Digital Skills and the Skills Gap

Perspectives, Skills Frameworks and Definitions, With a Focus on Canada

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The Future Skills Centre (FSC) is a forward-thinking centre for research and collaboration dedicated to preparing Canadians for employment success. We believe Canadians should feel confident about the skills they have to succeed in a changing workforce. As a pan-Canadian community, we are collaborating to rigorously identify, test, measure, and share innovative approaches to assessing and developing the skills Canadians need to thrive in the days and years ahead. The Future Skills Centre was founded by a consortium whose members are Toronto Metropolitan University, Blueprint, and The Conference Board of Canada, and is funded by the Government of Canada's Future Skills Program.

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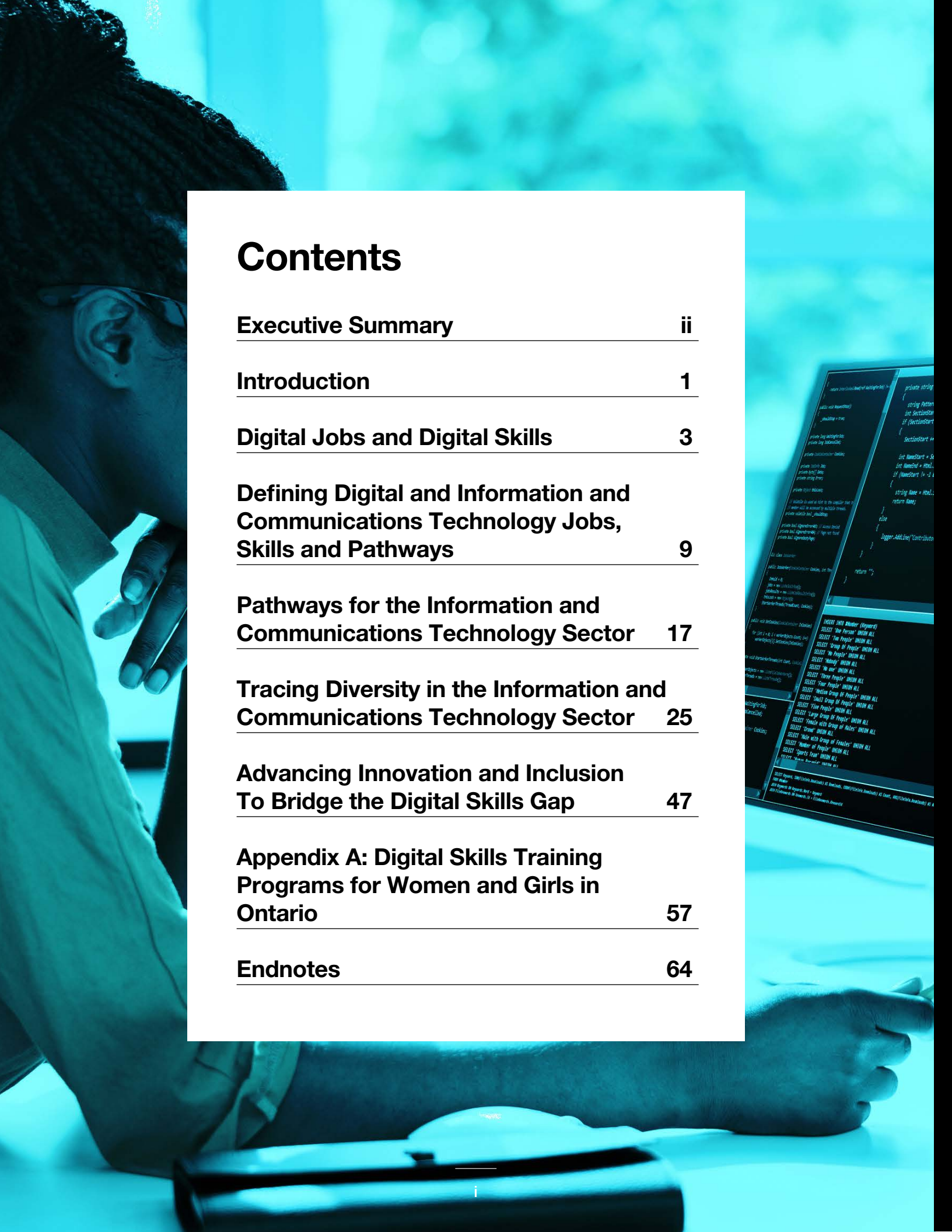

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Executive Summary

Scope and approach

This report, *Digital Skills and the Skills Gap,* reviews English- and French-language literature in Canadian and international contexts on the discussion around digital skills, the digital skills gap, and the digital divide in Canadian society and abroad. It provides insights on the definitions of digital knowledge, skills and competencies; benchmarks to assess digital skills; taxonomies of stakeholders; and models and strategies to promote digital training in Canada. It summarizes key themes extracted from the literature review and is divided into the following sections.

Digital Jobs and Digital Skills discusses the location of information and communications technology (ICT) work in the sector and high-value and intensive verticals like the financial sector that heavily use ICT and employ ICT professionals. Major trends are discussed to show growth areas for employment of ICT professionals. Last, the section provides a categorization of ICT key stakeholders based on the literature reviewed.

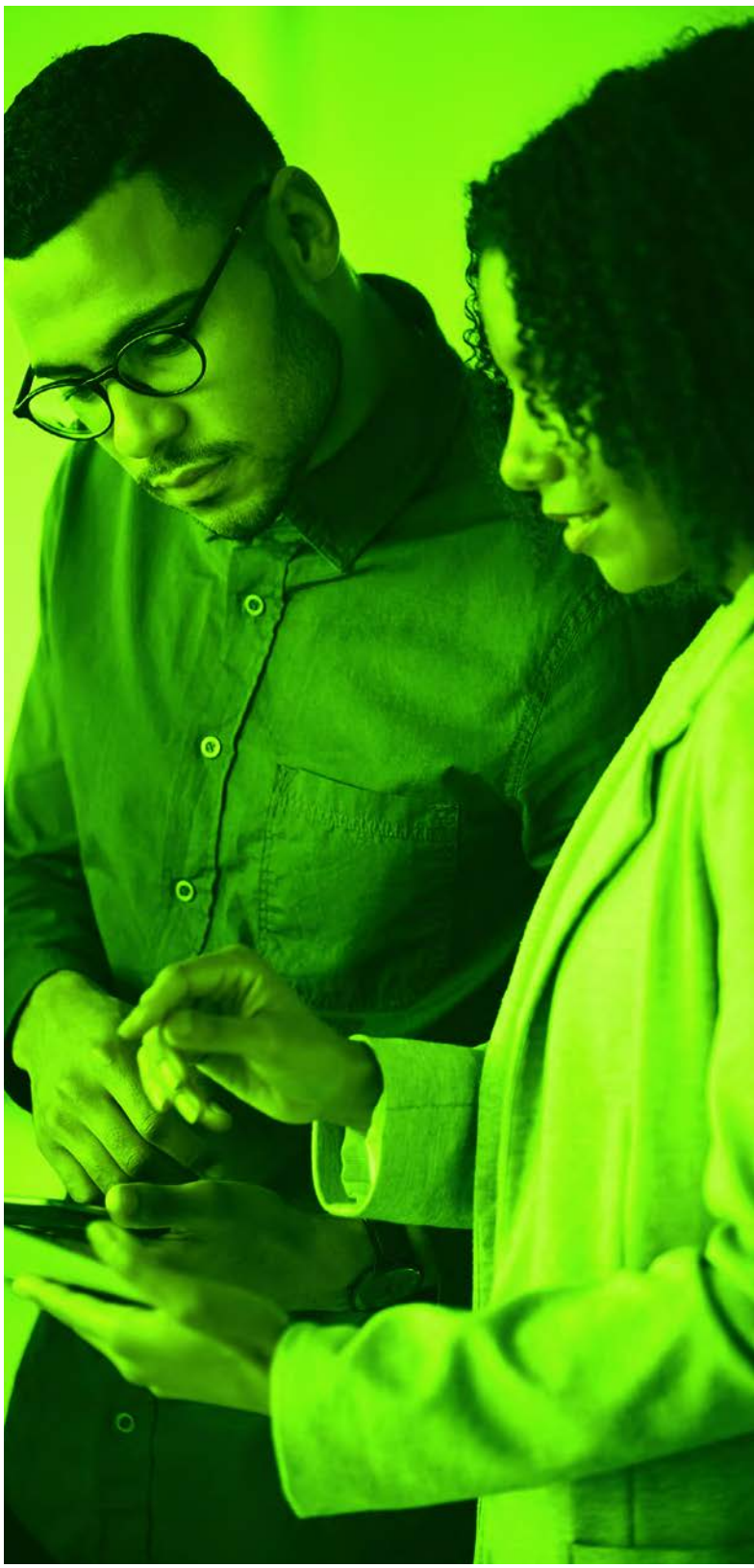
Defining Digital and ICT Jobs, Skills and Pathways reviews current attempts to catalogue and define digital skills, including attempts by diverse international players to create frameworks and maps of digital skills levels and types to articulate learning outcomes for training in digital skills and ICT. Additionally, it examines the definition of the skills gap. This section also considers evidence of employer difficulties in filling vacancies, particularly in terms of how a shortage of available candidates is identified.

Pathways for the ICT sector provides a snapshot of ICT and science, technology, engineering and math (STEM) graduates in Canada, showing that the number of graduates is far below the number of people working in tech professions. The section discusses changing recruitment measures by industry as well as remuneration, including how geography plays a role in talent demand and earnings. Last, the section identifies the key stakeholder categories in terms of training for ICT and discusses how innovation in training is changing traditional education models.

Tracing Diversity in the ICT Sector discusses the low participation of women, persons with disabilities, and other equity-deserving groups in the ICT profession. This section reviews labour statistics on, experiences of, and barriers facing under-represented groups in ICT, as well as measures to encourage participation of these groups in ICT. This section focuses on women in tech and the factors that dissuade women from entering and staying in STEM.

Advancing Innovation and Inclusion To Bridge the Digital Skills Gap concludes the report with recommendations and examples of innovative programs to bridge the digital skills gap.

The ICT sector and the training, recruitment and work of ICT professionals as well as exclusionary practices in ICT, particularly of women and other equity-deserving groups, is examined throughout.



Introduction

For more than 20 years, industry has been decrying the skills gap and the need for digital skills.[1] The problem of the so-called "digital skills gap" is a global phenomenon; however, there is little doubt that the COVID-19 pandemic has accelerated the digital transformation of many industries as products and services shifted online and working from home became more common. KPMG claims that 80% of businesses say they need more workers with digital skills, yet two-thirds are having trouble finding and hiring the right talent. Of Canadian CEOs, 79% say that the pandemic has changed how they work and that more employees with IT skills are required.[2] The most recent assessments of the information and communications technology (ICT) workforce suggest there are now more digital jobs outside the ICT sector—which is comprised of companies that make and sell hardware, software, services and networks—than within it. Retail, manufacturing, financial institutions, governments, non-profits, agriculture and resources are all intensifying their use of digital technologies.

Despite the claims of skills shortages, there is evidence that many segments of the population remain under-employed in the sector. The under-representation of women has persisted for decades, however, there is also evidence of a leaky pipeline; the women who work in ICT jobs are leaving. Internationally educated professionals—who are often racialized—as well as Indigenous Peoples and some racialized people, including those who are Black, are particularly under-represented. The digital divide is not just a function of geography or access to infrastructure, but is also about the skills needed to access and use the technology.

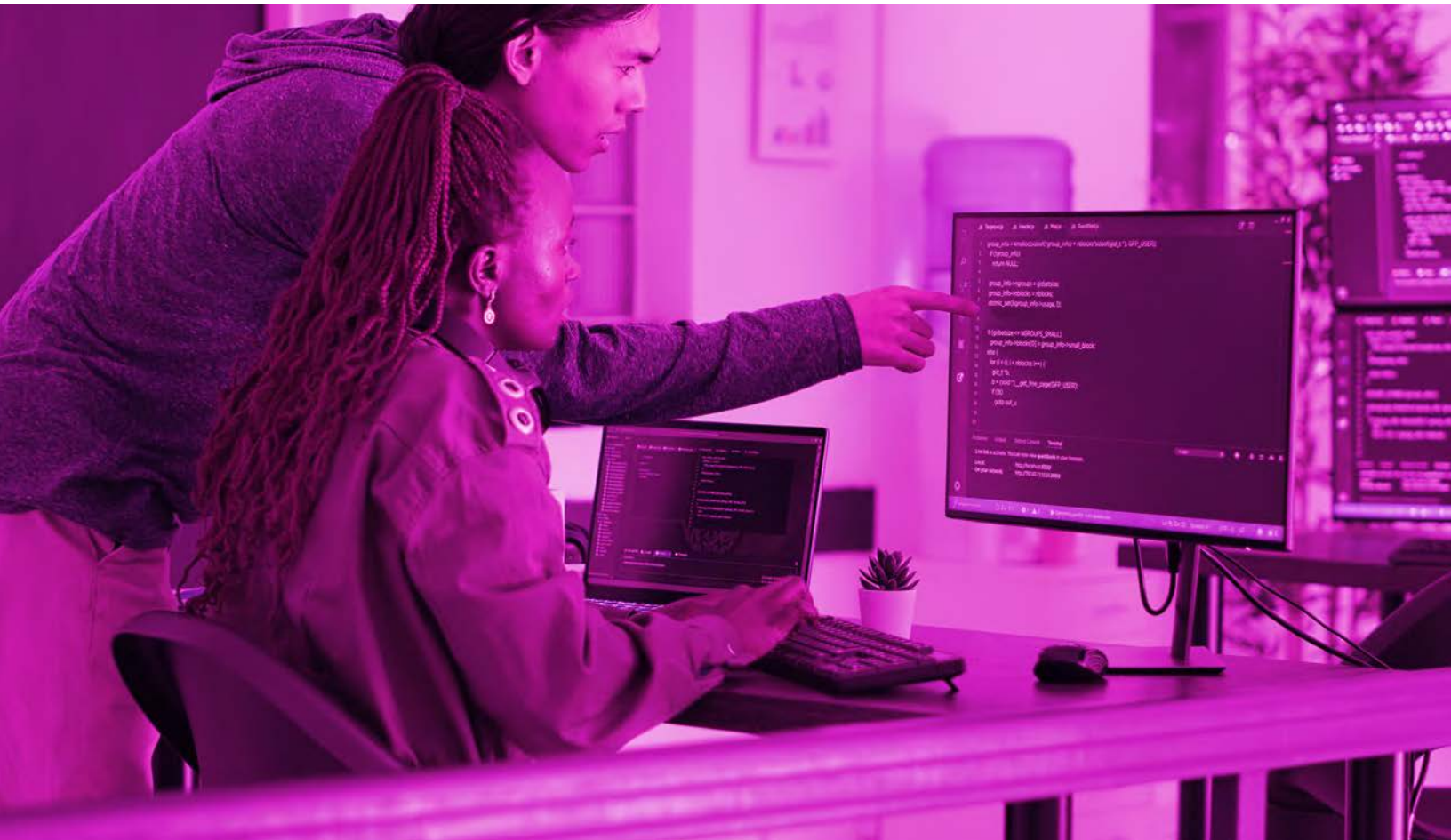
Digital skills are often seen as synonymous with computer science and engineering, with a focus on coding and the skills to develop technology;[3,4]; however, digital skills extend far beyond the development and provision of hardware, software and associated services. Some of the most significant gaps are for people who understand how to match the technology to organizational needs and support its adoption.[5]

While many employers are advocating for increasing the pipeline and encouraging younger students to embrace technology skills in order to increase the proportion of post-secondary graduates with relevant credentials, other employers have begun to question the value of traditional post-secondary credentials, arguing for stronger and more current competency frameworks

and alternative, more responsive pathways instead.[6] Typically, post-secondary institutions are slow to adapt.[7] While immigrants and racialized people are over-represented in the sector, there is evidence that they face barriers in gaining access to the workplace and are often under-utilized.[8]

Canada scored high on levels of skilled youth and the use of digital skills in people's daily lives in the Organization for Economic Co-operation and Development (OECD)'s[9] 2019 Digital Readiness review; however, the country continues to rank in the middle as an average performer with respect to leveraging innovation to stimulate skills use. Our overall innovation and productivity scores remain far behind, suggesting that we risk losing more ground if we do not address the need for digital skills in innovative ways.

So, what are the barriers to planning and training for the digital economy? How do we ensure that Canada is taking the right, evidence-based steps to building a digitally enabled society and a strong ICT talent pool for tomorrow that is inclusive of all the nation's talent? This report captures important insights in the digital skills debate and aims to contribute to it by reviewing definitions of ICT skills, digital skills and the skills gap, as well as evaluating evidence of worker shortages and tracing the participation and advancement of diverse groups in the ICT sector.



Digital Jobs and Digital Skills

Overview

The demand for ICT jobs is growing as a result of the acceleration of digitization and remote work. While we know the demand for talent is growing, the boundaries and definitions are unclear.

Demand for digital jobs

Information and communications technology is Canada's fastest growing sector, with $230 billion in revenue and a growth of $20.2 billion between 2014 and 2020. It includes 44,000 companies and a workforce of 671,000, over one-half of which have university degrees and an annual average salary of $83,300.[10] Despite the impacts of the COVID-19 pandemic, the sector posted strong growth in 2020 and outperformed the overall Canadian economy. ISED reports that between 2015 and 2020, employment growth in the ICT sector outpaced the overall economy, noting that in 2020 the ICT sector accounted for 3.7% of Canada's total employment.[11]

The ICT sector is driven by software and computer services. Of just under 44,000 companies that make up the sector, 91% (more than 40,000) are within the software and computer services industries, followed by 4% ICT wholesaling, 3% communication services and 2% ICT manufacturing.[12] The sector mostly consists of small companies: 37,600 employ fewer than 10 people and about 119 firms (including subsidiaries of foreign multinational corporations) employ more than 500 individuals.[13] According to IBISWorld, there is also sector growth in IT consulting services (4.5% annual growth from 2016 to 2021), which are becoming more prevalent as more businesses take advantage of cloud-computing technology and develop systems and processes to handle big data.[14]

However, there is evidence that the impact and growth of the digital workforce on the economy is even larger; focusing only on the ICT sector captures a small portion of the tech workforce. It is estimated that the sector itself (ICT companies) accounts for 3.7% of national jobs.[15] Thus, looking for ICT jobs only in the ICT sector omits many groups of ICT professionals. For instance, 8% of ICT professionals work in the public sector, and given that more than 20% of jobs in Canada are in the public sector,[16] it is surprising that the public sector is not a focal point in the discussion of the ICT skills gap.[17] Another 11% of ICT professionals work in information and cultural industries.[18] In health care, ICT and digital technologies support medical education,[19,20] health care management

processes[21] and patient care, particularly with the rise of telemedicine following the onset of the COVID-19 pandemic.[22] Travel and tourism companies around the world have almost entirely moved to digital platforms in the interest of strategic development and enhancing their ability to offer personalized services.[23] These observations point not only to the spread of ICT jobs across sectors, high demand for ICT skills and diversity of the ICT professions involved, in terms of changing roles and profiles of ICT professionals, but also the rationale for bold statements by industry like General Assembly's CEO Jake Schwartz, who has claimed: "All companies are becoming tech companies."[24,25] The COVID-19 pandemic has also accelerated the adoption of digital technologies across all sectors as many employees shifted to remote work and businesses needed to innovate to stay afloat.[26]

The Information and Communications Technology Council (ICTC) estimates that there are more ICT jobs outside the ICT sector than within it. In 2020, 1,935,100 people worked in the Canadian digital economy. They included 1,553,800 ICT professionals employed across all industries in Canada, with the remainder being non-ICT professionals working in the ICT sector".[27]

Digital occupations are also not only limited to the ICT sector. In fact, the employment of digital occupations across all sectors of the economy has been outpacing the employment of digital occupations within the digital industries. It is also noted that, as of 2020, 63% of ICT workers worked in non-ICT sectors of the economy.[28]

Information and communications technology trends in Canada

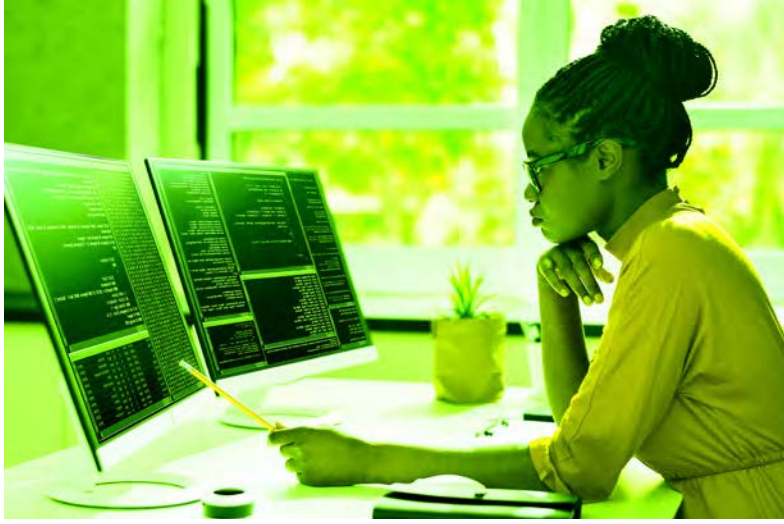
While the economic shutdown owing to the COVID-19 pandemic has had a negative impact on employment and revenue across several industries,[29] the ICT sector has largely been spared as business rapidly transitioned to digitization as working from home became more popular and many service offerings moved online.[30] Looking at the latest GDP data from Statistics Canada, in 2012 constant dollars, the ICT sector grew from $98.1 billion in 2019 to $99.9 billion in 2020, and continues to grow; the GDP from this sector rose again to $104.5 billion in 2021.[31] This follows a longer trend of ICT sector GDP growth, as shown in Table 1.

TABLE 1

Information and communications technology (ICT) sector gross domestic product (GDP)

Year	2016	2017	2018	2019	2020	2021
ICT sector GDP in billions (2012 constant dollars)	81.8	85.8	91.3	98.1	99.9	104.5

Source: ISED Canada[32]



The number of Canadians employed in the professional, scientific and technical services industry dipped slightly in 2020, but increased beyond 2019 numbers in 2021, as shown in Table 2.

TABLE 2

Canadians employed in professional, scientific and technical services

Professional, scientific and technical services	2015	2016	2017	2018	2019	2020	2021
Employment (x 1,000)	1,361	1,372	1,429.7	1,450.6	1,537.3	1,528.4	1,673.9

Source: Statistics Canada (2022)[33]

Online job posting data, which is one indicator of job demand, shows a slightly positive trend; the number of job postings in the professional, scientific and technical services industries increased in Q3 of 2022 compared to Q3 of 2021 and the industry showed some signs of recovery in 2022 compared to 2021, as seen in Table 3.

TABLE 3

Job postings in professional, scientific and technical services

Professional, scientific, and technical services	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022
Number of job postings	61,415	65,455	69,565	74,505	63,680

Source: Statistics Canada (2022)[34]

A report published by the ICTC found that in 2020, the highest number of ICT jobs created was for information systems analysts and consultants (47,800) accounting for over one-third of the net growth in ICT employment.[35] Other roles that saw significant growth include electrical and electronics engineering technologists and technicians, which grew by 66% and information systems testing technicians, which grew by 54%.[36] The employment of ICT professionals outside the ICT sector also grew by about 4%, which translates to 37,500 jobs. However, the same report also found that the COVID-19 pandemic has created volatility in the composition of ICT employment. While the overall ICT sector did not experience a decline in size in 2020, there was a decline in the number of workers for certain ICT occupations in 2020 versus 2019. Some of the

steepest declines were observed for electrical power line and cable workers, which saw a 25% decrease, and for telecommunications line and cable workers, which fell by 15%.

As many of the changes that were brought on by the pandemic, such as the shift to remote work, are becoming permanent, the ICT sector is expected to continue to grow.[37] The viability of remote work has also increased competition for talent with U.S. tech firms, which has already caused "brain drain" from tech programs in major universities in Ontario.[38] This will require private and public organizations, governments, education, training service providers and other stakeholders to collaborate to ensure that Canadians possess the necessary digital skills to keep up with this demand. Additionally, the Government of Canada has accelerated its investment into supporting high-speed Internet access for all Canadians, especially those in rural and remote communities, by 2030.[39]

The viability of remote work has also ***increased competition for talent*** *with U.S. tech firms, which has already* ***caused "brain drain" from tech programs*** *in major universities in Ontario.*

There are reports of sectors most in need and most dependent on ICT. According to a 2021 IBISWorld report,[40] there are several high-value and IT-intensive verticals with an intensive concentration of IT, ICT and tech work and services:

> Financial and capital markets

> Utilities, communication and media

> Manufacturing, retail and distribution.

The report notes that each of these sectors is increasingly dependent on ICT solutions and workers. In addition to these, ICTC has also highlighted several other high-growth sectors driven by digital and technical transformations, including health care and biotech, cleantech, advanced manufacturing, agri-food and food tech, interactive digital media and clean resources. It is worth noting that these sectors were already growing faster than other non-digital sectors prior to the pandemic, and the pandemic is likely to have accelerated digitization and boosted innovation in these areas.[41]

Looking at longer-term trends, ICTC predicts that tech workers increasingly will be found outside the tech sector rather than within it.[42] Looking at employment in the digital economy, while the general economy dipped in 2020 and only partially recovered in the same year, it managed to surpass its pre-pandemic levels. The above-average employment growth of the digital economy is expected to continue growing at an annual rate of 2.22% for 2021 to 2025 compared to 1.97% in the general economy. ICTC also forecasts that by the end of 2025, employment in the digital economy will reach

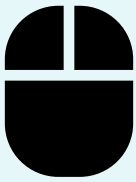
2.26 million, translating to about 11% of all employment in Canada, with a demand for 250,000 additional jobs.[43]

There is also growing recognition that "digital is business and business is digital," and that "as the Canadian economy continues to expand, many traditional industries will see growing need for digital talent."[44, 45] Changes in these sectors are highly visible, for instance, in health and biotech where the government has invested $275 million to develop vaccines and treatments for COVID-19.[46] Other Canadian sectors like cleantech are becoming a top area of investment as gas prices soar and Canada looks to become net-zero emissions by 2050.[47] Thus, it cannot be understated that the distribution of the digital and tech workforce is multi-sectoral and affects most, if not all, sectors today.

Impact of the COVID-19 pandemic

The full ramifications of the COVID-19 pandemic on the labour market are yet to be understood. Public health measures were taken by the Government of Canada to mitigate the effects of the pandemic on the Canadian population, and entire sectors of the Canadian economy were shut down. While the shift to digitization created jobs in tech, the number of tech job postings fell 32% in December 2022 compared to May 2022.[48] The pandemic worsened physical and mental health outcomes for Canadian workers[49] and had an impact on the educational outcomes of youth and, by extension, the future Canadian labour market.[50]

For example, in the ICT sector, youth unemployment jumped from 2.3% in 2019 Q4 to 16.9% in 2020 Q2 and has remained close to 10% for roughly a year, recovering to 3.7% in 2021 Q2.[51] As job posting data demonstrates, labour market demand has been greatly affected by the pandemic and public health measures in unpredictable ways.[52, 53, 54] Small and medium-sized enterprises (SMEs), which make up 99.8% of business employers in Canada (as of December 2019) and employ 90% of the private sector labour force,[55] were particularly hard hit,[56] leading many to go out of business.



*the COVID-19 pandemic has **accelerated the digital transformation** by forcing populations to **adopt digital technologies to facilitate daily life**, from children's educational activities to remote work.*

Accompanying the COVID-19 pandemic were labour market trends that cannot be adequately described by the numbers. For example, the so-called Great Resignation described the record-breaking number of resignations by workers, leading to unmet labour market demand.[57] The reasons for these unpredictable labour market trends are being debated and discussed by journalists in the public and scholars from various fields.[58] In response to the COVID-19 pandemic and the resulting uncertainty in the labour market, some are calling for alternative approaches like strategic foresight to provide a different context to the trends.[59]

The Government of Canada responded to the COVID-19 pandemic with public policy measures, one of which promoted a shift to digitization. For example, Budget 2021 includes a $4 billion Canada Digital Adoption Program (CDAP) to "help get your business online, give your e-commerce presence a boost or help digitalize your business's operations."[60] This corresponds with a general global trend worldwide; the COVID-19 pandemic has accelerated the digital transformation by forcing populations to adopt digital technologies to facilitate daily life, from children's educational activities to remote work.[61] Additionally, as the OECD notes in the *Digital Transformation in the Age of COVID-19* report, "It is unlikely that economies and societies will return to 'pre-COVID' patterns; the crisis has vividly demonstrated the potential of digital technologies and some changes may now be too deep to reverse."[62] As the digital transformation is permanent, requiring new digital skills and digital literacy skills from both citizens and workers, how might this affect the digital skills gap? The impact of the COVID-19 pandemic on the labour market promises to reverberate for years and even decades.

Defining Digital and Information and Communications Technology Jobs, Skills and Pathways

Overview

The pervasiveness of ICT across sectors, with diverse ways that ICT professionals are enabling business operations, makes it problematic to define the ICT profession.[63] In Canada and internationally, there is no consensus on who an ICT professional is, but there are attempts to define the knowledge, competencies and skills that pertain to ICT professionals to standardize the field. Compounding the challenges of defining ICT roles, there is also often confusion between occupations (the job), the basic skills and competencies needed to perform the job (e.g., computer programming, which typically takes years to develop), and the specific tools and techniques needed for the job (e.g., JavaScript or Python, which can be taught easily when someone has the foundational skills).[64] The National Occupation Classification (NOC) codes are the most-relied-upon coding system in Canada to understand employment trends, but they do not keep pace with rapidly changing sectors like ICT where new jobs emerge more quickly than the codes are updated. There is additional confusion associated with the definition of digital skills, which can range from deep technical skills and coding to basic digital literacy. We begin with a definition of ICT jobs and then end with a discussion of the various approaches to defining digital skills beginning with a national example (the Skills for Success framework) and ending with some international examples.

Defining information and communications technology jobs: National Occupation Classification codes

The National Occupation Classification (NOC) system is widely used to gauge the ICT sector profile. The NOC codes, a taxonomy of all the occupations in the Canadian labour market, are used for categorizing and standardizing occupations, and diverse analyses, including statistics and forecasts, to inform immigration policy. For many years, the ICTC, which emerged from the national Human Resources Sectoral Councils, has been tracking labour market trends and for the most part, relying on Canada's NOC codes. The ICTC's labour market research reported in their *Digital Economy Annual Review 2020* identifies 30 core ICT occupations by NOC code, which include diverse codes like 211 (engineering

managers and telecommunications carriers managers) and 2147 (computer engineers).[65] The list demonstrates that the types of jobs in the ICT sector and digital roles vary considerably in terms of key competencies, skills and tools.

There are challenges with NOC codes and their applicability in rapidly evolving fields. Many of the jobs in the ICT sector emerge within months, not years, and there is no uniform taxonomy. For example, the ICTC conducted a national survey and asked participants about new job titles that emerged within their companies, and found titles like embedded systems expert and demand generation specialist.[66] Many of these job titles do not correspond with existing occupational code categories or do not exist in the NOC at all, such as UX/UI designer, full stack developer or backend developer. Further, while software developer falls in the NOC 21232 software developers and programmers category,[67] full stack developer and backend developer do not represent alternate job titles in this category.

The NOC 21232 category also includes titles like multimedia developer and interactive media developer, but excludes NOC 52120 graphic designers and illustrators and 21233 web designers. NOC 21232 employment requirements specify that "a bachelor's degree in computer science or software engineering or in another discipline with a significant programming component or completion of a college program in computer science or related field is usually required;" however, this does not take into account UX/UI designers, an in-demand job title that does not exist in the NOC, but whose workers may not require specialization in deep technology skills to perform similar duties like writing, modifying and testing software code, and researching and evaluating software products.

Job titles that include "design" are particularly prone to miscategorization because they tend to include diverse training as well as hybrid skills and job roles.[68] This ICTC analysis of job postings demonstrates the limits of the NOC in terms of reflecting labour market demands and bias toward science, technology, engineering and math (STEM) in digital occupations. Government attempts at macro classifications and frameworks tend to be out of date quickly, particularly in fields that face constant innovation.[69] This is particularly true of the NOC; Canadian stakeholders frequently point out the limits imposed by the NOC and question the reliability of available data.[70, 71]

Defining digital skills

One of the challenges in creating effective policy and practice around digital skills is due to the lack of precision in how digital skills are defined. Digital skills are often seen as synonymous with engineering and computer science[72] and associated with "deep" technology skills; however, the opportunities are wide-ranging and do not all require in-depth technical skills. For example, an OECD survey cited data indicating that digital skills were in short supply in Ontario; however, after a deeper dive into online job postings in Ontario, they found that most of those jobs required basic skills associated with digital literacy, such as the use of Microsoft Office, and basic applications were cited by 75% of job postings (see Table 4).[73]

TABLE 4

Top digital skills in Ontario job postings

Skill	Number of job postings
Microsoft Excel	382,851
Microsoft Office	306,588
Microsoft PowerPoint	149,155
Microsoft Word	145,048
SQL	100,167
Software development	76,120
Spreadsheets	73,447
Java	68,847
Technical support	64,084
SAP	62,525

Source: OECD (2019)[74]

Basic digital skills and digital literacy have increased in importance across all sectors during the COVID-19 pandemic as work shifted to remote.[75] Before the pandemic, Canadian Internet users lacked the most basic skills required for teleworking, demonstrating the importance of focusing on basic digital skills.[76] For example, according to Statistics Canada's study of Canadian Internet users aged 15 years or older, only 35% of those surveyed reported that they have "shared files using an online data storage space."[77]

Further, there are reports of shortages of "hybrid" individuals with deep skills in sales, marketing, project management and more, but with enough knowledge of technology to bridge the gap between end users and developers. These hybrid roles are often miscategorized or uncategorized in the NOC framework.[78] This can be problematic, as these hybrid roles are growing fast. ICTC's most recent overview of the ICT sector highlights that, while demand for technical skills remains high, employers are increasingly looking for employees with a blend of business or soft skills such as communication and interpersonal skills, ability to work in teams and strong business acumen.[79]

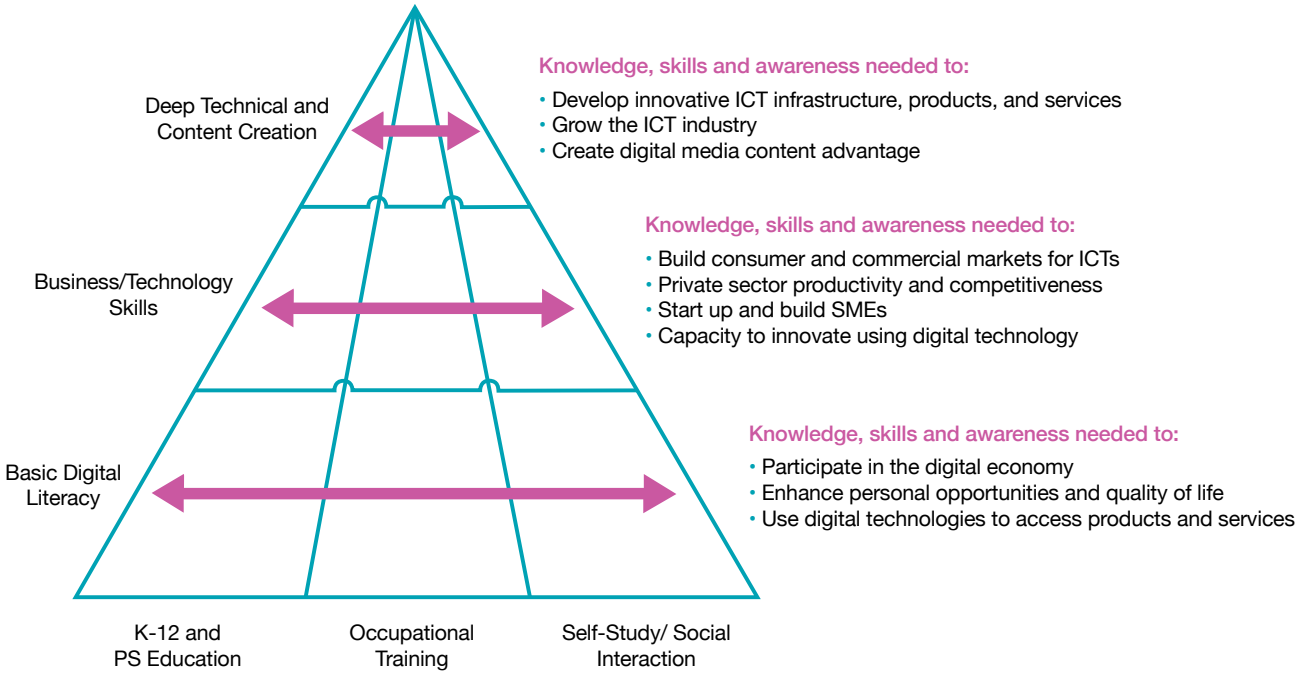
Beyond evident definitional issues in the counts (ICT worker, digital worker, high-tech worker), these figures point to the widening of job categories and functions in ICT, and the recognition that alignment of ICT with solely STEM is inaccurate, as pathways, qualification and success in ICT work includes business, soft and creative skills. One way to think of digital skills is to distinguish among three levels—deep technical knowledge, business and technology skills, and basic digital literacy—and their applications (See Figure 1).[80]

While deep technical skills are often prioritized in the ICT sector, the rapid pace of change in new technologies often causes many digital skills to become outdated relatively quickly. Digital and ICT-related skills are particularly vulnerable to rapid obsolescence as they are estimated to become obsolete after two years.[81] To remain competitive, workers need additional skills, such as flexibility and a positive attitude toward lifelong learning and curiosity to ensure that they continually acquire new

skills. A 2022 report by the Brookfield Institute echoes these sentiments, as even the highest demand digital skills are constantly changing over the years, and workers are at risk if they hyperspecialize on a particular digital skill. Instead, workers are encouraged to build malleability, critical thinking and general knowledge across skills to ensure they can adapt to new technologies.[82]

FIGURE 1

Information and communications technology skill type



Source: Cukier, Smarz & Grant (2011)[83]

Many studies have also shown that while STEM and high-tech skills are critical for many in-demand digital occupations, skills like reasoning or judgment are most associated with fast-growth roles. Thus, the ICTC notes that "according to this analysis, while learning to code may be important, the capacity to communicate and present results in an effective way is equally or more important in the long-term," and has shown that occupations requiring technical skills in addition to the broad skills identified tend to be higher paying.[84]

On the whole, while many see computer science and engineering as the principal pathway to the ICT sector and digital skills roles, there is growing evidence that there are multiple pathways.[85] For example, most of the women who lead the largest ICT companies in the U.S. do not have a computer science or technology degree.[86, 87, 88] Increasingly, the industry is recognizing the importance of multiple disciplines as pathways and the need for soft skills that can be delivered by diverse liberal arts education.[89, 90] The Royal Bank

of Canada (RBC) released a report based on employer feedback, which emphasized "Critical thinking, reading comprehension and communication skills are needed more than ever," adding that, "heading into the 2020s, we need more curiosity and creativity," and that from their consultations with employers it is "candidates with strengths in language and problem solving get hired."[91] The ICTC's survey on digital skills and core competencies crucial for student success after graduation shows that experts frequently identified critical thinking, communication and adaptability as indicators for success.[92]

These types of observations by stakeholders echo historical lessons around technological transformations: the adoption of technologies has typically been impeded not by the lack of products and services, but by the lack of attention to regulatory issues, consumer behaviour, organizational change, legal issues, content and other factors related to non-STEM disciplines. More and more research stresses the importance of non-technical skills in the technology sector.[93, 94, 95, 96, 97]

Global attempts to define digital skills

Definitions of general digital and specific ICT skills are challenging governments around the world as well as employers, job seekers and services providers, as the lack of common nomenclature exacerbates the skills gap. Diverse stakeholders have been identifying taxonomies for digital skills and skill levels, including digital skills maps, toolkits and frameworks to serve a range of audiences like educators, students, policy makers and employers. Looking at a sample of the most relevant general digital skills frameworks reviewed for this report (see Table 6 and Appendix A) shows that there is very little common understanding of the actual skills or knowledge that contribute to the skills gap; no common understanding of the dimensions of learning and training needed to close the skills gap; muddled terminology in terms of the distinction between areas of knowledge, competencies, skills and tools needed for 21st-century learning or work; and very little identification of levels, in terms of the age and capacity of the learner, and the level of proficiency of the worker.

Most frameworks reviewed are structured as learning and pedagogical tools with general learner and audience scope, aiming to improve digital literacy widely (e.g., the EU's DigComp 2.0 map and ITU's Digital Skills Toolkit), while a few of the frameworks, or maps, focus on addressing the digital skills gap to support workers in the digital era (e.g., Brookfield Skills Map and the BTM Learning Outcomes map). Most maps do not identify skill or learner levels, with the exception of Cukier et al.[98] Digital Skills and Business School Curriculum (Figure 1), and ITU's Digital Skills Toolkit; all of these maps identify three skills levels: basic, intermediate or business, and advanced. In terms of core areas of knowledge, general knowledge and specific ICT knowledge identified, there are no similarities between the maps other than an emphasis on social-emotional skills, particularly management and communication skills. It is evident that there is a lack of common and systematic understanding of the general digital knowledge, competencies

ICT generic skills *are those skills needed by workers across a* ***range of occupations*** *to be able to* ***use technologies in their daily duties****.*

and skills needed for digital literacy among the general populace, learning outcomes for students K-12 and higher educational institutions, as well as people already in the labour force needing to upskill.

Definitions of ICT professionals' knowledge, competencies and skills also vary, but on the whole give more recognition to the level of skills.[99] Overall, there is little agreement on how to define knowledge, skills and tools relating to digital skills generally and ICT specifically, and little understanding of how to distinguish between levels of expertise or how to measure those levels. These limitations point to a need for a unified digital skills framework with standardized nomenclature and skill levels so governments, educators, training service providers, corporations and other stakeholders are better able to collaborate and communicate with one another to identify where the digital skill gaps are, and what needs to be done to close the gap.

The OECD has developed a tiered taxonomy of digital skills focusing on ICT skills (in order of lowest to highest skills): ICT generic skills are those skills needed by workers across a range of occupations to be able to use technologies in their daily duties; specialist or advanced skills are those that are needed by workers to produce ICT products and services like software, web pages and cloud storage solutions. Complementary skills are related to the use and performance of professional tasks associated with the use of ICT products and services, like the capability to communicate on social networks and brand products on e-commerce platforms.[100] The OECD notes that there are skills gaps for ICT generic skills and ICT specialist skills, as 11% of European Union workers require additional training to be able to address the ICT-related demands of the job.[101] Another report by the European Union shows that for the 16 to 74 age group, only 54% possessed at least basic digital skills, as evaluated based on the European Commission's Digital Competence Framework 2.0.[102] Another report shows that across its member states 40% of employees lack ICT generic skills,[103] for example, competency with office software like Microsoft Word. A similar gap is not present in ICT specialist or advanced skills. While demand for ICT specialist skills is growing, there is not a substantial shortage of these skills.[104] "The skills shortage is not necessarily in adopting or engaging ICT technologies, but rather in conducting traditional business processes, interactions, and intermediations across digital mediums."[105]

The digital skills gap

The ICTC warns that by 2025 there will be growing demand for over 250,000 additional jobs in the digital economy that will need to be filled, totaling 2.26 million digitally skilled workers by 2025.[106] It projects that the "growth and prosperity of the Canadian economy" is contingent upon appropriately filling these positions.[107] Additionally, as digital skills tend to become obsolete after about two years, it is imperative that ICT workers also possess non-digital skills, such as innate curiosity and adaptability, that help them continually acquire new skills[108] to avoid further widening of the digital skills gap.

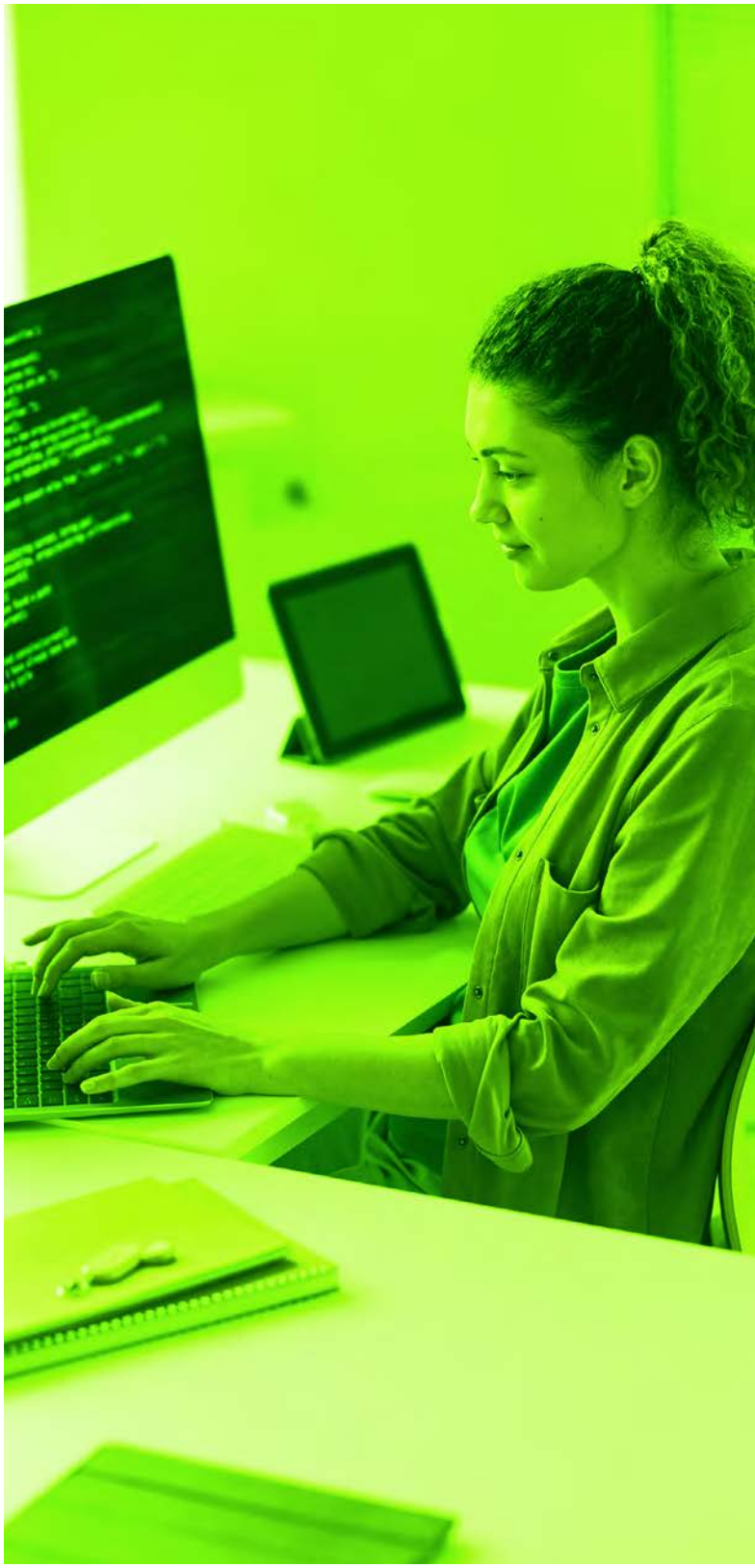
However, not all commentators and stakeholders agree that the issue is one of an insufficient number of workers. Some suggest that the solution to perennial skills shortages in any market is increasing the compensation[109] and argue if there were a real shortage we would see other signs, like increased real wages, hours worked per employee or overtime hours, and decreased average tenure and average worker age as firms bring in new or younger workers. These have been observed during other historical worker shortages like the tech boom from the mid-1990s to early 2000, but were not observed during the authors' 1987 to 2016 longitudinal study.[110]

The Council of Canadian Academies found that "at the national level, there is no evidence of a current imbalance in STEM skills."[111] Don Drummond, former chief economist for TD, has stated: "Do we have a huge shortage of workers? No. Are they in the right place at the right time? Probably not."[112] Drummond's commentary suggests that understanding and mitigating the ICT skills gap is contingent upon labour market measurements and information. A historical mismatch exists between the "measurement and interpretation of labour shortages, skills shortages, and skills mismatches"[113] and the difficulties defining "skills" itself. Other stakeholders agree that there is not enough evidence of a "dire skills shortage," particularly given the fact that equity-deserving groups continue to face barriers to access in the labour market.[114, 115] Skilled immigrants are a particularly powerful example and continue to be under-represented in the Canadian labour market.[116, 117] Thus, the debate includes a spectrum of perspectives around the issue, from framing it as a dire skills gap, to a mismatch in skills measurement, to consideration of skill set mismatches in the labour market.[118, 119, 120, 121, 122]

At the same time, industry leaders report difficulty filling job vacancies.[123] According to the Business Development Bank of Canada's *Tech Industry Outlook*, there is great demand for the products and services offered by the tech sector, but there is a scarcity of skilled workers and 55% of "tech entrepreneurs are struggling to hire the employees they need."[124] Not only is hiring difficult, but 29% of tech entrepreneurs are having difficulty with retention in a competitive sector. Other studies concur. According to the Bank of Canada's Business Outlook Survey for the second quarter of 2022, the percentage of companies reporting labour shortages has climbed, with businesses reporting their most severe labour shortages in nearly

15 years.[125] The Canadian Federation of Independent Business (CFIB)'s research report shows that 55% of its members experienced labour shortages.[126] An analysis of online job postings for 2021 also shows that 2.81 million jobs were posted, marking a 38% increase from 2020 (2.04 million job postings) and a 2% increase from 2019 (2.76 million job postings). It is notable that for the skills with the "largest increase in number of mentions in job postings" between 2020 to 2021, technical skills in C# and C++ rose the most, with a 406% and 330% increase respectively.[127] The implications are many, including the existence of a skills gap in which the training and field knowledge for new and niche positions lags behind that in industry, as well as issues with recruitment and employer expectations.

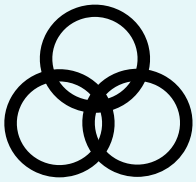
Employers often cite not enough applicants, lack of qualifications (in education level or credentials), lack of technical skills, as well as lack of motivation, attitude or interpersonal abilities as top reasons for difficulty filling positions.[128] On the candidate side, top frustrations with the application process include extremely long application periods and employers that are looking for a candidate that does not exist (often merging multiple job titles or functions).[129] This is supported by evidence that shows employers' unwillingness to consider candidates who require minimal on-the-job training, often asking for several years of experience for entry-level positions, even if the skills sought could be taught in a few weeks on the job.[130] This is supported by the fact that Canadian employers offer fewer training opportunities in contrast to other OECD nations.[131]



Pathways for the Information and Communications Technology Sector

Overview

There needs to be enough Canadians in the pipeline who are training to become ICT professionals to ensure that the digital skills gap will be filled. This requires the collaboration of formal education institutions, government of all levels, training providers of digital skills and businesses to recruit and train members of the Canadian workforce to develop the skills needed to succeed in the ICT sector. The first part of this chapter reviews the state of ICT training in traditional and non-traditional pathways. The second part summarizes the challenges of certification and credentialing in the ICT sector.



*This requires the **collaboration** of formal education institutions, government of all levels, training providers of digital skills and businesses **to recruit and train members of the Canadian workforce to develop the skills needed to succeed in the ICT sector**.*

Training of information and communications technology professionals

Some research shows that in Canada enrolment in ICT is lower than in other fields like business or law.[132] However, new figures are appearing that suggest there is growth in enrolment across trades, computer and information systems, and other ICT fields such as data administration.[133] In terms of post-secondary enrollments into STEM subjects, there is a more robust growth over time (see Table 5).

TABLE 5

Post-secondary enrolment into science, technology, engineering and math (STEM) fields

Year	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020	2020-2021
Science and science technology enrolment	201,939	205,893	208,611	213,165	217,884	221,418	223,401	228,222	234,210
Engineering and engineering technology enrolment	151,560	160,797	169,092	174,174	178,797	184,524	188,127	191,994	188,190
Mathematics, and computer and information sciences enrolment	65,928	69,156	75,405	81,495	91,296	102,498	113,223	125,697	135,474
STEM enrolment (total)	419,430	435,846	453,108	468,837	487,971	508,437	524,748	545,913	557,874

Source: Statistics Canada, Postsecondary Student Information System, Table 37-10-0163-01[134]

With demand for digital skills high, and industry reports of a lack of qualified candidates, there has been an expansion of technology training programs. Pressure is being placed on government and educational institutions to provide new programs for training and upskilling to increase the supply of ICT-ready employees, with most policies focusing on providing students with greater opportunities to learn ICT skills or offering financial incentives to attract students to the field.[135]

Post-secondary institutions have developed programming to respond to industry needs; examples include the Queens University's MBA in Artificial Intelligence[136] and George Brown College's Bachelor of Digital Experience Design. The changes are not limited to higher educational institutions; in public elementary schools there is growing emphasis on coding with many provinces making it a mandatory part of the curriculum.[137] The demand and interest from parents is also evident with growth in private extracurricular training for K–12 (e.g., Sylvan Learning, Coding for Kids, Tech School).

Traditional training, particularly in higher education, typically involves long cycles

of change. The process to add or adapt new curricula or programs often takes considerable time. As the ICT industry tends to change rapidly with continued innovation, this means that formal training curricula often lags behind industry standards.[138] This has left an education and training void that has increasingly been filled by diverse players from both the public and private sectors, including innovation centres within post-secondary institutions, public online platforms, private training, government-funded upskilling programs and others. Many of these are innovative short training programs (e.g., Bitmaker, Brainstation, Miami Ad School) that focus on specific tools or techniques. These programs are sometimes credentialed, speaking to the growth in popularity of microcredentials.[139] Some are upskilling programs offered by companies and public sector organizations focused on digital upskilling of existing employees (e.g., Cognizant, AT&T, Government of Canada, Amazon Web Services).[140]

Work-integrated learning (WIL) has also become a critical piece in the effort to upskill and reskill (e.g., nPower, Advanced Digital and Professional Training), and community-based models (e.g., Canada Learning Code) have emerged to increase basic digital literacy and build confidence. There are also new programs focused on developing pathways for internationally educated individuals in ICT trades and professions (e.g., Skills for Change, ICTC) or to provide a bridge for professionals to move from one sector into another (e.g., Humber College, Bridging Programs) or to level the field for equity-deserving groups in tech (e.g., Bridge).

Collaboration and outsourcing are often involved. Many companies and organizations outsource to third-party training companies to train employees in digital skills. For example, Google, RBC, Uber and Deloitte use a company called Brainstation that offers courses in design, data and development. Udacity is another popular platform that has been used by companies like AT&T that is available to train staff in six major technological skill types: data science, machine learning and artificial intelligence, business and marketing, web programming, cutting edge-technology and mobile programming. Galvanize is similar to Udacity in its delivery of training, but instead focuses on training employees in technology skills using cloud computing.

Training and upskilling are big business. The coding bootcamp market is expected to grow to US$1.2 billion from 2021 to 2026,[141] and there are many options like Lighthouse Labs, Red Academy, HackerYou and others offering intensive and short coding training (as little as 10 weeks) focused on hands-on experience and job placement.

With candidates holding diverse training and backgrounds (certificates, nanodegrees and other badges) and access to talent proving a challenge, employers are developing new practices to attract and recruit. Some have developed partnerships focused on attracting non-traditional workers to their organizations. For example, Specialisterne partners with organizations and companies to provide pathways for persons with disabilities. Other stakeholders have developed new event-style approaches to recruitment; for example, Capital One uses hackathons

to attract women. Others have focused on international recruitment to fill gaps or relocated closer to the talent pools they need; international recruitment agencies like Cowan International, Renard International and Outpost Recruitment are often involved. There are also dedicated human resources (HR) firms and professionals within established general HR agencies whose exclusive role is to search for tech talent. Examples of these are many and include big and niche national firms like Randstad, Pinnacle, Digi117, SI Systems Ltd. and Robert Half. Tech-specific networking sites, sites that connect employers directly with freelance or entrepreneurs, and upwork sites are also becoming common (e.g., Developers for Hire, Dice, Stack Overflow).

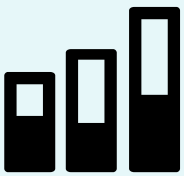
Credentials, assessment and skills measurement

Historically, employers have tended to use credentials or previous experience as an indication of skills and competencies, but the rapid speed of change and lagging higher education curricula has started to put to question whether credentials—and credentials alone—are the best indicator of candidates' job-readiness. A publication in *Canadian Business* claims that leading tech companies are questioning whether a university degree is still the best indicator of a candidate's aptitude; 15 of North America's top technology companies, like Shopify, Telus, Slack, Google, Apple and IBM, are either relaxing or phasing out educational requirements and instead identifying talent in new and novel ways.[142] However, research has also shown the

opposite: post-secondary education, particularly receiving training in STEM fields, increases the likelihood of acquiring employment in an ICT occupation by as much as 15%.[143] Additionally, the ICT sector as a whole has a higher percentage of workers with a university degree.[144] The ICTC reported a similar finding in a 2019 Alberta study, where employers showed a clear preference for traditional post-secondary credentials. Employers favoured local (Albertan) graduates, and for the most part regarded an undergraduate degree as the minimum educational requirement for a new hire.[145] The study notes that only 7% of employers considered no formal educational requirement and 2% considered a nano-degree alone, such as the ones offered by Lighthouse Labs or Udacity. However, the COVID-19 pandemic and the ensuing shocks

on the labour market may have changed general labour market dynamics. A recent survey by Indeed shows that this trend is also affecting the general labour market, as "67% of companies with 1,000 or more employees would consider doing away with the college requirement."[146]

Thus, while employer and recruiter perspectives vary on the importance of traditional credentials depending on job title and skills required, it is fair to say that traditional credentials are being called into question and there is recognition of diverse pathways into tech jobs. For instance, Randstad indicates that, "typically business systems analysts need to hold a bachelor's degree in an IT-related field from an accredited college or university. Some business systems analyst jobs may even require a master's degree."[147] However, in their description of training required for web developers, Randstad indicates: "While you do not need a formal degree to become a web developer, some clients favour applicants who have such qualifications… Some relevant courses to take include web design and development, computer science, digital media development and software engineering."[148] There is a significant difference between someone with a computer science degree and a design degree; yet, each may be suitable for the same job, depending on self-taught skills or other training the candidate received outside of formal education. The same is true of data analytics; while new programs are emerging targeting those with mathematics or technology skills, there is also evidence that for some roles mathematics and technology skills are less important than the ability to "tell a story" with data.[149, 150, 151] This signals multiple pathways to many jobs in the tech world and its various emerging niche fields. Hence, as employers and recruiters are questioning traditional credentials as an indicator of skills, there is immense interest in new approaches to measure knowledge, competencies, skills (as well as tools and technique use), and attitudes and behaviours of trainees and job candidates.



*While there are **increasingly diverse options** for developing essential and digital skills, there are also **uneven levels of quality**.*

While there are increasingly diverse options for developing essential and digital skills, there are also uneven levels of quality. With new training methods and certifications, there is the issue of standards and legitimacy. Employers have noted a growing difficulty in recognizing the legitimacy and perceived quality of various training and education options for employees.[152] A variety of new approaches are being used to assess competencies, like looking at portfolio approaches and e-portfolios, "badging platforms" and microcredentials,[153] hackathons[154] and WIL. This is particularly the case as more job seekers have diverse backgrounds, and more jobs are rapidly

changing shape.[155] New techniques are emerging to test and recognize these credentials, including self-assessments to test attitudes and behaviours, general standardized tests to assess essential skills, and tests to measure skills in specific tools or techniques. (These are often led by the industry leader that makes or distributes the tool, for instance, Pegasystems' Systems Architect Exam.) Table 6 provides examples of assessments that are on the market.

TABLE 6

Digital skills assessment tools

Self-assessment tests			
Test for skills and competencies	**Assessment focus**	**Method**	**Use**
Digital Competence Framework for Citizens (DigComp 2.2)	Knowledge, skills and attitudes	Online test	Provides an overall, complete and shared understanding of digital competence and measures digital skills (i.e., Digital Skills Index)
Northstar Digital Literacy Project Assessments	Digital literacy, skills	Online self-guided assessments	Measures adult digital literacy skills at a basic level; teaches digital literacy by offering online learning modules and assessments in 10 categories: basic computer skills, Internet, Windows OS, Mac OS, email, social media, Microsoft Word, Microsoft Excel, Microsoft PowerPoint and information literacy
Digital Competence Assessment Framework & Tool for Language Teachers	Knowledge, skills	Online questionnaire	Knowledge and skills assessment for language educators
Digital Literacy Global Framework (DLGF)	Information and data literacy, communication and collaboration, digital content creation, safety, problem-solving	Online	Measures the Sustainable Development Goal 4 indicator 4.4.2 (percentage of youth or adults who have achieved at least a minimum level of proficiency in digital literacy skills)
IC3 Digital Literacy	Knowledge, skills	Online	Ensures that students and employees are prepared to succeed in a technology-based world

Standardized tests to measure essential skills			
Test for skills and competencies	**Assessment focus**	**Method**	**Use**
Essential Skills Mobile App	Reading, writing, numeracy, communication, digital, collaboration, problem-solving	Online	Facilitate career recommendations
British Columbia's Digital Literacy Framework	Research and information literacy, critical thinking, problem-solving, decision-making, creativity and innovation, digital citizenship, communication and collaboration, technology operations and concepts	Online	Helps educators integrate technology and digital literacy-related activities into their classroom practice to provide a basis for the development of assessment tools for digital literacy competencies
Quebec Digital Competency Framework	Knowledge, skills	Online	Fosters the development of digital competency throughout the educational community so that Quebecers may be autonomous and exercise critical judgment in their use of digital technologies
Tests to measure specific tools or techniques			
Test for skills and competencies	**Assessment focus**	**Method**	**Use**
Essential Skills Self-Assessment for the Trades	Reading, numeracy, writing, communication, collaboration, problem-solving, digital	Online	Learning about essential skills strengths and areas for improvement in apprenticeship and trades
First Nations, Inuit and Métis Essential Skills Inventory Project	Reading, writing, numeracy, communication, digital	Online	Measuring a project's strengths, identifying areas for improvement and providing evidence of impact to funders
FAST	Digital	Online	Occupation-specific, skills assessment and development platform designed to aid newcomers in overcoming barriers such as the lack of recognition of international credentials and the absence of Canadian work experience

Psychographic testing has long been used to assess personality traits (which may map to certain competencies), particularly for leadership roles, and these tests are being adapted to assess a broader range of skills and competencies. Among the new standardized tests are empirical and self-assessment tests. Most standardized tests, whether self-assessed or prescribed, focus on the same fundamental categories of literacy, numeracy and use of technology. While often applied primarily as a diagnostic tool for adult learners, they may also be used to determine occupational fit or employer training needs. Some are distributed in a paper-based format. A third category of tests are used to determine certification on specific tools or digital platforms, such as Salesforce and Pegasystems. These certification exams are generally managed by the product firm but often administered through a testing centre such as Pearson VUE or through a third-party platform.

The increased appearance of various forms of testing and self-assessment presents new issues: greater stress is placed on the learner to recognize their skills and skill levels objectively; candidates may not have the knowledge to reach for such tests (if not enforced by the employer); and test results may not fairly judge the skills of candidates.[156] Further, there is debate about whether the onerous, often time-consuming and unpaid assessment and interview process is fair for candidates; many job seekers view testing as problematic and even a loophole to exploit in the recruitment process.[157, 158, 159] Some employers have started to pay candidates for their time in job interviews.[160] The appearance of these diverse forms of training, assessment and certification also are difficult to assess from the job seeker's perspective in terms of effectiveness, reputability and validity in the marketplace, and whether they are worth the time and monetary investment.

On the other hand, degrees, especially those from top schools in sought-after technical fields, continue to hold weight; they offer networks and streamlined pathways that can help a candidate get their foot in the door. Information and communications technology is considered a knowledge-intensive sector, and candidates with degrees from top schools command top salaries and receive wraparound supports that lone candidates cannot access. For example, MIT's 2021 survey of graduates shows that the average median salary for bachelor's degree holders in information or computer technology is US$118,000; for master's degree graduates, the average median salary is US$135,000.[161] The survey identified information and computer technology as the industry that graduates with a bachelor's or master's degree most often worked in after graduation.

Tracing Diversity in the Information and Communications Technology Sector

Overview

Despite the perceived shortage of skilled workers and explicit commitments to diversity, there is, paradoxically, also evidence to suggest the under-employment of diverse groups, particularly of women[162] and skilled immigrants.[163] Canada's technology workers have been noted to be generally more diverse relative to the Canadian labour market as a whole, but there is evidence of under-representation of vulnerable groups and pay inequality in the ICT sector.[164, 165, 166] In this chapter, we review the under-representation of equity-deserving groups in the ICT sector followed by a specific focus on women, persons with disabilities, Indigenous Peoples, racialized people and newcomers. We conclude with a discussion on why the diversity of the ICT sector is crucial for its success.

Representation in the information, communications and technology sector

According to a report published by the Brookfield Institute, while women have increased their participation in the labour force overall, this increase has been more muted in the tech sector where men are still four times more likely to work in tech than women.[167] The same study also found that while the gender wage gap is smaller in tech jobs, men on average still earn about $7,500 more than women in tech occupations. Research suggests that women and other members of equity-deserving groups, including racialized people, people with disabilities and Indigenous Peoples, face systemic and organizational barriers in technology fields, particularly during credential assessments and recruitment and hiring, and that their longevity and ability to advance is limited.[168]

Decades of initiatives aimed at advancing women in technology have scarcely moved the needle; the proportion of women in engineering and computer science in Canada has changed little in 10 years.[169] The "chilly climate" for women in technology persists, as do pay differentials for women STEM employees.[170] Immigrant and women technology entrepreneurs continue to confront gender-related industry barriers.[171, 172, 173] Technology fields not only fail to attract women, but also fail to retain them.[174]

According to Brookfield Institute research racialized workers[175] make up 31.9%

of Canada's tech workers, with those identifying as Chinese, West Asian, Arab or South Asian most likely to work in tech occupations, and immigrants making up 37.6% of the workforce.[176] According to the Brookfield Institute, immigrants are twice as likely to work in tech careers compared to non-immigrants. The study also found that those who identified as Black, Filipino or Hispanic have very low participation rates in the field and, on average, receive much lower compensation than non-racialized workers. These findings are important among literature claiming that immigrants, particularly those who are racialized, continue to face challenges in securing meaningful and relevant employment, and are often stuck in precarious and low-paying jobs, despite having high levels of skills and education, often in STEM.[177, 178, 179, 180, 181]

Studies have found that individuals with foreign-sounding last names are less likely to be interviewed for positions even if they have the same qualifications.[182, 183] There are many challenges facing immigrants, including a disconnect between the skills they are selected for and those that are valued by employers; moreover, foreign credentials and work experience obtained outside Canada are generally devalued in Canada, resulting in immigrant skills being underused.[184] These findings demonstrate a need for nuance in data collection and analysis of immigrant and racialized workers in technology fields, particularly in gauging the characteristics of the groups that face the greatest barriers. (Examples of these characteristics include education level, legal status in Canada, English-language proficiency, and foreign or Canadian credentials.)

Similar precision of data is needed when considering the participation of other vulnerable and equity-deserving groups like Indigenous Peoples and persons with disabilities. There is recognition that digital transformation may be especially harmful for these groups as well as for youth, and that greater inequality and labour disruption will result.[185, 186] There are also reports that age discrimination is prevalent in the tech world; for instance, the 2018 lawsuit pursued by employees at Google, Intel and IBM for age discrimination, and the continuing legal fights between disposed workers and large tech firms over this issue.[187] Research shows that barriers for diverse groups are compounded: people can face multiple barriers to employment and advancement when there is an intersection of multiple identities, such as disability, age, gender, religion, and ethnic or racialized identity.[188, 189, 190, 191, 192, 193]

Despite extensive activity, limited progress has been made in addressing barriers faced by diverse groups in the technology sector, and barriers persist.[194, 195, 196, 197, 198] This compounds the reported skills shortage and calls for more investigation. Classical diversity interventions such as recruitment and hiring from diverse communities, diversity training and mentoring programs have produced uneven results.[199, 200, 201] For example, European countries have instituted quotas for women in leadership, but it is unclear if such laws drive or reflect cultural values and their impacts are uneven.[202, 203] This may be because diversity strategies and outreach campaigns are often based on unproven assumptions and have uneven impact. The principal assumption is that the solution lies in increasing the number of equity-deserving employees. Organizations may have significant

representation of designated groups but may expect them to assimilate.[204]

Mor-Barak and Cherin propose an inclusion-exclusion continuum, in which they suggest that the degree of diversity and the overall organizational culture would influence employee perceptions of inclusion-exclusion; the degree to which employees feel included or excluded would consequently determine organizational commitment, individual well-being, job satisfaction and effectiveness.[205] Rather than focusing only on individual perceptions, scholars and others have expressed the need for deeper understanding of complex interactions between context and organization and individual initiatives and change.[206, 207, 208, 209] Maintaining that organizations may have representation of designated groups but not value them,[210] attention has shifted to the creation of "inclusive" organizations that espouse a commitment to integrating different identities and valuing them.[211, 212]

Women's training and work in technology fields

The proportion of women with a university degree more than doubled between 1991 and 2015, from 15% to 35%, and women have accounted for most post-secondary graduates across Canada since the 1990s.[213] In STEM fields, however, the figures on women's training over the last two decades vary, with some indicating more participation and some indicating decline. According to a recent analysis conducted by Statistics Canada, women are 29.8% less likely than men to enrol in a post-secondary STEM program, and by far the largest gender gaps were observed in engineering programs.[214] Table 7 shows post-secondary enrolment trends from 2012 to 2021.

TABLE 7

Post-secondary enrolment in science, technology, engineering and mathematics (STEM) fields

Year	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020	2020-2021
STEM enrolment: men	266,676	277,272	287,025	294,612	305,280	316,311	323,418	334,194	337,500
STEM enrolment: women	152,412	158,235	165,789	173,877	182,355	191,109	199,635	209,124	216,903
STEM enrolment (total)	419,430	435,846	453,108	468,837	487,971	508,437	524,748	545,913	557,874

Source: Source: Statistics Canada, Postsecondary Student Information System, Table 37-10-0163-01[215]

Once enrolled, however women were just as if not more likely than men to persist in their initial field of study and were faster to complete their degrees.[216] At the same time, other sources show that while women are under-represented in engineering, there are huge variations in the proportion of women in engineering across universities, with recent successes[217] suggesting that institutional policies and practices play a role.

while women are under-represented in engineering, there are ***huge variations in the proportion of women in engineering across universities****, with recent successes suggesting that institutional policies and practices play a role.*

While figures on the historical training of women in STEM and ICT are varied, what is consistent are figures of gross under-representation of women in the tech workforce in Canada and internationally. The OECD shows that while women represent the majority of all graduates from tertiary education, fewer women than men complete their degrees in STEM.[218] According to ICTC's *Digital Economy Review 2020* report, while the Canadian ICT workforce has diversified over the past 10 years, much of the diversification was driven by newcomers, whose representation in the ICT workforce has risen from 28% in 2010 to 38% in 2020 despite the restrictions that were implemented during the COVID-19 pandemic.[219] In comparison, there was less growth in the representation of women, who made up 27.3% of the ICT workforce in Canada in 2020 compared to 24.6% in 2010.

A report by the Brookfield Institute notes that within the ICT workforce in Canada, the proportion of men is four times that of women in ICT occupations: 778,000 men (7.8% of all men in the workforce)[220] are employed as tech workers compared with 194,000 women (2.1% of all women in the workforce). However, when considering the growing industry verticals such as health care, biotech and creative industries, the representation of women rises from 25% to 32% in 2019 for this "new" digital workforce, demonstrating that these numbers can fluctuate with differing definitions on what constitutes an ICT job.[221] On the whole, there has been scant improvement in the representation of women in the ICT sector and in ICT roles in the digital economy. In some cases, representation has declined, according to data from the nonprofit group Women in Communications and Technology, in collaboration with the ICTC (Table 8).[222]

TABLE 8

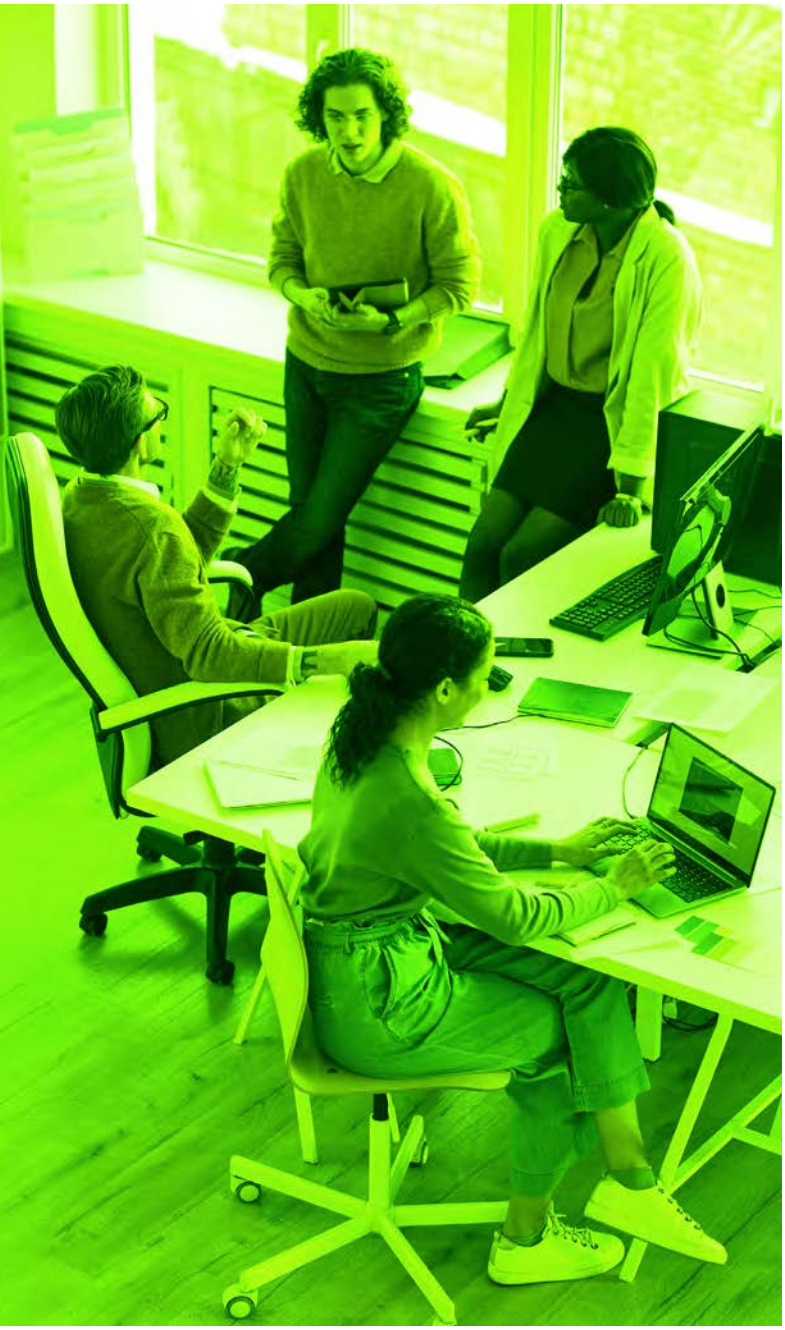
Women in the information and communications (ICT) sector and in ICT roles

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Percentage of women in the ICT sector: all jobs	32.1%	31.7%	32.3%	30.4%	31.1%	31.2%	31.2%	30.7%	31.3%	30.9%
Percentage of women in ICT roles in the ICT sector	16.7%	18.1%	18.0%	17.8%	18.8%	19.8%	19.8%	19.7%	21.3%	21.3%
Percentage of women in the ICT sector in management: all jobs	30.4%	31.2%	29.9%	27.8%	28.8%	32.4%	32.2%	28.8%	33.5%	31.3%
Percentage of women in management in ICT roles in the ICT sector	19.6%	21.1%	21.3%	16.5%	22.6%	23.3%	23.8%	26.3%	23.4%	23.6%
Percentage of women in ICT roles in the digital economy	24.7%	25.4%	25.2%	25.7%	26.9%	26.9%	26.9%	26.3%	27.3%	27.8%
Percentage of women in management ICT roles in the digital economy	23.4%	25.5%	23.4%	23.6%	22.2%	24.7%	24.6%	26.3%	22.4%	21.0%

Source: Up the Numbers: 2021 Report[223]

Researchers also used the Stack Overflow Developer Survey database to look at the representation of women software developers in Canada.[224] The survey collected responses from 83,439 software developers from 181 countries, 2,434 of which were respondents from Canada. The survey was conducted between May 25 and June 5, 2021. Respondents were recruited through the main channels of Stack Overflow through onsite messaging, blog posts, email lists, banner ads and social media posts and thus are not necessarily representative of the overall population of software developers.

Based on the survey data, the gender breakdown of software developers in Canada was as follows: 2,188 were men (89.9%), 125 were women (5.1%), and 121 were other (prefer not to say or non-binary [5%]). On average, men coded about three years longer than did women (15 years for men vs. 12 years for women). Men and women did not differ on when they started to code: for each group, about 40% started coding between the ages of 25 and 34 years, and about 20% started coding between 18 and 24 years. Across genders, about 70% were developers by profession, but more women than men were students learning to code (16% women vs. 10% men). More men than women were likely to code primarily as a hobby (7.6% men vs. 4.8% women). More women used to be a developer by profession but no longer were (3.2% women vs. 1.5% men); as the sample sizes are small, results should be interpreted with caution. Seventy per cent of men and women surveyed were employed full-time, but more women than men were employed part-time (5.6% women vs. 1.6% men), whereas more men than women were independent contractors, freelancers or self-employed (9.1% men vs. 5.6% women). Once again, results should be interpreted with caution as the sample sizes are small.



In terms of skills, one study reported minimal difference in aptitude and technical applications needed to do ICT work, for instance when looking at average scores in standardized testing on skills (Problem Solving in Technology-Rich Environments); depending on the definition of ICT used, men's average scores range from 305.12 to 310.55, and women's average scores range from 301.32 to 302.40.[225] Another study reported the opposite—that Canadian women score higher than men on basic ICT skills.[226] The first study suggests that there appears to be non-gendered divisions of labour in ICT fields; women

are performing the same tasks as men, which shows that, in terms of distribution of skills and responsibilities, the ICT sector is equitable,[227] and women are not relegated to work thought to be more suited to their strengths as happens in other fields. But this finding is in opposition to a slew of previous research on ICT professionals that suggest that not only are skill sets and roles in ICT still determined by gendered stereotypes,[228] interventions to address stereotypes are sometimes themselves based on stereotypes, particularly when it comes to gender.[229] For women, gender biases in hiring and promotion are partly due to stereotypical biases that often fail to situate women as "good fits" for ICT positions.[230] Lawsuits filed by women employees of large tech companies is further evidence of this point. For example, Google recently agreed to pay US$118 million to settle a pay discrimination case.[231]

In essence, technology fields not only fail to attract women, but also to retain them.[232, 233] MetLife's annual TTX Survey on Women and STEM shows that women in STEM are almost twice as likely to say they are considering leaving their workforce in comparison to women in other industries (22% vs. 12%).[234] Also, in the U.S., it has been shown that women in tech who experience bias have continued to leave the sector at a 45% higher rate than men.[235] Women leave their tech jobs for various reasons.[236] Some may leave to attend to family responsibilities, further their education or for other personal reasons. A longitudinal study of women in ICT in the U.S. shows that, compared with other women in professional fields, women who leave STEM are not likely to return to the field.[237] Given that women working full-time in STEM still earn more than their men counterparts in the general working population in Canada,[238] the finding suggests that challenges and barriers within the tech sector may outweigh the financial benefits.

There are also gender pay disparities in the ICT sector, where men experience an average of $3.49 per hour increase in pay compared to women, and an average difference of more than $7,500 in annual income. An immigrant woman who is racialized working in tech without a university degree in Canada is expected to make, on average, $8.94 per hour less than a white, non-immigrant man without a university degree. This suggests that women at the intersection of equity-deserving identities are at an even greater disadvantage when it comes to pay in the ICT sector (see Table 9).

In the U.S., it has been shown that ***women in tech who experience bias*** *have continued to* ***leave the sector at a 45% higher rate than men****.*

TABLE 9

Wages and identity

Identity	Hourly wage (2001 constant $)	Inflation-adjusted 2016 wages	Inflation-adjusted 2022 wages	Yearly equivalent 2016	Yearly equivalent 2022	Gap 2016	Gap 2022
Base identity: 30–40-year-old, unmarried white man with a university degree	$31.49	$41.31	$48.23	$85,931.13	$100,328.31	N/A	N/A
Being a woman	$29.21	$38.32	$44.74	$79,709.57	$93,064.38	-$6,221.5	-$7,263.9
Not having a university degree	$21.52	$28.23	$32.96	$58,720.01	$68,558.16	-$27,211.11	-$31,770.15
Being Black, Indigenous or racialized	$28.53	$37.42	$43.69	$77,837.65	$90,878.82	-$8,093.48	-$9,449.49
Being an immigrant	$28.21	$37.01	$43.21	$76,978.09	$89,875.25	-$8,953.0	-$10,453.06
Having 10 more years of experience (being 40–50 years old)	$37.33	$48.97	$57.17	$101,856.13	$118,921.43	$15,925.00	$18,593.12
Being married	$35.61	$46.72	$54.54	$97,168.13	$113,448.00	$11,237.00	$13,119.68
Young, unmarried immigrant non-white man with a university degree	$14.462	$18.97	$22.15	$39,463.21	$46,075.01	-$46,467.92	-$54,253.30

Source: Vu (2022)[239]

Extensive research suggests women who enter the field face multiple systemic and organizational barriers, which drive them to leave the field after graduating with a related degree.[240, 241, 242] The "chilly climate" or culture of ICT—whether real or perceived—is one major factor that can be enough to deter women from progressing in these fields.[243, 244] A Pew Research Center survey shows that 50% of women in STEM experienced gender discrimination at work as opposed to 19% for their men counterparts.[245] Organizational barriers such as lack of investment in women's advancement opportunities or lack of

appropriate mentorship for women in ICT play a role in deterring women.[246] Networking is also a challenge for women in these areas, with the "old boys' network" being alive and well in ICT companies.[247] This means women also have a harder time advancing in ICT as they tend to feel like outsiders.[248, 249, 250] Additionally, women are often forced to shoulder additional barriers at home: "43% of women in STEM careers left their full-time job within four to seven years of having their first child ... compared to 23% of new fathers."[251]

A 2017 Women in Communication Technology survey confirms these and other factors deter women from entering and remaining in ICT. The top five barriers identified by participants were: 1) lack of developmental or advancement opportunities (54.7%); 2) not having an executive sponsor (51.4%); 3) inability to navigate organizational politics (50.3%); 4) the old boys' network" (50.3%); and 5) not having a mentor (41.9%). Other factors cited include work-life balance, lack of training, lack of a network, inability to influence others and lack of self-confidence.[252] Socialization, misinformation about what ICT careers entail, lack of women role models, the marketing of technology to young men, and discrimination against and hostility toward women in the tech workplace are all reasons why young women choose not to pursue STEM and technology fields, even if they demonstrate aptitude.[253]

There are, however, some signs of positive change for women in the ICT sector as the economy recovers from the COVID-19 pandemic and businesses move to digitization. In the most recent quarterly monitor of Canada's ICT labour market,[254] the number of women in the ICT workforce has been on the rise for four consecutive quarters, with an increase of 6.5% in Q1 of 2021 and an increase of 17.5% in Q2 of 2020. Women accounted for 28.2% of the ICT workforce in Q2 of 2021, rising slightly from 27.7% in Q1. The unemployment rate in ICT-related professions has also dipped from 3.3% in Q1 of 2021 to 2.3% in Q2 of 2021. These rates are much lower than the national unemployment rate of all sectors (8.2% to 7.8% over the same period). The results of the 2020 CEO survey of the 50 fastest-growing tech companies in Canada mirror these improvements, as the number of women applying for tech roles has increased and the hiring of women in tech has also improved.[255] However, the same survey showed smaller increases for women in tech in leadership positions. Some of these improvements could be attributed to the greater flexibility in work-from-home policies that the COVID-19 pandemic has triggered for many of these tech companies, which is especially beneficial for many women who need to juggle child care duties with work.[256]

The gender digital divide for girls

While much of the knowledge surrounding the gender digital divide has focused on women over the age of 18, data also shows that girls face similar challenges when it comes to accessing and using technology.[257] Boys are more likely than girls to use various digital platforms, access the Internet and own a cellphone. The United Nations recognizes that technology plays a fundamental role in a girl's ability to exercise her fundamental rights for her to participate not only in the economy but also

*A key factor in why girls decide not to enter ICT and STEM fields is that they **lack women role models in ICT**, and also because the career paths in IT are either unknown to high school students whose parents are not employed in the field, or their **perceptions of the field are inaccurate**.*

in culture and politics.[258] Providing girls with early access and training to technology leads to higher levels of education and better careers.[259] Additional benefits include access to health care information, reduced risk of unwanted pregnancies and improved access to career opportunities.[260] Digital literacy is increasingly seen as an essential skill globally, as 90% of jobs globally contain a digital component.[261]

There is a critical need to ensure that girls have access to and can adopt technology early on; this encourages the development of digital skills needed to widen their employment opportunities and facilitate their path to workforce participation.[262] Another aspect that must not be overlooked is that women and girls face a disproportionate amount of digital harm and online harassment,[263] and limited digital literacy makes them more vulnerable to online risks compared to men and boys. They may have little to no access to information on how to stay safe online, or lack the support if they encounter a negative digital experience.[264] Digital products, content and services are often geared toward men, as women are often not involved during their development; as a result, many women and girls often do not see the need to use these tools and engage less with these technologies.[265]

"Leaks" in the pipeline toward a career in STEM or ICT begin in the early school years and continue through to employment, with many women choosing fields outside of STEM and ICT in university, and other women STEM and ICT graduates failing to progress in the field.[266] This has also been observed of women in STEM academia.[267] According to a 2019 report by the Mowat Centre, "The ICT gender gap appears to be less a matter of STEM-trained women not choosing ICT occupations, and more a matter of many young women choosing not to pursue the fields of study that lead to ICT occupations."[268] The study found that when men and women both hold degrees in STEM disciplines, they have similar chances of having a career in ICT.[269]

A key factor in why girls decide not to enter ICT and STEM fields is that they lack women role models in ICT, and also because the career paths in IT are either unknown to high school students whose parents are not employed in the field, or their perceptions of the field are inaccurate.[270] Studies show that discourses on IT often frame the field as an insecure, stressful, boring and unwelcoming

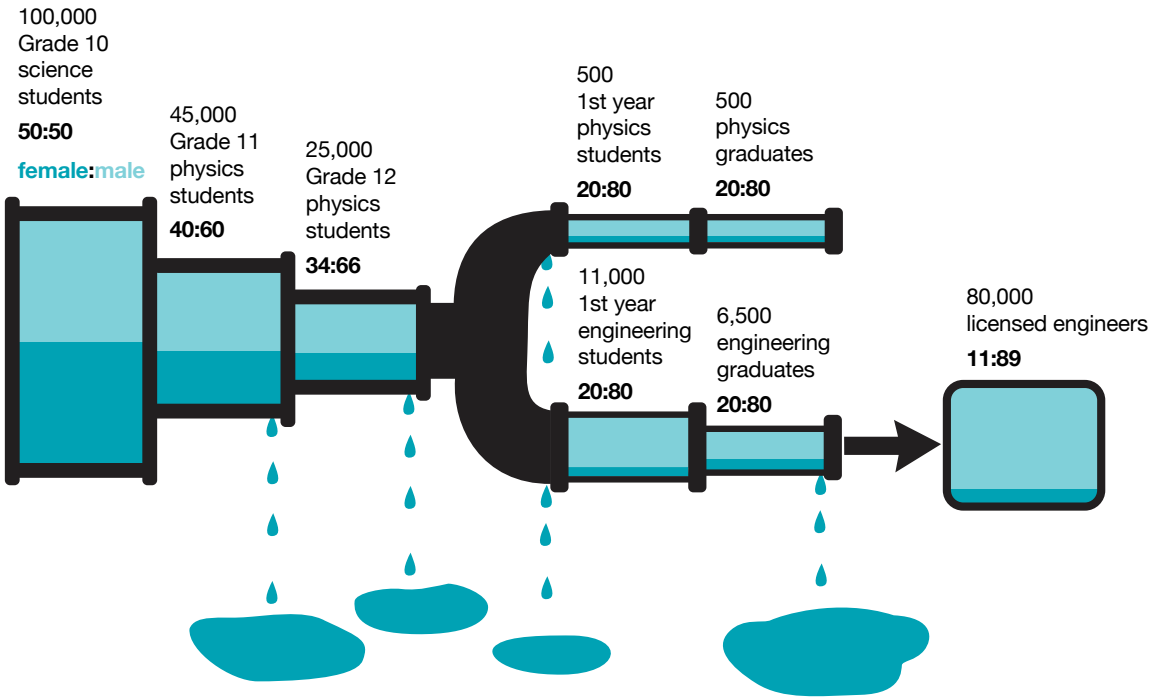
environment for women that would strain work-family balance and may be difficult for women to advance in.[271] A 2019 study found that cultural norms was one of the main reasons for girls entering the information systems (IS) field, along with personal interest in the area.[272] Other studies cite a lack of role models in technology, as well as media stereotypes as major discouraging factors.[273] The problem is not girls' lack of receptiveness to IT as a career, but that adequate information is often not provided in a way that resonates with young women.[274] Hence, many girls and young women form the impression that they do not belong in STEM and ICT.

There are significant gaps in girls' and boys' aspirations for becoming ICT professionals. Boys are 10 to 12 times more likely to expect to work in ICT-related jobs than girls.[275]

Research has suggested that there is a lack of appropriate and early interventions to "target youth at key junctures in their career decision-making processes, both before and during high school,"[276] and that to encourage women's participation in ICT occupations policy makers should target educational choices more than post-graduation career choices.[277] High school has been identified as the critical point of loss of women STEM students; for example, of all girls who have completed the required Grade 10 Academic Science in Ontario, only about 15% enrol in Grade 12 Physics compared with 30% of boys, a loss that is not due to an achievement gap between the sexes, but rather a loss of highly talented girls who demonstrate potential to excel.[278]

FIGURE 2

Ontario's leaky pipeline of women in engineering education



Source: Wells et. al. (2018)[279]

These studies are connected to a growing body of research on the gender gap in professions and how students learn that raise questions about pedagogy at the secondary school level, and whether changing how courses are delivered will lead to changes in the (gender) composition of students interested in different majors. In their publication, Hoffmann, Zohar and Bronshtein suggest that within physics classes "the notion of what it means to understand physics and physics curricula is heavily biased toward boys' interests, knowledge, and abilities."[280] The role of educational institutions should be to inspire interest in these roles by providing education on technology as a career in a way that acknowledges the skills and values of young women.[281]

There are several interventions at the K–12 level that have shown some promise in improving girls' attitudes and participation in STEM. Inclusive STEM schools with open-admissions processes that assign more problem-based projects and offer a more supportive environment have been shown to improve girls' motivation and performance in science; in turn, girls would be more likely to be interested in pursuing a future career in STEM.[282] Increased awareness of the stereotypes surrounding women in math can help improve their math performance.[283] Women role models have also been shown to improve girls' interest and performance in STEM. For instance, having more women instructors was shown to foster girls' interest in STEM and encourage them to major in STEM and graduate with STEM degrees.[284, 285] Women also showed better comprehension when a picture of a woman scientist was presented with a passage in a chemistry lesson compared to when the passage was presented with a man scientist.[286]

There are also organizational efforts in Canada to encourage the participation of girls in STEM. University of Alberta's WISEST Summer Research Program places girls in Grade 11 in placements across STEM fields.[287] The program has been running for 40 years, and based on recent data looking at the past 30 years, 84% of its participants have gone on to attend one of the STEM disciplines at the University of Alberta.[288] Canada's Girl Guides created STEM Career Exploration and Automotive Engineering badges, which are earned by "exploring nature, learning new life skills, learning about feminism, conducting science and engineering experiments, and exploring big-picture ideas."[289] Girl Scouts are almost twice

as likely as non-Girl Scouts to participate in STEM-related activities, and 77% of Girl Scouts say that they are considering a career in technology because of Girl Scouts.[290] There are also numerous programs such as STEMforGIRLS and Girls who Code that are working to encourage and facilitate the participation of girls in technology.

Extending beyond K–12 education

Targeting efforts to increase diversity in STEM at a younger age will pay dividends throughout children's lifetimes as gender stereotypes will begin to dissolve and people across all genders will be socialized from an early age to engage with technology. However, there are initiatives that can be implemented among STEM programs at post-secondary institutions that make them more attractive to women. For instance, women still do most of the housework, such as laundry and meal preparation, compared to men.[291] According to a poll from April 2022 conducted by the Canadian Women's Foundation, mothers were disproportionately affected by the COVID-19 pandemic as they often bear more of the child care duties; 37% of mothers have had to put their careers on the back burner to manage parenting responsibilities compared to 18% of fathers. Prior to the pandemic, women reported, on average, 68 hours per week of caregiving compared to 33 hours for men, and this disparity has widened since the pandemic as women reported 95 hours per week of caregiving compared to 46 hours for men.[292]

While the pandemic has increased the burden of caregiving for women, it has also forced many post-secondary institutions to introduce virtual and hybrid programs that allow students to complete their coursework at home. As many courses are also delivered asynchronously, they offer more flexibility, making them attractive to students who are juggling their jobs and families. Furthermore, as online courses are easier to scale, they can be offered at a lower cost for the institution and students. Georgia Tech's pioneering online Master of Computer Science program costs US$7,000 and reached over 10,000 enrolments for the fall of 2020.[293] There are now more than 70 master's degree programs available online, many in the field of technology, ranging from data science and analytics to cybersecurity.[294] The lower cost and flexibility of these programs make them an attractive option for mothers who often shoulder the burden of child care.

Another strategy is to offer more technology courses alongside traditional university and college programs. Instead of having students take computer science courses to apply them to their own fields, technology classes can be integrated into biology and nursing curricula that may be of greater interest to women.[295] For instance, George Brown College offers a fashion tech program that helps students acquire digital and hands-on training to enter digital fashion technology fields; fashion is a field that is dominated by women.[296] Broadening the applicability of computer science courses to other fields can increase their attractiveness to a greater range of students across genders.[297]

There is also a growing trend for CEO compensation to be tied to the hiring and promotion of equity-deserving groups to ensure shared accountability among leaders

and their employees. For example, one-sixth of the bonus pay of the CEO of Microsoft, Satya Nadella, is based on achieving their diversity goals.[298] The same strategy can be applied to post-secondary institutions, where funding and salary bonuses can be directly correlated with their diversity metrics to hold leaders accountable for ensuring that there is healthy representation of women and other equity-deserving groups in their organization, particularly in STEM departments. The Government of Canada can promote initiatives like the 50 – 30 Challenge to post-secondary institutions so that those that have met their diversity targets will have access to additional government programs and supports.

Several strategies can also be applied in the workplace to increase the representation of women. As women often take on more child care responsibilities than men do, a family-friendly workplace is also important in attracting women to ICT.[299] Flexible work hours; remote or hybrid working models; increasing vacation, sick and personal days; and compassionate and caregiver leave can all help attract and retain women in the workplace.[300] Providing additional support systems and resources for caregivers, such as employee resource groups, backup care policies, offering full-time benefits to part-time workers and on-site daycare can all help alleviate the burden of parenting and offer more time and resources for employees to pursue their own career goals.[301]

Another important factor in achieving gender equality in the workplace is transparency. ***Pay transparency*** *laws have been found to* ***reduce the gender wage gap by 30%*** *in university faculty salaries.*

Another important factor in achieving gender equality in the workplace is transparency. Pay transparency laws have been found to reduce the gender wage gap by 30% in university faculty salaries.[302] A related factor, accountability, is also critical. Organizations must set clear targets and keep progress transparent to hold themselves accountable.[303] While transparency and accountability are recognized as critical in achieving gender equality, a workplace survey of 69 Canadian companies by McKinsey & Company found that 55% of companies had not set any targets for the inclusion of women, 75% of leaders were not rewarded for fostering gender diversity and none of the organizations surveyed had monetary incentives tied to gender diversity.[304]

Persons with disabilities in the information and communications technology sector

The persons with disabilities talent pool is often overlooked in the Canadian labour market. Figures exist, but only on the

general level of labour participation of people with disabilities, with estimates of the number of Canadians with disabilities in the workforce, and some information about the characteristics of the demographic in terms of gender, level of education and severity of disability. Overall, persons with disabilities are significantly more likely to be unemployed, lose their job, be employed in low-wage work, and be turned down for promotions or overlooked for positions in the first place than persons without disabilities, and thus are more likely to live below the poverty line.[305]

Data from the Canadian Survey on Disability (CSD), which is the main statistical source on persons with disabilities in Canada, shows that 22% of Canadians within the working-age adult population (aged 25 to 64 years) have at least one disability, representing about 20% of the Canadian population or 3.7 million working age adults; women are more likely than men to have a disability (24% women vs. 20% men).[306] The four most common types of disability are pain-related (15%), flexibility (10%), mobility (10%) and mental-health related (7%). In 2017, 57% of persons with disabilities in Canada had a "mild" or "moderate" disability, and 43% had a "more severe" disability, in which the severity was such that those persons with disabilities experienced limitations to some extent in their daily lives. Persons with disabilities have an employment rate of 59%, compared to 80% for persons without disabilities, but the CSD shows that those with more severe disabilities often have lower rates of employment and income and greater likelihood of living in poverty. Persons with severe disabilities are two-and-a-half times less likely to be employed than those with mild disabilities. The median total income of persons with disabilities is $10,000 less than the median for those without disabilities.

Beyond the CSD data, there is little data on disability, specifically on the experiences of persons with disabilities with regards to employment in Canada. Disability reporting is voluntary, with most companies either not collecting this data or unwilling to share it. Recent figures show evidence of underreporting because of stigma associated with identifying as someone with a disability. Of respondents surveyed by the CSD, 27% indicated that their employer was not aware of their limitation as a result of disability, and 44% felt that their employer would be likely to consider them disadvantaged in employment because of their condition.[307]

Over the last decade, government has been working on introducing new programs, tools and incentives to ameliorate the labour participation outcomes of persons with disabilities. Employment Ontario's 2010 *Hiring Qualified Workers with Disabilities – A Guide for Employers*, and the Government of Ontario's more recent multi-tier strategy, pivoting on a new grant and training programs, to improve unemployment rates for the province's persons with disabilities community with a focus on disabled youth, integrating and coordinating employment services, and ensuring the government itself takes a proactive stance in hiring persons with disabilities.[308] However, little is known about the effectiveness of these programs.

Because disability is not included in most technology companies' public diversity

reporting, there is little knowledge about the participation of persons with disabilities in the technology workforce. The tech industry promises to be an enabler for persons with disabilities, particularly for people with physical mobility issues, and there are cases recorded where technology has facilitated social mobility for persons with disabilities. However, for the most part, tech companies have a reputation for being unwelcoming and inaccessible to persons with disabilities; work cultures that stress long hours present many barriers to persons with disabilities in particular, for whom rest, medical appointments or tests may not be optional.[309] Amazon has repeatedly faced allegations of using performance reviews as precursors to phasing out employees.

The New York Times reports that employees returning to work after receiving cancer treatment, or experiencing miscarriages and other personal crises are evaluated unfairly, given low performance ratings or are put on "performance improvement plans" for reason of personal life difficulties interfering with fulfillment of work goals.[310] A 33-year-old former Apple employee sued his employer for lost wages and damages because the latter refused to work out an individual accommodation plan with him,[311] despite that Section 15 of the Canadian Charter of Rights and Freedoms prohibits discrimination on the basis of disability. Thus, persons with disabilities in tech companies often report subtle and building bias that gradually leads to bad performance reviews or dismissal. This is paradoxical in view of the tech world's focus on developing products and platforms with a view of universal design and diversity and inclusion.

Studies have shown that persons with disabilities experience systemic discrimination and barriers to participation in employment and education, and pervasive obstacles to accessing financial services.[312] In addition, the social isolation of some persons with disabilities limits their networking possibilities and access to training. Many employers are unaware of the capacity and ability of people with disabilities in the workforce and lack nuanced knowledge about disability issues.[313] Common barriers persons with disabilities face in the workplace include fear

of discrimination related to their capabilities if they were to disclose their disability; fear of people's judgment of "faking it," particularly with disability that is invisible; and inaccessible workplaces and tools.[314]

Research has begun to debunk the stereotypes and stigma about disability in the workplace. There is evidence to show that companies that champion people with disabilities outperform other companies financially, with 28% higher revenues, 200% higher net income and 30% higher profit margins.[315] Further, there is also evidence to show that in many cases persons with disabilities need no or minimal accommodation, and that accommodation can have no or very low costs. In 57% of cases, no workplace accommodation is required for people with disabilities,[316] and only about 37% of Canadian employees with disabilities aged 25 to 64 years that were surveyed in 2017 required a minimum of one workplace accommodation to be able to work.[317]

According to a recent survey by Job Accommodation Network (JAN), 59% of accommodations in the U.S. cost nothing, with the rest typically costing $500 per employee with a disability.[318] Adding to this, more people are sharing their experiences of disability in the workplace, which opens up debates around definitions of disability and inclusion, including about "health as not binary," and the idea that illness and disability can fluctuate and are a natural part of the human experience.[319, 320] There are also efforts to recognize companies that are hiring persons with disabilities or offering innovative programming to increase the participation of persons with disabilities in the workforce. The Disability Inclusion Champions list put together by Accenture in partnership with Disability:IN and the American Association of People with Disabilities (AAPD) highlight companies that have embraced disability and inclusion best practices and are financially outperforming companies that have no inclusion strategy.[321] There are indicators that attitudes toward persons with disabilities in tech are shifting, but these give us only a glimpse of the issues facing this group's labour participation in technology fields.

Indigenous workers in information and communications technology

The category of Indigenous Peoples includes Inuit, First Nations and Métis, but within groups there are often considerable differences. For instance, the gaps between highly educated, wealthy professionals and poor, marginalized populations may be greater than the differences based on Indigeneity alone.[322] Only 31.4% of all Indigenous Peoples are employed in the Canadian ICT sector, and 27% of these are women.[323] Moreover, 47% of the Indigenous ICT professionals are First Nations, 47% are Métis, 2% are Inuit and 2% represent other Indigenous persons.[324] Figures also show that Indigenous Peoples in Canada, particularly Indigenous youth, experience wide and persistent gaps in income, education and labour participation.[325] Studies show that more Indigenous workers are in jobs prone to automation, and fewer are in knowledge-driven jobs compared with the general

workforce, with the share of Indigenous workers in ICT at 1.2%,[326, 327, 328, 329] equaling about 10,300 people.[330] Indigenous workers also experience discrimination at work.[331] Indigenous Peoples are most represented in fields like construction, the arts and public representation, but in high-growth areas of tech jobs, like advance manufacturing, fintech, finance and insurance, and professional, scientific and technical services, their representation is less than 1%.[332] The ICTC notes that Indigenous Peoples are often overlooked and not seen as a potential labour pool to address the digital skills gap, but estimates show that Canada's Indigenous workforce could increase by more than 72,000 by 2026.[333]

The main barriers recorded that face Indigenous workers are: literacy and education (high school and basic literacy rates have been cited as very low for Indigenous youth—roughly 24% in 15–24 year-olds in Canada, compared to 84% in the non-Indigenous population); language and cultural differences; racism and stereotypes, particularly about "special treatment" of Indigenous Peoples; low self-esteem linked to chronic poverty of Indigenous communities; lack of access to transportation, as many Indigenous Peoples live in rural communities; and limited access to child care.[334] In recent times, post-secondary education attainment among Indigenous Peoples has seen improvements. A survey conducted in 2016 indicates that among the 52% of Indigenous women who had post-secondary education, 8% had an apprenticeship or trades certificate, 28% had a college diploma, 3% had a university certificate and 14% had a bachelor's degree or higher.[335] Nonetheless, geographical distribution has been a major hindrance to accessing education. Access to education is limited in most reserve areas, forcing First Nations, Métis and Inuit women to leave their communities to attend schools elsewhere.[336]

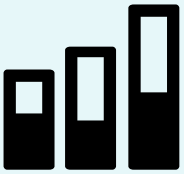
Recommendations on how to leverage the Indigenous workforce in tech occupations have included: improving broadband access in rural communities; more government and industry efforts to support teachers and school administration staff in integrating ICT and STEM into curriculums that are culturally appropriate, including access to mentorship and coaching; ensuring funding for on-reserve students is equal to non-Indigenous students; and improving resources for the support of basic literacy and digital literacy in Indigenous communities.[337]

Racialized people and immigrants in information and communications technology

Within sub-groups of racialized people, there are significant differences in the experiences of people who identify as an immigrant vs. non-immigrant, Caribbean vs. African, or Trinidadian vs. Jamaican, as well as important intersections with gender, education, class, and religion, among others.[338] In technology fields, these differences have been studied in terms of rates of participation, differences in pay and access to advancement.

The ICTC claims that "making up nearly 40% of all technology-based occupations in Canada, immigrants play a central

role to our ability as a country to support economic growth and propel forward new opportunities."[339] 593,600 ICT professionals are immigrants, and the proportion has grown from 28% in 2010 to 38% in 2020.[340] While the participation of immigrant tech workers is on the rise, studies suggest that their integration, especially of those who identify as racialized, is fraught with barriers.[341] According to a 2020 Labour Market Information Council (LMIC) survey, 39% of unemployed recent immigrants agreed that a lack of Canadian work experience constitutes a barrier to employment, 21% cited lack of professional contacts and 21% pointed to a lack of Canadian education.[342]



*While the **participation of immigrant tech workers is on the rise**, studies suggest that their **integration**, especially of those who identify as racialized, is **fraught with barriers**.*

In addressing these barriers, a survey conducted by ACCES Employment points out that 78% of the respondents agreed that ensuring a diverse hiring panel would reduce employment barriers that racialized people are confronted with, and 54% supported the notion of a fair and inclusive hiring process.[343] For immigrants who are ICT professionals, workplace integration was challenging if English was not their first language.[344] This challenge was especially pronounced for women.[345] Other findings show that internationally trained individuals face specific challenges in obtaining work in their fields once in Canada. These include a high financial cost of skills upgrading and length of the credential recognition process; challenges navigating the process and labour market information; obtaining Canadian work experience and networks; and employer discrimination due to their lack of experience with internationally trained individuals.[346]

The report *Who are Canada's Tech Workers* shows that racialized people earn less than non-racialized people, with the exception of South Asian and Chinese workers (see Table 10).[347] On average, among racialized people working in technology fields, Filipino and Black workers have the least participation and lowest earnings in relation to other racialized people and non-racialized minorities. The authors also note that when Black and Hispanic students major in tech-oriented fields, they are less likely than their white and Asian peers to pursue a career in technology fields.[348] In a follow-up study, they found that while there was no observable pay gap between immigrant and non-immigrant tech workers in 2001, a gap emerged between 2001 to 2016 of an average of more than $5.70 per hour after controlling for other factors.[349]

TABLE 10

Racialized people in technology fields

Racialized person	Number of tech workers	Share of tech workforce (%)	Participation in tech (%)	Pay in tech	Pay in non-tech occupations
Not a racialized person	641,000	68.6	4.37	$79,400	$46,800
All racialized persons	294,000	31.4	7.65	$76,300	$38,700
South Asian	79,000	9.2	8.92	$74,000	$40,100
Chinese	91,000	9.8	11.94	$79,700	$42,700
Black	24,000	2.6	4.27	$63,000	$35,900
Filipino	16,000	1.7	3.4	$69,000	$37,400
Latin American	16,000	1.7	6.08	$72,900	$35,700
Arab	19,000	2	9.14	$70,000	$36,000
Southeast Asian	10,000	1.1	6.06	$72,300	$35,900
West Asian	13,000	1.4	10.14	$69,000	$33,300
Korean	6,000	0.6	6.39	$68,100	$34,700
Japanese	3,000	0.3	6.37	$84,400	$45,300

Source: Vu, Lamb, & Zafar (2019)[350]

Further, the study notes that disparities in pay are even starker for women tech workers belonging to a racialized minority group; racialized women (with the exception of Chinese women) earn less than all non-racialized women. Women who identify as Korean, West Asian, Black, or Filipino have the lowest earnings in tech occupations.[351]

According to a MaRS survey on diversity, inclusion and belonging,[352] racialized people comprise 56.1% of workers in tech occupations, but women, racialized people and Indigenous tech workers are paid significantly less than men and non-racialized workers. According to the survey, Black workers—particularly Black women technology workers in Toronto's tech community—reported the lowest levels of diversity, inclusion and belonging. Black workers were less likely to feel that they

could thrive and advance in comparison to their white, Asian and other racialized peers. The survey found that 66% of Black employees were subject to bias on one or more aspects of their identity, compared to 47% of white employees.[353] The survey also raised the issue that many tech employees feel the need to "code-switch" (change one's behaviour or speech due to a fear of being judged unfavourably) in their workplace, and report feelings of tokenism, all leading to a feeling of "belonging uncertainty."[354]

Women of colour are even more likely to experience racialized and gendered marginalization, and Indigenous, Black and other racialized women represent a smaller percentage of the tech workforce than white women.[355, 356] An analysis by the National Center for Women & Information Technology (NCWIT) in 2021 shows that 26% of the computing workforce are women, and that 14% of these women are white, while only 7% are Asian, 3% are Black or African American, and 2% are Hispanic or Latina.[357] In its *Women in Tech Report*, TrustRadius found that, among women who identify as Asian, Latino, Black, American Indian, Pacific Islander or "Other," nearly two in five women (37%) see their race as a barrier to getting promoted within the tech industry and that women of color are more likely than their white counterparts to identify gender bias, lack of trust and budget issues as hindrances to their promotion.[358] Furthermore, TrustRadius opines that women of color are 27% less confident in their promotion prospects than white women.[359] It is therefore important to take into consideration the intersectional experiences of women who belong to multiple equity-deserving groups to be able to proffer meaningful solutions that will increase women's representation in the ICT sector.

Significant and timely research is shedding light on the specific barriers and inequalities faced by diverse equity-deserving groups, with much-needed attention to issues of intersectionality, inclusion, belonging and power dynamics; however, more work is required, particularly larger sample sizes that reflect the Canada-wide situation of equity-deserving groups in technology fields.

Benefits of a diverse tech workforce

For businesses to keep up with the rapid pace of digitization, they need to ensure that they employ workers with the right talent to help facilitate the transformation. However, many sectors, including ICT, have been facing severe worker shortages that have been exacerbated by the COVID-19 pandemic. This means organizations need to expand their talent pools to equity-deserving groups who are disproportionately unemployed and underemployed.[360] Labour market stakeholders believe that ensuring a diverse tech workforce is good for business. According to the report *Gender Equity in Canada's Tech Ecosystem*, about 1.7 million workers (representing 9% of the total Canadian workforce) are employed in the ICT sector and these numbers will increase as the demand for digital skills continue to grow.[361] Labour market demand comes as Canada continues to become more diverse. Projections by Statistics Canada show that the working population will consist of 34.7% to 39.9% racialized groups by 2036.[362] The

Indigenous population has grown 42.5% since 2006, four times faster than the Canadian population. The 39% growth of Indigenous youth between 2006 to 2016 promises that this trend will continue.[363]

Even without the pressures of worker shortages, there are other benefits of a diverse workforce. A diverse workforce can help respond to increasingly diverse communities and gain support from diverse stakeholders. For instance, job seekers, particularly youths, increasingly prefer to work in diverse and inclusive workplaces.[364] Diversity can also foster innovation, creativity and new perspectives which can give organizations a competitive edge and increase profitability.[365] It can also help mitigate legal and reputational costs,[366] and increase employee retention and job satisfaction.[367]

Research on the importance of diversity specifically in technology fields also stresses that homogeneity in the tech worker population does not produce good products and services. Research suggests the digital landscape is far from neutral, but rather is designed with bias that may unintentionally expand and exacerbate discrimination.[368, 369, 370] Vainionpää et al. states that, "Our digital environments are currently largely constructed by men and, as the significance and effect of digitalization in our lives grows all the time, we are in dire need of more diverse views to what kind of 'digital life' we could and should have."[371] Thus, it is important that our technology is designed and developed to include people with disabilities, women and other equity-deserving groups, and that they are considered in the design of mainstream products and services. Technology can help people overcome barriers to mobility, communication and economic and social inclusion.[372] Additionally, diversity in the tech workforce can lead to innovation that addresses unmet needs in a diverse Canada and in diverse global markets.[373] Therefore, it is crucial that those who experience these barriers are included in the fields most responsible for creating this technology.

However, there are challenges that can prevent the formation of a diverse tech force, such as:

> exclusionary language in job postings and websites that lack sufficient inclusivity

> difficulties sourcing candidates of marginalized genders due to reliance on inhospitable recruitment and networking events, algorithmic biases in job boards, social media and talent acquisition software, as well as limited referral networks

> stressful interview techniques and unconscious bias

> lack of real leadership support

> gender-coded workplace cultures, microaggressions and systemic biases in promotion processes

> lack of well-meaning accommodations and benefits policies.[374]

Overcoming these challenges requires an integrated approach that takes macro-, meso- and micro-level factors into account, as well as a strategy that evaluates and transforms an entire organization.

Advancing Innovation and Inclusion To Bridge the Digital Skills Gap

Overview

The problem of advancing inclusion of women in the ICT sector is a complicated issue dependent on a variety of interacting factors at the macro-, meso- and micro-levels. The critical ecological model for change provides an integrated framework by conceptualizing the interactions between factors on the societal level, the organizational level, and the individual level.[375] This section of the report explores the potential actions that could be taken to bridge gaps using the framework.

An integrated and effective strategy to advance equity, diversity and inclusion in the ICT sector must address all three levels. Factors at the societal level could include government policies and the cultural context, such as role models and stereotypes that exclude women in the ICT sector. At the organizational level, factors include organizational practices, processes and policies, all of which affect the extent to which women are included. Finally, the individual level accounts for individual agency, or personal choices, behaviours, decisions and attitudes that affect inclusion in the sector.[376]

Societal level

At the societal level, government legislation like the *Employment Equity Act* have required federally regulated companies to report the representation of "designated groups," which includes women, visible minorities (racialized people), Aboriginal people (Indigenous Peoples), and persons with disabilities.[377] Similarly, Bill C-25, an act to amend the Canada Business Corporations Act, the Canada Cooperatives Act, the Canada Not-for-profit Corporations Act and the Competition Act received Royal Assent on May 1, 2018[378] and has been in place from August 31, 2022.[379] Bill C-25 requires federally incorporated public companies to disclose the diversity of their board of directors and their senior management team. Disclosure must cover the employment equity-designated groups. Corporations must either comply or explain why they have not disclosed diversity information.[380, 381]

Legislation like the two mentioned above exert a powerful influence on the macro-, meso- and micro-level, and, when applicable, has a direct impact on the representation of women in leadership positions in the ICT sector. Other types of policy also level the playing field for women

in the ICT sector. Family-friendly policies, like support for child care and parental leave, can increase the participation of women in ICT workplaces. For example, Quebec's universal child care policy has increased participation of women in the workforce.[382]

While these examples mark legislative progress, legislation does not necessarily provide an explicit roadmap for implementation, such as various strategies and practical considerations. In order to evaluate the effectiveness of policy, the Government of Canada needs to do rigorous research and analysis of its policies, funding, programs and the outcomes. Some of this is impeded by the current lack of data collection. For example, Statistics Canada did not start to recognize the difference between sex at birth and gender until Census 2021, and there is limited statistical data on non-binary people.[383] Additionally, there is also a lack of data collection on the meso-level; efforts like the *Diversity Leads 2020* report are an attempt to address these gaps.[384] In addressing the hiring practices of industry and equity issues, scholars are recommending that government address its limited purview over private employers,[385] particularly the issue of privately owned companies' diversity tracking.[386]

The Government of Canada can also influence organizations on the meso-level through funding and programs. Mainstreaming existing tools like gender-based analysis (GBA) and gender-based analysis plus (GBA+) can require organizations to share data for government funding.[387] The recent 50 – 30 Challenge is an example of how Government of Canada funding can lead organizational actors to collect diversity and gender data in their senior leadership teams and tie it to Government of Canada procurement processes and to encourage organizations to advance inclusion as a part of organizational strategy. Additional recommendations include government-backed incentives to encourage transparent hiring and promotion of metrics among private employers, as well as other types of incentives and rewards, like favourable taxation policies, to promote information sharing and raise diversity standards and participation in the private sector.[388]

To some extent, the Government of Canada can shape culture through the Canadian Charter of Rights and Freedoms[389] and so does Ontario with the Ontario Human Rights Code,[390] which sets societal and cultural expectations for Canadians. However, culture also exists separately from government actions, and the path to breaking stereotypes and social expectations about and for women is difficult. A concerted effort from actors on the macro-level, meso-level, and micro-level is required to break these long-standing beliefs. Organizations like the 30% Club are attempting to change stereotypes about women; organizations can voluntarily commit to the goal of having at least 30% women on their corporate boards.[391] Such initiatives can address the current under-representation of women in leadership roles in the ICT sector.

On the training side, there has been progress and investment. Innovation, Science and Economic Development Canada's Innovation and Skills Plan aims to increase the number

of professional, science and tech-related jobs in the Canadian economy (as a share of total employment) to 40% by 2025. Many programs have been launched[392] to bridge the digital skills gap and support this goal, for instance: CanCode, Digital Skills for Youth (DS4Y), Let's Talk Science, PromoScience, Jelly Academy, Actua, Future Skills, and others, including programs like the Indigenous Skills and Employment Training Program, which focus on historically under-represented groups in technology fields. But little evaluation work has been done to measure their impact, and these programs reflect only core government programs.

The Future Skills Centre (FSC) has provided funding to NPower Canada to develop a workforce development program to equip low-income young adults with in-demand digital skills that are sought by employers.[393]

Past government programs have been criticized for ***not recognizing the men-dominated composition of STEM*** *and adjacent fields and thus* ***reproducing biases and misperception*** *through its marketing to youth.*

Jelly Academy offers rapid reskilling, upskilling and microcredentials of digital skills to help Canadians land a job in the digital marketing industry. They also partner with Indigenous businesses and offer Indigenous scholarships to provide substantial discounts and subsidies for Indigenous Peoples who are interested in transitioning to a digital marketing career. Similarly, PLATO creates careers for Indigenous Peoples through their train-and-employ model, where they offer five months of in-class instruction and three months of paid internship to Indigenous people, who are then offered a guaranteed, full-time, well-paying job as a software tester at the end of the program.

There are concerns about whether these new programs address systemic barriers for equity-deserving groups and whether implementation is even across the country.[394] Past government programs like Access to Opportunities Program (ATOP) and the Federal Economic Development Agency for Southern Ontario's Youth STEM initiative have been criticized for not recognizing the men-dominated composition of STEM and adjacent fields and thus reproducing biases and misperception through its marketing to youth.[395] Thus, many have called for government to play a greater role in addressing women's participation and the "leaky pipeline" with initiatives that intervene in elementary and secondary schools.[396, 397]

Other commentators have pointed out the continued need for close collaboration between post-secondary institutions and stakeholders in the ICT sector to ensure that graduates have the deep technological skills and the ability to create digital content.[398] It

is also imperative that graduates have the social-emotional skills to help them adapt to a rapidly changing environment. The response, in part, has been reflected in the government's investment and push for WIL and other initiatives to streamline youth into experiential learning opportunities, including volunteer positions and apprenticeships.

For example, in partnership with the Diversity Institute, Future Skills and Technation, ADaPT is a work placement program aimed at bridging the gap between post-secondary education and employment; the program helps students in their final semester find jobs through intensive training of in-demand skills such as data analytics and UX design along with presentation skills and sales. The program has served more than 101 universities across Canada and trained more than 1,200 youth, 79% of whom identify as belonging to an equity-deserving group. The program has consistently achieved placement rates of 90%, even during the COVID-19 pandemic.

Finally, the macro-level includes the media and media representation, which shape culture and values. Media coverage is gendered in North America, meaning that there is biased media coverage.[399, 400] The studies on media representation has shown that women are less likely to be positively portrayed in expert or leadership positions and are under-represented in key roles.[401]

Organizational level

Organizations have a tremendous influence on meso-level factors.[402] Organizational processes, practices and policies have a significant impact on equity, diversity and inclusion (EDI). Organizations in the ICT sector can advance inclusion of women with their actions. Tools like the Diversity Assessment Tool (DAT)[403] offer guidance to organizations, which can mainstream diversity and inclusion throughout their organizational activities, ranging from HR practices to activities in the value chain. There are six categories in the DAT:

1. Leadership, Governance and Strategy: This section addresses the representation of leadership, strategy development and tone from the top.
2. HR Practices: EDI considerations can be embedded in HR practices, including recruitment, selection and promotion of employees.
3. Values and Culture: Purposeful design of an organization's policies and values can create an organizational culture to which women and diverse people in the workplace feel like they belong.
4. Measurement and Tracking Equity, Diversity and Inclusion: The measurement and tracking activities evaluate organizational efforts to advance inclusion and ensure that they are effective.
5. Gender Equity and Diversity Across the Value Chain: This section addresses activities in the value chain, including procurement, product design, communications and customer service.
6. Partnerships and Outreach: Organizations can develop partnerships and conduct outreach to create new opportunities for women in the ICT sector.

Leadership, governance and strategy

At the meso-level, organizations could examine their leadership, governance and strategy to advance gender equity, diversity and inclusion in the organization. A gender-equitable leadership team and board of directors demonstrates that the organization is serious about EDI initiatives; this commitment can be reinforced with documents like a Board policy or a skills matrix. Leadership and governance can communicate the importance of EDI to set a strong tone at the top through to the rest of the organization. Not only that, but the leadership team can also take responsibility for initiatives to mainstream gender equity in their organizations by forming diversity and inclusion committees.

Leadership and governance in the organization is also responsible for determining organizational strategy. Leaders in the organization can incorporate gender equity, diversity and inclusion as a part of their organizational goals, in their key performance indicators and as a part of the organization's mission and mandate. The Future Skills Centre, in collaboration with the Conference Board of Canada, conducted stakeholder interviews with executives and upper-level managers at leading Canadian companies to better understand their digital skills needs, the impacts of the COVID-19 pandemic in the workplace, and ideas for training and upskilling.[404] The interviews are being used to inform a larger survey that will be administered to better understand the specific digital skills that are needed to provide recommendations for leaders on the tools and training to ensure that their strategies will prepare them for the future.

Human resources practices

Human resources practices are focused on employees throughout the employee lifecycle, comprising a range of activities including recruitment, selection, promotion, training and termination. Organizations can identify gaps and remove barriers for women in the ICT sector at every step. For example, in the recruitment phase, organizations can review job postings to ensure that the required qualifications fit the demands of the job. As some of the research has shown, diverse academic backgrounds can contribute to the ICT sector.[405] Organizations may be presenting barriers to women if they enforce strict academic qualification requirements, given the under-representation of women in STEM. Reviewing job postings as well as other actions, such as encouraging equity-deserving groups to apply, play a role in developing a comprehensive recruitment strategy for women.

In terms of candidate selection, a gender equitable and diverse selection committee ensures that unconscious biases are kept to a minimum. There are resources to support bias-free selection processes as well, such as diversity training and interview guides. Promising new technologies aim to increase equity in the workplace by confronting unconscious bias. For example, apps like Blendoor and GapJumpers provide diversity hiring through sourcing, anonymization and analytics; software like interviewing.io offers mock interviews and even voice-changing masks that disguise a candidate's voice to take gender out of the hiring equation; AI software that screens for success traits; and others. However, there is disagreement on their efficacy and actual outcomes, with some suggesting that blind-hiring may not produce intended results because it does not confront the underlying and systematics issues in workplace diversity;[406] others point out that trust in the neutrality of technology is misguided as AI systems themselves have been shown to carry and even exacerbate bias.[407]

To widen the talent pool, there has also been a shift from credential-based hiring to a skills-based hiring system. For instance, Shopify has dropped their degree requirement in job postings in favour of participants demonstrating specific skills during interviews.[408] Similarly, the FSC-funded Blueprint to develop a pre-arrival program for newcomers called FAST: Facilitating Access to Skilled Talent.[409] FAST is an online, occupation-specific skills assessment and development platform that helps newcomers overcome barriers in the workplace such as the lack of recognition of international credentials and Canadian work experience. However, there is a dearth of skills assessments available to organizations as many have not been properly tested or validated against an external criterion. Additional research is needed to map innovative approaches and promising practices and technologies in recruitment and hiring.

Values and culture

Organizations in the ICT sector can create a welcoming organizational culture for women, providing a safe space free of discrimination and allowing them to bring their full selves to work. One aspect of creating such an organizational culture is through policies, which formalizes cultural expectations and behaviours. An equity, diversity and inclusion policy and a code of conduct and ethics policy are examples; through these policies, organizations can address core values, standards of professional behaviour and the importance of diversity and inclusion.

Inclusive organizations also support women and diverse groups by examining their day-to-day practices. Organizations can provide flexible working arrangements and family-friendly working arrangements to help women manage personal lives and family lives; alternatively, they could provide child care services as a part of the benefits package.

Measurement and tracking equity, diversity and inclusion

As management guru Peter Drucker wrote, "What gets measured gets managed." It is important to measure and track the

progress of initiatives so that organizations know that they are advancing in the right direction. Setting targets and goals directs organizational efforts into specific actions and helps organizations determine if their strategies are working to meet these targets and goals. For example, organizations can set targets for increased representation of women in leadership positions, and then they can track and review the progression of women within their organizations to see if their strategies are working. As an additional step, organizations can set accountability measures to reinforce these targets and goals. Another important measure that organizations can track is pay equity. Pay audits reveal if women and men are provided equal remuneration for an equal amount of work.

Gender equity and diversity across the value chain

The value chain runs a large range of organizational activities from procurement to customer service. Organizations can ensure that gender equity, diversity and inclusion are mainstreamed each step of the way. In procurement, organizations can focus on purchasing their goods and services from majority-women-owned businesses. Diverse supplier councils like WEConnect International Canada and WBE Canada certify women-owned businesses and help connect them to procurement opportunities. A supplier diversity policy can also formalize practices to ensure that the organization regularly considers supplier diversity in purchasing decisions.

EDI can also be mainstreamed in product and service development and design. If products and services are only developed and designed with men in mind, this could have repercussions for women users. This is particularly evident with AI technology. AI algorithms have come under scrutiny because they perpetuate gender- and diversity-related biases.[410] Gender and diversity must be considered in the design and training of AI algorithms to benefit all users. Likewise, organizations could embed gender and diversity considerations in product and service development processes.

Organizations interact with users, customers and clients in their marketing and communications materials as well as through customer service. A comprehensive approach to gender equity and diversity across the value chain should consider

how women and diverse groups are being represented in communications and marketing materials, with an eye to eliminating stereotypes and profiling women as role models to highlight skills and achievements. In terms of customer service, organizations could offer training so that customer service is able to respond to diverse customer or client needs.

Partnerships and outreach

Finally, organizations can create outreach strategies and for partnership development to develop the future pools of talent of women in the ICT sector. Organizations can do this by partnering with external partners on projects to improve the representation of women in ICT. External partners can vary, including individuals, government, private sector organizations and non-profit sector organizations. Organizations can also engage with girls earlier on in the education system to encourage them to explore STEM subjects and ICT careers.

Appendix A displays a list of programs in Ontario that include training for software development, cybersecurity and the development of hybrid skills such as entrepreneurship and sales. Many of these programs are free. They range from workshops that are as short as two weeks to accelerator programs that span over two years. The programs also vary in sectors, such as cleantech, e-commerce and tech sales. The training programs are hosted by a mix of public and private institutions, non-governmental organizations and post-secondary institutions. These programs are just a few of many that are underway in addressing the ICT worker shortage and ensuring that Canada can meet the needs of the digital economy.

A contributing factor to the lack of representation of Indigenous Peoples in the ICT sector is low interest and motivation to participate in the industry. To tackle this obstacle, FSC has funded a project with Actua to work closely with Indigenous community leaders, local school boards, Elders and industry partners to develop a locally and culturally relevant curriculum to build the digital literacy of Indigenous youths.[411] Similarly, FSC has funded the InTeRN project, which provides training in ICT to Indigenous women and youth to equip them with the skills needed to work as frontline technicians in Manitoba-based ICT industries that service the North.[412]

Individual level

On the micro-level are individual attitudes, decisions and behaviours.[413] While individuals are shaped by macro-level factors (e.g., culture, government policies and media representation) and meso-level factors (e.g., organizational practices, policies and processes), they also have agency to shape their own opportunities and create opportunities for those around them.

Instead of being mere bystanders, individual actions can have a powerful effect on gender equity and inclusion in the ICT sector. For lasting change, everyone in the organization needs to participate to contribute to inclusion. Individuals with some degree of influence can mentor, sponsor and act as allies for women in the ICT sector. Individuals

can also use their influence and privilege to call out bad behaviour in the workplace and support initiatives that could advance equity, diversity and inclusion in organizations and in their communities.

By taking action and using one's individual sphere of action, everyone can initiate positive feedback loops that reverberate to meso- and macro-levels, effecting change in organizations and society.

Innovative initiatives to promote the development of digital skills

The key to filling the digital skills gap and meeting the demands for the digital transformation of the economy, is a focus on skills and in particular, digital skills training. Numerous initiatives are aimed at filling this need. The Government of Canada–funded FSC is advancing and funding innovative programs that create alternative pathways to bridge the current programming gap. The FSC looks to create an agile and collaborative training ecosystem that equips Canadians with the skills to thrive in a rapidly changing economy. The FSC also integrates inclusion as a key organizational principle and aims "to ensure an inclusive approach to supporting underserved groups such as women, youth, Indigenous Peoples, newcomers, racialized peoples, 2SLGBTQ+ peoples, persons with disabilities, veterans, and Canadians living in rural, remote, and Northern communities."[414]

*The FSC looks to create an **agile and collaborative training ecosystem** that equips Canadians with the **skills to thrive in a rapidly changing economy**.*

Skilling Canadians for the ICT sector is an essential interest to the FSC, which has partnered with a many organizations to fund innovative programs with this purpose in mind. Table 11 below highlights and summarizes some of these programs. A full list is available on the website of the Future Skills Centre.[415]

TABLE 11

Selected Future Skills Centre programs to skill Canadians for the information, communications and technology sector

Program partner	Program name	Target participants	Program description
Actua	For-Credit InSTEM Program	Indigenous youth	Actua improves Indigenous youth representation in digital and STEM-based economies. The for-credit high school program combines cultural teachings and Indigenous knowledge with skills development.
NPower Canada	Upskilling Canadian youth for in-demand tech careers	Vulnerable, unemployed youth	NPower Canada offers a workforce development program that works with employers to identify IT hiring needs and then equips youth with these in-demand skills. The program offers skills training, job placement and post-hire services like mentorship at no cost to participants.
Technation Canada, Diversity Institute	ADaPT: Digital competencies	Post-secondary graduates not in STEM	AdaPT provides pathways into digital jobs for graduates not in STEM subjects by training participants in digital skills, competencies like innovation and entrepreneurship, and core skills like communication and adaptability. The program also offers supports like coaching and job placement assistance. ADaPT participants are largely from under-represented groups.
University College of the North	InTeRN	Indigenous women and youth	The InTeRN program takes a culturally sensitive approach to ICT training for Indigenous women and youth. It offers Indigenous storytelling, flexibility to match family and community priorities and work-integrated learning with industry. There are also wraparound supports like mentorship, transportation and counselling.
Rogers Cybersecure Catalyst	Emerging Leaders Cyber Initiative	Under-represented groups, including women and racialized people	The program looks to upskill under-represented groups into the cybersecurity industry to meet projected demands.

Appendix A: Digital Skills Training Programs for Women and Girls in Ontario

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
ACCESS employment	Non-governmental organization (NGO)	Ontario	Women in Technology	The Women in Technology program helps newcomer women to start a career in IT by building essential technology skills in areas like programming, web development and coding. In addition to industry-specific technical training, the program also provides newcomers with an understanding of Canadian workplace culture, connections to employers, job search coaching and mentorship. To be eligible, clients must reside in Ontario and hold valid permanent residence status in Canada.	X		8-week program (experienced stream) 12-week program (inexperienced stream)	$0
International Development and Relief Foundation (IDRF)	NGO	Ontario, Alberta	Women in Tech	Women in Tech teaches young Canadians the skills to build websites and apps and prepares them to launch careers as Full Stack Developers. IDRF is committed to eliminating barriers for young women interested in the digital space who cannot afford coding programs.		X	30 hours Intro to Web Development program & 12-week intensive bootcamp	$0

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
Skills for Change	NGO	Ontario	Women in IT	Women in IT empowers women with education or experience in the technology sector by providing them with training in tech sales and accounting management. This program prepares women with knowledge of professional workplace practices and communication and connects them with employment through employer connections and mentorship.		X	20 weeks	$0
TALENT-MINDED	Private	National	Women in Tech Sales (Virtual) Bootcamp	Less than 20% of tech sales positions are held by women—even less if you are a woman of colour. This industry-vetted, intensive training program helps match women who want to pursue or advance their skills in tech sales with leading organizations looking to tap into a diverse, sales-ready talent pool.	X		5 days	$199
L-SPARK	Private	Ontario	Compass North	Compass North is an accelerator program for women-led startups in the greater Kingston region. Compass North is looking for women entrepreneurs who live in eastern Ontario and who are leading and building a tech-based company with primary operations in select areas of eastern Ontario.		X	5 months	$0

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
MindBridge	Private	Ontario	HERoes program	Twice a year, a HERoes masterclass takes place in Ottawa, offering students a full-day experience alongside the brightest leaders in business, academia, and government. Rather than focusing on technical skills, the HERoes masterclass is designed to teach leadership and business acumen to lead the STEM projects of the future.		X	1 day	$0
VentureLAB	Public/Private	Ontario	Tech Undivided	Tech Undivided offers a comprehensive program to challenge women-led tech companies to scale their businesses. Through the pillars of capital, talent, intellectual property and technology, and customers, this program creates a support ecosystem of resources and networking opportunities for women founders to thrive. Tech Undivided is designed for founders building breakthrough solutions leveraging hardware or enterprise software technologies. It draws on the combined expertise of VentureLAB Advisors, Strategic Mentors and exclusive partners to offer strategic and tactical support to help participants refine their product-market-fit, amplify their sales, navigate relevant sources of funding and help hone their pitch to better prepare for customer and investor meetings.		X	6 months	$0

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
UforChange	NGO	Ontario	Graphic Design and Web Development	The Graphic Design and Web Development program is offered to all womxn aged 16–29 who are interested in learning the fundamentals of web development and foundations of graphic design. Students learn to build a website from scratch using programming languages with HTML, CSS, JavaScript and jQuery. They also delve into Adobe Photoshop, Illustrator and XD, learn design thinking and develop their personal branding.		X	2 months	$0
MaRS	Public/Private	Ontario	Women in Cleantech Accelerator	To solve the world's climate challenges, we need more than just good ideas. We need diversity of thought to deliver meaningful impact. This means women and individuals from underrepresented communities, more than ever, need to be part of the solution. The Women in Cleantech Accelerator, sponsored by RBC, is part of the answer. We are recruiting a mix of seven to 10 exceptional women entrepreneurs and will coach them through an intensive 24-month program, connecting them to top government laboratories, investors and corporate partners.		X	24 months	$0
Girls Who Code	NGO	National	Self-Paced Program	This virtual program teaches girls and non-binary students the computer science skills they need to make an impact in their community while preparing for a career in tech. Participants will get exposure to tech jobs, meet women in tech careers and join a supportive sisterhood. More advanced courses in Python with a focus on cybersecurity are also offered.	X		6 weeks	$0

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
Girls Who Code	NGO	National	Summer Immersion Program	This virtual program teaches girls and non-binary students the computer science skills they need to make an impact in their community while preparing for a career in tech. Participants will get exposure to tech jobs, meet women in tech careers, and join a supportive sisterhood grounded in tech.	X		2 weeks	$0
hEr VOLUTION	NGO	Ontario	GO!stem Virtual Summer Program	GO!stem Virtual Summer Program provides a safe space for girls and gender non-conforming youth aged 13–17 to explore study and career pathways in the field of STEM.	X		1 week	$0
hEr VOLUTION	NGO	Ontario	STEMing UP	In collaboration with Canada's technology leading industry partners such as Shopify, STEMing UP equips BIPOC girls and gender non-conforming youth in Ontario with the confidence, skills, professional portfolios and networks to pursue fulfilling careers in the STEM industries. Participants have the option to return for two years in the program and are increasingly challenged with real-world problems set by mentors, and solved through skills they develop in the program.	X	X	6 months	$0

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
Rogers Cybersecure Catalyst	Post-secondary education (PSE)	Ontario	Accelerated Cyber-security Training Program	The Accelerated Cybersecurity Training Program is designed to give promising individuals from diverse backgrounds the skills they need to launch careers in the cybersecurity sector. Rogers Cybersecure Catalyst created the program in partnership with the SANS Institute, the world's leading cybersecurity training and certification firm. The program is supported through the generous partnership of the Government of Canada, Rogers Communications and Royal Bank of Canada.	X	X	7 months	$500
Rogers Cybersecure Catalyst	PSE	Ontario	Mastercard Emerging Leaders in Cyber Initiative	The Mastercard Emerging Leaders in Cyber Initiative (ELCI) is a unique leadership program designed to support the development of women-identifying executive leaders in cybersecurity. It will meaningfully contribute to the development of a diverse community of cybersecurity leaders, growing the talent pipeline Canada needs to secure the nation's digital transformation and deliver on its national cybersecurity strategy. The program targets high potential women-identifying professionals in mid-to-senior-level roles, giving them the skills needed to progress their careers toward executive-level leadership positions, such as CISO or CTO.	X	X	6 months	$0

Organization	Type of organization	Region/ province	Program	Description	Online	In-person	Length	Price
Lighthouse Labs	Public/Private	Ontario	OWN Initiative	OWN Initiative provided 250 Ontarians (with a focus on newcomer women) with the technical and pre-employment or soft skills needed to achieve careers in web development. Lighthouse Labs is coming together with community partners and training delivery partners (Achēv, Ottawa Chinese Community Service Centre, YMCA) and CATA Alliance, to provide an innovative, made-in-Ontario solution to the employment and skills barriers experienced by unemployed and underemployed Ontarians and newcomer women. This initiative will be used to address skills and labour market access barriers for Ontarians and newcomer women and the employers who hire them.	X		12 weeks	$0

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