or career days</td>
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<td>5. Working with community groups and agencies</td>
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<td>6. Anti-racism or cultural awareness training for current employees/management</td>
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<td>7. Working with, and recruiting through, educational institutions</td>
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<tr>
<td>8. Adapting work schedules to accommodate hunting and/or other cultural activities</td>
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<td>9. Assistance planning career and advancement pathways</td>
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<tr>
<td>10. Offering flexible work arrangements (e.g., late/early start/finish; four-day week; 10 days on/five days off)</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.

\(^6\) Activities and outputs generally agreed upon and frequently deployed in access programming.
Additional Resources


Sources


67 Duever, Dr. T. (2017, December). It’s Time for Cultural Shift: Why allyship, equity, diversity and inclusion are the future of STEM. The Voice (Ontario Society of Professional Engineers), 26–27.