

THE STATE OF DIGITAL LITERACY IN CANADA

A LITERATURE REVIEW



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EXECUTIVE SUMMARY

The main purpose of this literature review is to bring together relevant research in order to contextualize the Brookfield Institute’s broader *State of Digital Literacy in Canada* study. While scoping out Canadian policy texts and existing programs, it also draws on international research, best practices, and the work of digital literacy experts globally to define digital literacy, the skills it comprises, as well as its importance. These sources have pulled mainly from educational and pedagogical research, work on technology and the economy, as well as a variety of policy papers, reports, recommendations, and studies.

One of the challenges in synthesizing research on the subject of digital literacy is the sheer number of sources, as well as the fact that the concept intersects with many others, such as computational thinking, coding, e-literacy, media literacy, ICT skills, STEM, and so on. The lack of a single common definition of the concept implies that sources have varied conceptions of the term “digital literacy” itself. Much of the work cited was relatively recent, given that the concept of digital literacy has become more frequently used since approximately 2009, and that meaning of the concept has changed over time. This literature review focuses particularly on the skill sets that comprise digital literacy from a labour market perspective.

Although the Government of Canada (along with provincial governments) has identified innovation and the development of local digital talent as a key priority, recommendations remain imprecise. The focus on coding as a crucial skill for the economy of the future has arguably obscured the necessity for a broader emphasis on digital literacy as such, as well as the spectrum of skills the digital economy will require by 2020.

This review has found several broad themes of focus in the digital literacy: defining the term itself and what skills it comprises (Theme 1), its place in the digital economy and the changing nature of the workplace (Theme 2), how digital literacy can and should be taught from kindergarten to the workforce (Theme 3), and how digital literacy can address and exacerbate

existing digital divides and exclusions (Theme 4). In Emerging Research Questions (III), we identify perceived gaps in research. Appendix A documents key research institutions and researchers on the topic of digital literacy. Appendix B contains an annotated bibliography of consulted sources.

MAIN FINDINGS + CONCLUSIONS

BACKGROUND

Digital literacy in Canada

Despite growing recognition of the importance of digital literacy in preparing students, workers, and citizens for the increasingly digital economy of the 21st century, Canada appears to lag behind significantly in promoting it. As will be explored at length in Section 1, there is no common definition of digital literacy among theorists, policymakers, and educators, and no standard method of measuring it, which makes it difficult to say with certainty what the state of digital literacy among Canadians is. Studies which claim that digital literacy in Canada is low use other indicators, such as Canada's lack of institutional response to digital literacy needs in education, the lack of a national strategy, and what some find are low levels of university graduates in ICT and STEM.

There are evident and substantial gaps in studies on the state of digital literacy in the country, though the topic is gaining momentum, with the majority of relevant studies published in the last two years. Although the concept of digital literacy dates from the mid-1980s, it has risen to greater prominence in the last decade, and taken on new meaning. Attention began to be paid to the topic in 2010, with a Media Smarts study and ICTC white paper in the same year. In 2010, an ICTC white paper suggested that one of the crucial steps in bolstering digital literacy in Canada was designing a standardized system by which to measure it. They recommended a reference scale which would measure digital literacy levels, which would be used to advertise the needed level for particular occupations. This would allow the government to identify specific sectors lagging behind. In 2013, Media Smarts director Matthew Johnson declared that Canada

was at a crossroads in regards to digital literacy at the Canadian Internet Registration Authority (CIRA) Canadian Internet Forum (Gall, 2013).

However, Canada does not have a national digital literacy strategy which would support digital literacy in K-12 and post-secondary education as well on-the-job training and upskilling (Media Smarts, 2010). This is a recommendation that has been stressed by different actors since 2010, including by a panel at the Canadian Science Policy Conference (2015). ICTC (2010) suggested that any national strategy for digital literacy will necessitate strong partnerships between levels of government, civil society, and the private sphere, citing First Nations organizations, educational institutions, organizations such as the Canadian Advanced Technology Alliance and Canadian Coalition for Tomorrow's ICT Skills, and large companies such as IBM and Microsoft as natural partners in such a strategy.¹ In the same year, Media Smarts argued for the need for a national strategy, positing that Industry Canada was the best government department to lead and oversee it.

Despite recognition of the problem by non-governmental actors, the government has been slower to act. In 2002, a National Summit on Innovation and Learning yielded a set of recommendations which included establishing “a pan-Canadian literacy and essential skills development system” and integrating “innovation-related skills in curricula” (Government of Canada 2002). Though not explicit, these recommendations were evidently aimed at boosting digital skills. A 2010 Digital Economy Strategy Consultation process begun by the Conservative Government lobbied for digital literacy skills, but the governments focus remained on boosting infrastructure and security (von Hamel, 2011). A Government of Canada report called Digital Canada 150: Building digital skills for tomorrow (2010) identified these gaps, recommending a long-term strategy that would expand post-secondary education in ICT and related fields, increase placements and co-ops, strengthen the opportunities for those in the workforce to grow their digital skills, though it is unclear that such a strategy ever took root. Part of the Government of Canada's 2015 Open Government commitment included promoting digital literacy. One of their three goals was completed – developing an online assessment tool to

¹ Though there is some evidence of these cross-sectoral partnerships in specific provinces, as yet they do not appear connected to federal government initiatives.

measure Canadians' skills, including digital skills. The other two goals achieved only limited completion: funding 'private sector and civil society initiatives aimed at improving the digital skills of Canadians' and sponsoring 'projects to increase understanding of the relationship between digital skills and relevant labour market and social outcomes' (Government of Canada, 2015).

Without a national strategy, provincial education systems do not have streamlined curricula that incorporate digital literacy and computer science courses, nor is professional training for teachers secured across the board. This leads to wide variations between provinces. There are no official government avenues to train older people who are already in the workforce, or retrain workers whose positions necessitate greater digital skills. Some schools in Canada have begun offering coding classes 'voluntarily' (i.e., despite it not being curriculum prescribed), with Saskatchewan teachers offering such classes as early as Grade 1 (Cassidy, 2015). Cassidy (2015) points out that while coding was offered in school courses in the 1980s, by the 1990s users of computer technology no longer had to understand the code underlying it – and thus learning it dropped out of the curriculum. Interestingly, it is increasingly becoming acknowledged that simply being users or consumers of digital technology does not fully equip one with the digital skills necessary for the workplace.

Media Smarts has the first wide-ranging survey of digital literacy skills among youth in Canada, "Young Canadians in a Wired World," which was based on a 2013 poll of over 5,000 students in public Canadian K-12 education. They found that most Canadian youth have a basic level of digital literacy skills, and that they overwhelmingly learn these skills from parents and teachers (Media Smarts, 2015). This is the only measurement of its kind of digital literacy skills in Canada, and it was defined by simple tripartite understand of literacy, assessing the students' ability to use, understand, and create digital technology. Each of these skills had subsets such as verifying information found on the web and understanding privacy online. However, the study did not include a defined set of literacy levels (ex., from low to high) that could easily be applied across the workforce.

A 2013 Statistics Canada study on the OECD Programme for the International Assessment of Adult Competencies (PIAAC) measured the literacy, numeracy, and problem-solving in

technology-rich environments (PS-TRE) skills of Canadians. They found that Canadians were above the OECD average in technology use, and that problem-solving skills were higher than average. Canada was second in the proportion of its population at the highest level of proficiency in technological problem-solving, with 37% of Canadians scoring at higher levels, compared to the average of 34%. However, there was significant in-country variation. The study also noted that digital problem-solving skills varied with age and education level – PS-TRE scores were lower than the OECD average in Nunavut and Newfoundland. Canada also had a higher proportion of its population at the highest and lowest levels of literacy, suggesting a large national divide. While PIAAC’s PS-TRE measurements cannot be used as a proxy for digital literacy, it does shed some light on the digital skills of Canadians. It is likely that digital literacy is affected by similar intervening factors (age, education, gender), for example. The aforementioned Canadian Science Policy Conference (2015) panel underscored the importance of including young women, indigenous youth, and youth living in poverty in digital literacy programs, stressing that every future career will require such skills (see Theme 4 – the digital divide).

The lack of unified public sector education in digital literacy has made space for a host of private and non-profit organizations which offer courses for children and adults. Coding in particular is increasingly seen as the marker par excellence of digital skill and as such a popular activity – the growing number of private ‘bootcamps’ and courses offering coding classes to youth are testament to this. Often, however, the focus on offering coding classes obscures the wider spectrum of digital literacy and STEM training which underpins a strong knowledge economy and innovation sector. For example, Hunter (2015) argues that code should be designated Canada’s third official language – in particular making the case for nurturing in-demand skills in the economy. While unquestionably important, studies continue to identify a lack of enrollment in higher level STEM courses, a general lack of digital literacy embedded in curricula, and digital divides as more pressing issues. A host of other organizations have stepped in to fill the void, including Actua (which offered programming to over 100,000 excluded youth in 2015-2017 [Flanagan, 2015]), Let’s Talk Science, Ladies Learning Code, Kids Code Jeunesse, and Youth Science Canada. Jeremy Depow of Canada’s Digital Policy Forum argues that the organizations tend to be under-resourced and regionally focused, however (n.d.), and many come with high

price tags. If the digital divide is not to be exacerbated, programs which offer literacy and coding courses to underprivileged youth (such as Actua and Covenant House) need more government support in order to be the rule rather than the exception.

A 2015 Media Smarts report reiterated the call for the creation of a national digital literacy strategy as well as a ‘digital literacy taskforce’; neither has been created to date. Their envisaged taskforce would take inventory of all existing digital literacy programs in Canada, the lack of which presents a significant gap in the research, and without which there would be no starting point for a national strategy which would bring all relevant stakeholders together. Without a common understanding of the basic level of digital literacy needed across all Canadian students, workers, and citizens, it is unlikely that literacy can be promoted in any uniform way. To date, Media Smarts is the only organization to attempt to map and measure digital literacy in Canada.

Gaps in Skills, Innovation, and Productivity in the Canadian Economy

Canada’s ICT sector suffers from talent shortages which are predicted to worsen in the coming years. A 2010 Government of Canada report (“Digital Canada 150”) identified the Temporary Foreign Worker program as a short-term response to these shortages, and recommended permanent immigration as a longer-term solution. In 2010, Media Smarts asserted that the lack of digital literacy strategy was linked to Canada’s declining productivity and performance in the digital economy. Indeed, a 2014 Media Smarts report titled “Digital Literacy in Canada: From Inclusion to Transformation,” finds that research and international precedents have demonstrated that digital literacy is key to an inclusive and innovation-drive knowledge economy. They argue that investing in the digital skills and knowledge of Canadians (i.e., digital talent) is crucial to a functioning digital economy. Digital literacy provides a guarantee that Canadians have the skills to adapt to, engage with, and innovate in a digital economy, as well as benefit from it (Media Smarts, 2014).

The Connectivity Scorecard, which measures connectivity performance in 50 countries, ranks Canada 12th in innovation driven economies (2017), down from 5th place in 2012. This low score can be attributed to the low level of ICT investment in Canada as opposed to the U.S., as well as

“Canadian businesses' lower digital literacy” (Industry Canada, 2014a). Industry Canada pointed especially to the need for industries to train workers in digital literacy, particularly SMEs (2014a).

In terms of digital skills, there is no standard in training or upskilling workers. Industry Canada noted in 2010 (“Digital Literacy and Essential Skills”) that Canada lags behind in adult education, including training and retraining members of the workforce. Although companies have trouble filling their vacant positions with skilled workers (as noted recently in the ICTC survey from 2016[a]), they are not willing to train potential workers to fill them: “Canadian firms spend proportionately less on workforce training than employers in the US” (Industry Canada 2010). ICTC suggested in 2016 that the government issue subsidies or tax credits for SMEs in particular to alleviate financial costs of digitally upskilling employees (Asliturk, 2016).

It is clear that bolstering digital skills in youth and the workforce is a crucial part of talent development. ICTC has published several reports on the state of Canada’s digital talent. A 2016 report (Digital Talent Road to 2020 and Beyond) suggests that growth in digital jobs has outpaced talent supply, and that domestic supply of ICT graduates will be insufficient to fill a demand for 182,000 skilled ICT workers by 2019, a number echoed by Wolfe (2016). A 2014 strategy document published by Industry Canada during the previous Conservative government, called “Seizing Canada’s Moment,” purported to “develop, attract and retain highly-qualified and skilled individuals” that will boost Canada’s place in the global knowledge economy. Many of Canada’s ICT workers are indeed from abroad. According to ICTC (2016b), 40% of Canada’s ICT workers are immigrants, much higher than the share of immigrants in any other profession. Most of these immigrants are permanent residents, while only 4% are temporary foreign workers. This suggests that much of Canada’s supply shortage of skilled digital workers is dealt with via attracting immigration rather than by educating its graduates. However, the country struggles both with education as well as with attracting (and retaining) global talent. Jeremy Depow of Canada’s Digital Policy Forum frames this problem as a ‘global race for digital skills’, linking the lack of ICT investment and education as well as hurdles for companies seeking to attract global talent with Canada’s falling innovation scores.

A late 2016 ICTC study (a) was based on wide-ranging surveys with businesses and graduates, and points to a growing skills mismatch between demand and supply of new graduates, with far

less students enrolling in STEM disciplines than required by the labour market. In fact, enrolment in post-secondary education appears ‘inverted’ to market realities, with graduates in the humanities twice as numerous as in technology. The problem of low STEM enrolment can be traced back to secondary school, where STEM courses are dropped by more than half of students in Grades 11 and 12 by students who see it as ‘too hard’ or irrelevant to their careers (Let’s Talk Science, 2013).

Beyond the lack of ICT-specific graduates, ICTC warns that non-ICT workers will increasingly need to be skilled in the use of new technologies. Estimates say that around 84% of jobs in Canada currently require use of a computer and basic technical competencies (ICTC, 2016a) and that even low-skilled jobs increasingly require a basic level of digital literacy (Essential Skills Ontario). Employers in Canada also identify that ‘soft’ skills are lacking among applicants (ICTC, 2016a), though how these skills are related to digital literacy is unclear. However, there was evidence that employers do not have recruitment strategies which involve the seeking out or training of new workers, and that as such much of the ‘talent shortage’ can be ascribed to an underutilized workforce with little practical training.

In contrast, a 2015 study from the Council of Canadian Academics found no significant evidence of a shortage of STEM-skilled graduates nationally, stating that long term economic projections were difficult to predict, and it was not possible to accurately quantify skills shortages of the future. More specifically, they found no link between Canada’s innovation gap and a shortage of STEM skills. They also claim that although many highly skilled Canadians leave the country, they are ‘more than offset’ by skilled immigrants. Both studies underscored the untapped labour resources among women, indigenous youth, and poor youth in particular, who are as yet underrepresented in technology-skilled positions, as well as in STEM classes in high school and postsecondary enrolment.

Many studies reference a growing gap in Canada’s relative innovation and productivity. A report from the *Institute for Competitiveness and Prosperity* in Ontario (2016) argues that the growing skills gap may threaten Ontario’s economic growth, and that this gap is linked to the province’s productivity and prosperity gaps with peer economies. Canada’s underperformance in innovation has led to advocacy for more direct support to the innovation process (Creutzberg,

2011). Responses to this gap, however, have to date not brought digital literacy to the fore. Ontario's 2015 Innovation Agenda, frequently cited in ICTC reports, speaks vaguely of the spectrum of skills required for innovation. It fails to name digital literacy, digital skills, or 21st Century skills as an area of particular focus.

More recently, innovation agendas by the federal and provincial governments have promised more investment in STEM in higher education, particularly focused on technology, including cloud computing, advanced research computing and big data strategy (SSTI 2017). The Canadian Advisory Council for Economic Growth recommended that building a skilled and resilient Canadian workforce would be crucial to this innovation agenda, as would easing immigration barriers for global talent acquisition (SSTI 2017).

However, it is increasingly clear that digital literacy among *all* Canadians is crucial for building a healthy 21st century economy that is innovative, productive, and competitive. The country's government has to date focused more on internet access as vital to the economy, declaring broadband internet access a 'basic service' in 2016, admittedly a crucial move to improve access and speed in remote and rural communities (Kupfer 2016). However, the dominant question in the literature is no longer one of whether people can access the internet, but whether they can adequately use and understand the changing digital technologies that increasingly define the workplace. Colledge and Haight (2016), for example, argue that building digital infrastructure and broadening access to the internet *without* teaching digital literacy is imprudent and will lead to increased inequality.

THEME 1: DEFINING DIGITAL LITERACY

There is no unitary definition of digital literacy or what comprises it, though there are many taxonomies and typologies of it and similar concepts. Some studies conflate concepts of digital, media, information, and computer literacy, while others use 'digital literacy' as a broad umbrella term presupposing all other tech-literacies. Some authors, such as Boechler (2014) track the evolution of the concept through time, while others such as Stordy (2015) and Chinien (2011) have compiled taxonomies of its different uses. Older classifications (e.g. Addison and Meyers, 2013; McClure, 1994; Spitzer et al., 1998; Bawden, 2001; Savolainen, 2002; Lonsdale and McCurry, 2004) are arguably outdated, which points to the quickly changing nature of the concept's

definition. As such, there is no single measure of digital literacy, and large studies like the OECD’s PIAAC are imperfect indicators of the same.

Most authors are in agreement that there is no singular definition of digital literacy and no static definition of the skills it comprises – rather, digital literacy is seen by most as the capacity to navigate and adapt to a changing digital environment. This includes the capacity to continue to learn over one’s lifetime – not “a one-off achievement, but as something that is constantly enacted” (Jisc, 2016), which speaks to the fact that technologies are ever-evolving, as is the workplace.

The meaning of digital literacy shifts between disciplines and authors’ backgrounds – be they academic, librarian, policymakers, NGOs, business, or tech sector. Stordy (2015) counts 685 articles and books published on digital literacy from 2012–2015 – with 35 distinct types of literacy mentioned among them. Stordy categorizes these into a framework of 6 perspectives on literacy, with one axis viewing literacy as a cognitive ability or as a social practice, and the other axis ranging from views that these ‘new’ literacies are not new, to the belief that digital literacy introduces both new technological and ethical elements.

	Conventional literacies <i>No new “technical stuff” or “ethos stuff”</i> (Lankshear and Knobel, 2007)	Peripheral cases <i>Just new “technical stuff”</i> (Lankshear and Knobel, 2007)	Paradigm cases <i>New “technical stuff” and new “ethos stuff”</i> (Lankshear and Knobel, 2007)
Autonomous literacies <i>Literacy as a cognitive ability</i> (Street, 1984)	Autonomous-conventional perspective	Autonomous-peripheral perspective	Autonomous-paradigm perspective
Ideological literacies <i>Literacy as a social practice</i> (Street, 1984)	Ideological-conventional perspective	Ideological-peripheral perspective	Ideological- paradigm perspective

Figure 1. Stordy's six perspectives of literacy

These six perspectives can roughly be associated with different sectors and disciplines. Stordy finds that US school curricula for learning digital literacy and technical skills often fall into the

‘autonomous conventional perspective’, which posits that digital literacy contains no particularly new technical stuff or ethical concerns, and is primarily a cognitive ability. EU institutions and UNESCO tend to believe that digital literacy requires new technical skills, but that the underlying cognitive functions are not new. On the other hand, some believe that web technologies are a paradigm shift which changes the meaning of literacy itself – this is typically associated with the belief that programming is a new literacy. The work of Mark Prensky (who first wrote on ‘digital natives’) falls into this ‘autonomous paradigm perspective’. Academic librarians often fall into an ‘ideological conventional perspective’ which focuses on social practices of literacy but does not center on technology. Work that studies young peoples’ internet practices considers literacy a social practice while centralizing the role of new digital technologies, particularly the internet. Stordy argues that most of these ‘ideological peripheral perspectives’ date from the late 1990s. Lastly, those in the ‘ideological paradigm perspective’ consider that new social practices have arisen with digital literacy: the digital presents a paradigm shift in technology as well as ethos. This perspective is most often found in academic settings.

Stordy’s integrated definition for digital literacies is as follows:

“The abilities a person or social group draws upon when interacting with digital technologies to derive or produce meaning, and the social, learning and work-related practices that these abilities are applied to” (2015).

Jisc, an NGO which works on digital services for higher and further education in the UK, similarly emphasizes that digital literacy changes across time and contexts, and is “essentially a set of academic and professional situated practices supported by diverse and changing technologies” (2014) which allow someone to live, learn, and work in digital society (Jisc, 2015).

A host of other terms are associated with digital literacy – each with a set of definitions as varied. The terms ‘ICT literacy’, ‘computer literacy’, ‘ICT skills’, ‘technological literacy’, ‘media literacy’, ‘information literacy’, ‘e-literacy’, ‘multiliteracies’ and ‘new literacies’ (Pinto, 2010) are used in similar ways. Spengler (2015) views digital literacy as a combination of the qualities of some of these older notions: computer literacy, media literacy, and information literacy. Boechler (2014) tracks the evolution of these concepts over 40 years. Computer literacy, she

argues, began in the mid-1970s as a way to talk about programming skills – the concept remains in use as ICT literacy. In the later 1970s, the concept of Information Literacy was used mainly by the librarian profession; the 1990s brought the concept of network literacy, and the late 1990s blended the technical skills of computer literacy and critical skills of information literacy to introduce digital literacy. Digital literacy was popularized by Gilster in 1999 (Stordy 2015) and from then on was defined either as a set of skills, or as a type of knowledge (Boechler).

In line with Boechler’s taxonomy, current studies focus either on what skills digital literacy is comprised of, or what type of knowledge it is. Some authors argue that digital literacy is more than a set of defined skills – rather, they offer frameworks for what digital literacy does. This sort of classification falls close to the EU concept of digital competences, which focuses not on one-off skill sets but on the sort of thinking and knowledge that allows one to continue learning as technology shifts. There is growing use of ‘digital competence’ as a synonym for digital literacy (Vuorikari, 2016). Ng (2012) argues that digital literacy has more aspects than technological skill, and that it “embraces technical, cognitive and social-emotional perspectives of learning with digital technologies, both online and offline.” The focus on the ability to learn and adapt quickly speaks to what authors call ‘metacognition’ and the ability to pick up ‘new semiotic language’ (Ng) in technological environments. Gui and Gianluca (2011) stress that digital skills should include an awareness of the ‘technical and logical structures’ underpinning digital environments – not just a mastery in using them. Pinto (2010) cites Elmborg’s thesis that the goal of digital literacy should not be to produce a checklist of skills but to create people who are able to continue learning and using the digital to resolve problems (2006).

Many studies do indeed break down digital literacy into a set of elements – some more complex than others. Park and Nam (2014) use a simple set of four literacy categories in their study of digital literacy among the disabled: internet use, internet production, smart device use, and smart device production. MediaSmarts (2015) identifies four levels of literacy: first, access to digital tools, second, the ability to use these tools, third, understanding how they work, and finally, creating digital tools and innovations. Hinrichsen and Coombs (2013) identify five crucial resources of digital literacy, which moves through the abilities to use digital technologies, to decode information, to make meaning from the information, to analyse it, and finally to manage one’s digital persona. Europe’s digital competence framework focuses on five broad

areas whose specific skill sets can be continuously redefined: information, communication, safety, problem solving, and content creation (Ferrari 2013). Doug Belshaw has an 8-component model of digital literacy, also very broad – his eight elements are cultural, cognitive, constructive, communicative, confident, creative, critical, and civic (UBC). Von Hamel (2011) sees digital literacy as encompassing three broad abilities: using digital media, understanding it, and creating it – this three-level view has been used in Canadian, American, Australian, and British policy documents.

Studies that see digital literacy as a set of skills often include long lists of what it is comprised of, such as Nelsons’s list of 20 aspects of literacy (2011) and ACM Europe’s list of 15 basic skills (2017), often conflating these with digital and 21st Century skills. Essential Skills Ontario (2012) uses the term ‘literacy’ to denote digital literacy, arguing for an expanded definition of literacy and essential skills themselves. ECORYS UK envisions three levels of digital skills: baseline skills (needed by everyone in society), workforce skills (needed for those in the workforce), and professional skills, which focus on sector-specific ICT and digital roles (2016). Workforce skills included being able to navigate and understand IT language, social networking and media, and office programs. In particular, the following were in demand:

- “Cyber security (awareness)
- Office skills and business processing skills
- Working with office software and databases (ECORYS UK 2016).”

Sector-specific skills in ICT were focused on sectors that had become digitized or automated, and such as digital skills in industries such as agriculture, manufacturing, design, retail, and publishing. There is a larger demand for digitally skilled workers in some specialized than training and education can supply, particularly:

- “Analytics (Big Data)
- Cyber security specialists
- Web developers
- Cloud storage

- Innovators
- Programmers.”

The types of training that would be required to attain these skill levels are not fleshed out.

Some authors emphasize the emergence of a new ethos that accompanies digital literacy and understanding how to use new technologies not only effectively but safely and ethically (ACM Europe, 2017). Ng (2012) cites online etiquette and cybersafety as new aspects that digital literacy introduces, and ECORYS UK (2016) categorizes cyber security as a ‘basic function’ of digital literacy. Hinrichsen and Coombs identify reputation management and identity awareness as a key site for digital literacy development (2013). Jisc (2015) includes ‘career and identity management’ as a crucial part of digital literacy skills. Privacy is a major concern — Yuhyun (2016) and von Hamel (2011) cite privacy management as an increasingly crucial component of digital literacy.

Others focus on the need to understand the relationship between digital practices and power. Neil Postman’s famous five theses on technological change, delivered in 1998, provide an interesting view into critical digital literacy.

“First, that we always pay a price for technology; the greater the technology, the greater the price

Second, that there are always winners and losers, and that the winners always try to persuade the losers that they are really winners

Third, that there is embedded in every great technology an epistemological, political or social prejudice. Sometimes that bias is greatly to our advantage. Sometimes it is not. The printing press annihilated the oral tradition; telegraphy annihilated space; television has humiliated the word; the computer, perhaps, will degrade community life. And so on.

Fourth, technological change is not additive; it is ecological, which means, it changes everything and is, therefore, too important to be left entirely in the hands of Bill Gates.

And fifth, technology tends to become mythic; that is, perceived as part of the natural order of things, and therefore tends to control more of our lives than is good for us. When a technology become mythic, it is always dangerous because it is then accepted as it is, and is therefore not easily susceptible to modification or control.”

Postman's theses pertain to critical digital literacy, a stream which began in the 1980s as an attempt to introduce "sociocultural perspectives of literacy and sought to contextualise digital practice within history, culture and power" (Pangrazio, 2016), echoing the critical pedagogies of Freire (1970), who saw literacy education as a means to address sociopolitical inequalities. The New Literacy Studies movement, spearheaded by Brian Street, sought to conceive of literacy as a social practice rather than a set of skills, situated in history and culture and modified by class. Pinto (2010) argues that technological literacies must include a critical dimension in order to understand the 'culturally grounded phenomenon' that is "based on the way that communities construct their interpretation of reality and the outcomes of this interpretation."

Pangrazio (2016) believes that digital literacy must follow from the critical literacy literature of the 1980s which stressed the mastery not only of technical skills but critical thought. She lists as crucial the ability to 'manage the relationship between language and power', having the metaknowledge to understand the sociocultural context these 'meaning systems' are embedded in, having the skills to navigate these systems, and understanding how they operate in the interests of power. She cites Kellner (2001), who worries that "without the 'proper resources, pedagogy, and educational practice' technology has the potential to increase the existing divisions of cultural capital, power and wealth." This necessitates thinking about new ethical dimensions of digital literacy.

Bhatt et al (2015) argue that digital literacy is not merely literacy that has been 'technologized'; rather, they view it as a radical reshaping of literacy itself. Dobson and Willinsky (2009) showcase the opposing views of digital literacy as a "great transformation" versus digital literacy as continuous with earlier developments in print culture. Crucial to the debates surrounding critical digital literacy is the work of Street (2003), Bawden (2001), Kahn and Kellner (2005), and elaborations by Marcus (2009), Pinto (201), Hamilton and Gourlay (2013), and Pangrazio (2016).

Pinning Down a Working Definition

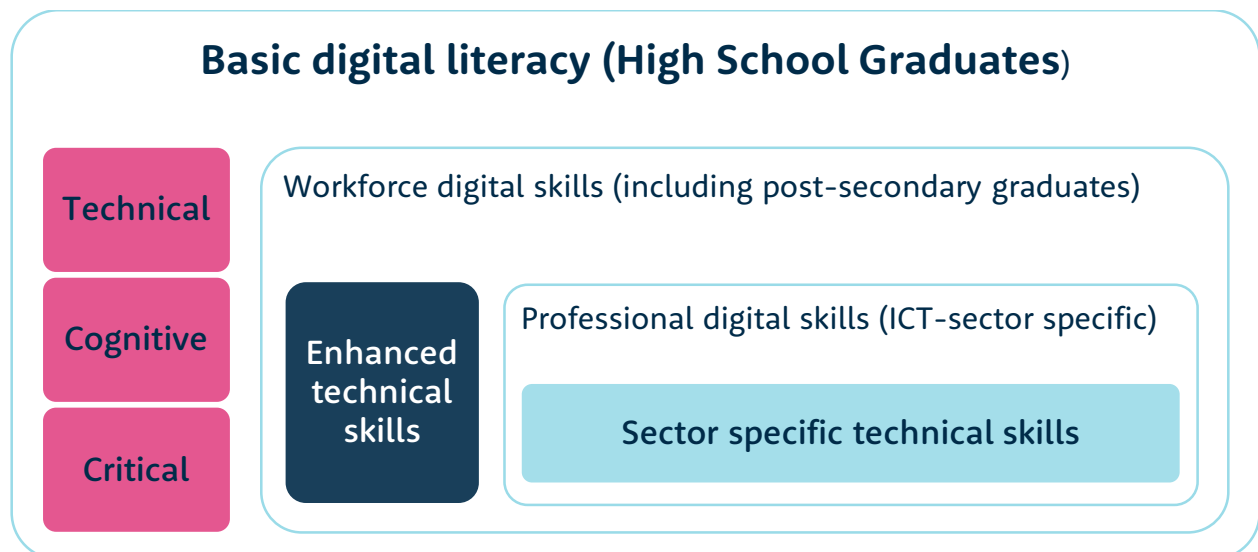
The weaknesses of various definitions of digital literacy contribute to the inability to properly assess it. Approaches that focus on lists of relevant skills are fated to become obsolete as technology and expectations shift. Approaches which consider digital literacy to be a paradigm

shift in the way we understand literacy itself are undoubtedly useful texts, though few seek to pin down what we mean by digital literacy or how it can be assessed. From a policy standpoint, we find attempts to sketch out the shape of different levels of digital literacy the most useful. The UK Digital Task Force, for example (a body for which a counterpart as yet does not exist in Canada), introduces three digital skill levels relevant to the digital economy:

1. Basic: “Digital skills everyone needs to participate in the digital economy,”
2. General: “Digital skills required for all job roles across the economy,” and
3. Advanced and specialist: “Digital skills required for specialist job roles.” (2016).

If we were to propose a framework to understand digital literacy, we would propose a matrix which would take into account these skills levels, but which would include what we consider three distinct components of digital literacy, drawing on the sources mentioned in this section:

1. Technical skills,
2. Cognitive abilities, and
3. Critical thinking.



For example, MediaSmarts tripartite understanding of digital literacy (Use, Understand, Create) is perhaps more easily widely applicable if ‘Use’ and ‘Create’ are subsumed into a single category of technical skills. Technical digital skills include everything on the spectrum of using digital technologies to creating content and coding. Relevant proficiency levels and useful technologies necessarily shift, and as such it would be necessary to continue to redefine them over time.

Cognitive skills would imply what MediaSmarts refers to as the ability to *understand* digital technologies. This includes modes of thinking such as computational thinking (Wing 2006, Grover & Pea 2013). Computational thinking was championed in the mid-2000s by Wing as a method of problem-solving with technology, and she sought to define it as a newly important cognitive skill for all sectors of society (Gasson and Haden 2014). Cognitive skills underscoring digital literacy include being able to evaluate and process information (Iqbal 2014), and being able to adapt to changing technologies and easily pick up “new semiotic language for communication as they arise” (Ng 2012). Soft skills such as teamwork and collaboration would complement these skills, as they are increasingly emerging as crucial 21st century skills along with the digital.

Lastly, critical thinking skills are crucial for anyone engaging in the digital world. Pangrazio describes critical digital literacy as the ability to situate the relationship between digital practices and power and having the capacity to understand their sociocultural contexts. What many authors peg as ‘media literacy’, which includes the ability to critically read and assess information, would fall under this concept. It would also involve understandings of the social underpinnings and impacts of digital technology use, including security, privacy, identity management, and social etiquette – what Stordy (2015) calls the ‘new ethics stuff’ that digital literacy introduces.

These three components make up the underpinnings of a basic level of digital literacy that is necessary for all Canadians who graduate from public education. When considering digital skills necessary to move into the digital workforce and into the ICT sector in particular, technical skills would build upon these cognitive and critical skills.

THEME 2: THE DIGITAL ECONOMY

The digital economy is defined as a new ‘economic paradigm’ which is marked by the increasing reliance on digital technologies and ICT (adapted from Rouse, 2016). This paradigm increasingly underscores the growing importance of digital literacy as an economic necessity in a time of workplace digitization and the growing automation of labour (in 2016, the Brookfield Institute

found that 42% of the Canadian labour force is at a high risk of being affected by automation in the next 20 years).

One of the most frequently cited worries surrounding the digital economy is the disappearance of jobs, particularly low-skilled and manufacturing jobs. Particularly at risk of being disrupted by technological shifts are blue-collar jobs in manufacturing, which some project will for the most part be replaced by automation (The Economist, 2017, “Politicians cannot”). Automation is also a concern in white-collar jobs such as bookkeeping and bank telling (Bessen, 2016a). However, the Harvard Business Review (Bessen, 2016a) found that it was not as simple as jobs being ‘lost’ – rather, jobs were being replaced with other jobs. These new jobs often require more [digital] skills than the ones they replace, and this disproportionality affects low-wage workers (Bessen), who are less likely to be retrained. Currently, less than a quarter of low-paid workers receive any type of additional training on the job – and thus are less likely to get the skills upgrade they desperately need to remain relevant in the labour market – including digital skills (Shanti and King 2013).



Essential Skills Ontario finds that low-skilled workers are most vulnerable to being edged out of the knowledge economy (2012). These findings are corroborated by The Economist (2017, “Equipping people”), which states that the types of ‘upskilling’ and lifelong learning available today are more likely to benefit those already at the top of the economic ladder. Technological change, they claim, is “more likely to exacerbate inequality than diminish it,” and policymakers must address this quickly growing divide. Shanti and King (2013) echo the fear that the knowledge economy will not implicitly be beneficial for all workers. Rather, they worry digitization may polarize the workforce, recommending targeted government investment in the digital literacy training of those most in need. Bessen (2016a) demonstrated that the inability of displaced workers to quickly upskill/retrain leads to wage inequality, particularly burdening workers who cannot afford the high costs associated with learning new skills. There appear to be no accessible low-cost options for workers wishing to retrain on their own.

The pace of technological change has also led to large skills gaps in other industries, with many companies being hampered by their inability to recruit highly-skilled workers (Grossman 2016). Digital skill shortages are not just a problem in Canada. UK consulting firm ECORYS outlines the shortages and mismatches of skills in the UK, citing them as a risk for “business growth, innovation and broader societal development” (2016). The report claims that all sectors of the economy, including manual labour, are increasingly reliant on digital skills, and thus there exists a second-order “latent skills gap.” US consulting firm McKinsey warned that the digital skills gap imposes the effects of a permanent recession on the American economy (Chau 2015). Gunnion (2016) argues that there is an increasing human capital challenge not only for the IT sector, but for many other industries that require IT skills, and this is crucial for the health of the economy.

The UK Digital Skills Taskforce echoed growing concern on the UK skills gap in 2014 (“Digital Skills for...”), stating that while the digital economy is growing, many vacancies remain unfilled. The Taskforce identified that over 90% of all jobs in the UK economy require basic digital literacy skills and further training (2014). This is in accordance with the notion that all jobs will become increasingly digitized. However, it is important to retain distinctions between needed levels of digital skills – the UK Digital Skills Taskforce breaks this down into three levels in the aforementioned document. They identify basic skills as skills needed by every citizen to participate in society; digital skills for the general workforce as a cross-sector minimal

requirement for additional skills needed to process information using digital technology and IT; and digital skills for ICT professions, which involve the development of new digital technologies, products, and services (2014).

Essential Skills Ontario finds in a 2012 discussion paper that the increasing labour focus on [digitally] skilled work has threatened menial labour positions – citing Miner’s estimate that by 2031, “77% of jobs will need some form of post-secondary education or training.” However, Essential Skills Ontario projects that rather than the disappearance of low-skilled labour, previously low-skilled jobs will increasingly “demand solid digital skills” and continue to grow, though they will no longer necessarily be menial. They stress the importance of skills upgrading across sectors (especially among low-skilled workers) and envisage a new structure of Ontario’s labour market, with uniform essential digital literacy skills for the entire workforce.

Part of the skills gap can be attributed to the fact that for quite some time new generations were considered to be digital natives with inherent digital skills. As a result, self-reported digital skills among current students are high, but these skills rarely match up perfectly with those that businesses seek. In Canada, ICTC (2016a) found that although students believe they have excellent digital skills, the skills they are most proficient in (office software, social media, and mobile devices) are not the skills most in demand by business (cloud computing, IT infrastructure, adopting new software, and app development). The most prevalent skills are those which can more easily be self-taught, while those in demand by companies are evidently skills which require some form of instruction. There is a need for digital competency frameworks that are more granular about digital skills – though these would necessarily change quickly.

Not only does it exacerbate inequality, the skills mismatch costs productivity – inadequate digital skills slow productivity by about 21% or a \$65 billion loss overall in the Canadian economy (Asliturk et al, 2016). Businesses, however, have been slow to address the growing gap themselves. A survey of 800 Canadian companies in 2016 found that while employers had trouble filling vacancies, they did not have recruitment strategies to identify and attract highly skilled graduates, nor did they want to invest in upskilling existing workers or training new hires (ICTC, “Innovation Agent Project”). In addition, only 25% of surveyed Canadian firms had a “policy to recruit more women (a significantly under-represented group) and only 33% ...to

recruit young professionals” (ICTC, 2016, “Innovation...”). New graduates had trouble entering the labour force due to the lack of entry-level positions and lack of training provided, pointing not to an unskilled labour force but, at least partially, an underutilized one.

Defining the ever-changing digital and 21st Century skills required in the new economic paradigm appears to be as difficult as pinning down the definition of digital literacy. Digital literacy appears consistently as a crucial part of the 21st Century skill set. In Canada, ICTC proposed a skills spectrum with five categories, of which digital is only one: foundational skills, business-interpersonal skills, digital and technical skills, informational skills and entrepreneurial skills (Asliturk et al, 2016). Increasingly, soft skills such as communication and critical thinking are referenced as crucial 21st Century skills often lacking in new graduates (Campbell and Kresyman, 2015; Deming 2015; The Economist 2017). In 2015, surveyed US Employers cited teamwork as a more important skill than analytical skills, while others include collaboration and oral communication skills (Deming 2015).

The Institute for Competitiveness and Prosperity in Ontario found that graduates from highly tech-heavy fields, such as life science, too often lack necessary soft skills (2016). Deming (2015) finds that with increased automation, jobs which are difficult to automate increasingly require high social *and* technical skills. In fact, jobs that require both skills sets have been rising, as jobs which require high technical and low social skills have been disappearing. For Deming, the cachet of soft skills is the ability to work flexibly in teams and efficiently share tasks. As routinized jobs increasingly become automated, jobs which require flexibility and social interaction grow. However, this tends to push low-skilled labour even further out of the job market.

Some authors are critical of the ‘knowledge economy’ discourse due to its overwhelming technological determinism (see Thompson and Harley). Much of the work on the topic, but particularly policy documents, emphasizes the positive aspects of technology and portray

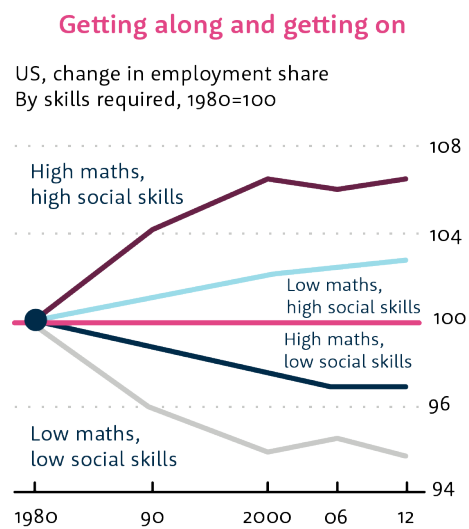


Figure 2. “What employers can do” (The Economist, 2017)

technological progress alone as a salve for social problems. Rodino-Colocino (2006) cogently examines the state of labour under the digital world, arguing that the digital divide (further explored in Theme 4) will merely be exacerbated if the structural problems that lead to it are not directly addressed. She argues that ensuring access to the digital and increasing digital literacy cannot alone guarantee entry into the labour market because the digital divide exists in the labour market itself and in the “hiring practices of IT and contract employer.”

Leon Benade (2014) speaks to the growing demand for highly skilled workers in the knowledge economy, and the concurrent requirement for these workers to constantly upskill in their lifetime and adapt to changing technologies. Benade argues that the notion that it is up to individual economic actors to continue learning and adapting in order to reap the rewards of the knowledge economy shifts “the emphasis of responsibility from society to the individual.” Countries such as Singapore, where the state invests in the upskilling of its workers through a Smart Nation Initiative, have demonstrated that providing incentives and rewards is a successful way to grow digital talent.

Additionally, Benade considers other critiques of the notion that digital competences automatically lead to employment and monetary rewards – citing work that finds no “direct link between increased skills, competencies and qualifications, and increased mental or material rewards in the workplace” and that the “reality of the labour market is dull, routinised, digitised jobs, and not creative jobs and networked teams envisaged by twenty-first century learning advocates” (Lauder 2012, in Benade, 2014).

Alves Pena’s 2016 study found that PIAAC skills were *not* highly correlated with income inequality within countries, suggesting that there may be other more influential causes, such as “union density, employment protection legislation, statutory minimum wages, product-market regulation, and public-sector worker share.” This suggests that supply and demand is not the best predictor of wage inequality.

Most authors referred to find that governments and businesses must respond quickly to the skills gap, job losses, and exacerbated inequality. The Economist quite strongly warned in early 2017 that “if 21st-century economies are not to create a massive underclass, policymakers

urgently need to work out how to help all their citizens learn while they earn” (“Equipping people...”). The Economist stresses that ‘learning’ itself will become a core skill for workers (ibid) – and the burden of costs of this learning cannot entirely be placed on workers themselves. Workers who use digital technologies on the job experience both more on-the-job learning and higher wage growth – this additionally benefits people in higher-skilled and higher-paid jobs, further contributing to inequality (Bessen, 2016b).

Bessen suggests that policies must enable displaced workers to quickly acquire skills (2016a) if they are to be kept in the economy. The Economist suggests ensuring accessible adult learning via government retraining and vocational programs, colleges, MOOCs, companies, and trade unions (2017, “What employers can do...”). Businesses that provide “on-the-job training, mentoring (...) sharing knowledge and social learning, skills gap analysis [,] and talent development plans” (Asliturk et al 2016) would boost their own productivity. Meanwhile, governments could issue tax credits or vouchers to SMEs who upskill employees.

Equipping new graduates with the digital (and social) skills to make their entry into the job market is also crucial. The Economist suggests more vocational training for post-secondary students, along the lines of Germany’s vocational training system for SMEs (2017, “What employers can...”). ICTC suggests short-term ‘bridge-training’ whereby recent graduates could quickly get the training necessary to move into the workforce. They announced a Canadian pilot program in 2016 to “provide under/unemployed youth with added understanding and skills related to innovation (management, creativity, technology and soft skills)” (“Innovation Agent Project”), in an attempt to make up for the fact that there is little practical training in these skills in formal education.

Graham (2017) calls it the ‘retraining paradox’: while manufacturing working class jobs in America seem to be disappearing, employers have been “insisting for years that they have a hard time finding workers to fill many skilled blue-collar jobs.” In particular, the missing skills are tech; manufacturing now requires high tech skills which older ‘displaced’ workers must be retrained in. Though the US government offers some retraining programs, many are confusing to navigate and thus fail to successfully connect potential employees with the skills employers need. A crucial determinant of successful retraining programs, Graham finds, is coordinating

with local industry to develop programs that are demand driven and focus on the real needs of the labour market. This would include industry input on training curricula as well. In Canada, the ‘Shopify Carleton’ program fits this mould well – it connects Carleton University with Canadian business Shopify, providing experiential learning to students and mentors ‘creators and makers’.

Indeed, “educational interventions at all levels are also important factors to bridge the skills gap” (Asliturk et al 2016). Specifically, ICTC and the Economist agree that reforming K-12 education to incorporate mandatory computer science training is crucial. Having streamlined curricula is desirable (Asliturk et al 2016), but how to teach digital literacy is complex, explored more Theme 3. At a basic level, consequences of the digital economy suggest that basic digital literacy must be fostered in the education system in order to produce a workforce for the future, but also that it must quickly be taught to those who have already exited formal education.

THEME 3: PEDAGOGY AND THE ‘FOURTH LITERACY’

Teaching Digital Natives: Digital Literacy Curricula in K-12 and Post-Secondary Education

Though there is increasing recognition of the need for training in digital literacy, there is no consensus on how best to go about it. Assefa and Gershman (2012) cite a 2007 poll of US voters which found that 99% recognize that teaching 21st Century skills in schools is crucial to the economic success of the country, though their study of such initiatives yielded no significant results. Ripley (2013) sticks to a simplistic view of digital natives as having an ‘innate’ understanding of technology which is necessary for the economy. There is evidently a need for lifelong training in digital literacy which accounts for fast-moving technological changes. Campbell and Kresyman (2015) call this ‘sustainable employability’ – the ability to learn new skills as required or transition into new opportunities. Murray and Perez argue that early education is crucial to equipping university graduates with the skills needed to enter the workforce (2014).

There is increasing recognition that ‘digital natives’ (Marc Prensky’s concept; 2001) who grew up using technology are not ‘innately’ different from those born earlier (‘digital immigrants’) (see

Bayne and Ross 2007; Jimenez and Corral 2015; Jones et al 2010; Kennedy and Judd 2011). As such, Ng (2012) argues that digital natives *must* be taught digital literacy in order to enable them to use these technologies effectively and safely. Ng considers digital literacy to be developmental, building progressively on “foundational and achieved skills and knowledge” and adapting easily to new semiotic language. Nelson’s study (2011) finds that digital native university students are not highly skilled – they are sophisticated users, but do not need to learn ICT skills in order to utilize digital technology for their needs. Their skills also vary based on socio-economic background and personal motivation. Hinrichson and Coombs (2013) underscore the belief that digital literacy will not emerge spontaneously due to the abundance of technology or early exposure to it – and that education has a crucial role in “inculcating, moderating and extending such [literacy practices].”

Increasing concern over the need to teach digital literacy to children has been seen globally, with many underscoring the importance of formative years. In the US, a 2007 found that 99% of registered voters thought that the future economic success of the United States was linked to teaching 21st Century skills, and that the education system was not doing so (Assefa and Gershman 2012). In Canada, a 2016 ICTC study called for a “strong talent pipeline for science, technology, engineering and math (STEM) and information communications technology – starting with elementary and secondary education through to post-secondary education to employment transition” (“Digital Talent...”). Vivian, Falkner, and Falkner (2014) identify the growing awareness that in order to ensure students are technology creators and participants, they must be taught “computational thinking, the problem-solving processes and intellectual practices [in order to] ... understand the scientific practices that underpin technology.”

Pedagogical concerns over digital literacy are incredibly numerous in the literature, with many consulted authors considering how best to teach it (Alper 2011), (Assefa and Gershman 2012), (Benade 2016, 2015, 2014), (Gasson and Haden 2014), (Gavrila 2014), (Grover and Pea 2013), (Higgins 2014), (Hobbs 2016, 2012), (Littlejohn 2012), (Lucking 2012), (Sancho Gil 2015), (Shadbolt 2016), (Sun 2008) as well as how to train teachers (Erstad 2015), (Fernandez-Cruz and Fernandez-Diaz 2016). However, there is no common consensus on what teaching digital literacy in schools should look like. Most authors agree that mandatory computer science courses are key, but also that low enrollment STEM courses should be addressed. Indeed, many policy reports seem to be

addressing both the skills gap (the lack of STEM and ICT graduates) as well as the need for *all* high school graduates to graduate with basic digital literacy skills. Many studies stress that investment in K-12 education yields direct results for the digital economy. According to the ICTC (2016), every \$70,000 invested in ICT-focused high school programs yields potential 100 future ICT workers in Canada's economy. Education figures prominently in the ICTC's National Digital Talent Strategy for Canada.

The European chapter of the Association of Computing Machinery, which publishes various curricula-setting guides across the world, suggests that digital literacy training must begin in first grade and equip students with basic skills by age 12 (2017) – though what basic skills consist of is undefined. They emphasize the need not only to focus on skills and mastering digital technology but also teaching the ethical aspects of literacy (ibid).

Beyond teaching digital literacy in specific courses, some advocates for literacy suggest infusing digital technologies throughout the curriculum. Carey (2014) suggests simply incorporating the digital into already established classes, in ways such as assigning projects that require digital creation or online research. Carey is careful to add the caveat that if the curriculum *does* become digital, digital divides caused by class, race, and gender have the chance to become unduly exacerbated.

Other authors argue that the proliferation of digital technology requires higher levels of critical digital literacy. Thornton (2011) views such critical skills as crucial in training students how to sift through and critically assess information in a “data-drenched society”. This strain of thought argues that the digital has profoundly changed the way information is processed and interacted with, leading to altered cognitive processes that make critical thinking more difficult (ibid). The concepts Thornton cites as potential remedies – hyper-literacy and critical information literacy – chime with notions of critical digital literacy, which would ‘promote a transformative notion of pedagogy’ which would expose and upend power relations. Interestingly, most mainstream notions of teaching digital literacy written since Thornton's 2011 article do indeed reference critical skills as crucial component. Erstad et al cite OECD reports which claim that new approaches are needed for 21st Century learning – in particular, teaching ‘deep’ or ‘meta’ knowledge which would allow students to understand underlying logics (2015).

Currently, the major gaps in Canada are the lack of unified curricula to incorporate digital literacy, enhance computer science classes, and increase STEM enrollment. ICTC focuses on the need to create “21st Century learning environments” that will integrate modes of critical, abstract, and analytical thinking into the curriculum, arguing this will help teach foundational STEM skills without necessarily having a heavy tech focus (2016 “Digital talent...”). One of the ideas of the 21st Century learning environment is teaching cognitive skills to students that will help them continue to learn.

The ICTC (2016) recommends mandatory computer science classes starting from kindergarten, computational thinking for young students, coding for intermediate students, and app development, networking, and cyber security for high-year students. They also recommend boosting awareness about ICT careers as well as enhancing hands-on learning opportunities through co-ops and apprenticeships, which chimes with the findings from other research about their importance. Embedding digital literacy in post-secondary education is also a key recommendation. In terms of encouraging the youth talent pipeline, the ICTC also recommends that governments subsidize companies (especially SMEs) to provide on-the-job training for new graduates, thus bridging the ‘experience gap’. Also, creating awareness among new graduates of job opportunities and ensuring access to high quality career guidance would help steer students into high-demand jobs.

One of the major issues contributing to the skills gap in Canada is that students fail to take STEM courses even in high school – less than half of high school students take math and science in Grades 11 and 12 (Let’s Talk Science 2013). Commonly cited reasons are the difficulty of the courses as well as the view that they are irrelevant to future careers – which is erroneous given that 70% of the highest-paying jobs require STEM skills, including in the skilled trades (ibid). Let’s Talk Science suggests that both raising this awareness and teaching STEM better is crucial. They suggest supporting and scaling effective STEM teaching programs inside and outside of formal education, providing compelling programming, as well as making information available about how STEM skills are in demand in the labour market (2014).

To date, Media Smarts is the only organization to compare digital literacy teaching in the country – their 2015 report, *Mapping Digital Literacy*, focuses on primary education. They found a shift in policy discourse over time, with ‘ICT skills’ being replaced by a broader notion of digital literacy, along with the recognition that the digital implied dramatic changings in our modes of living, learning, and teaching (2015). In Canadian curricula, they found several different manners in which digital literacy is taught. In Ontario, each subject area is joined by a consideration of how ICT can be used to teach and to learn it. Most commonly these subject areas are art and business. In New Brunswick and PEI, every course entails an ICT component, while in Manitoba and Northwest Territories, basic literacy courses have been expanded to include the digital.

Training Teachers

Aside from STEM, teaching computer science courses is seen as crucial for digital literacy training. However, this tends to be linked to school resources. In a study of US K-12 Schools, Google for Education found that 60% of polled public schools do not have computer science classes (programming/coding) available; the most cited reason was the lack of qualified teachers (2016). Canadian teachers agree that the lack of qualified teachers is a huge reason for the lack of computer science courses in primary and secondary schools – only a third of Ontario high schools have computer science courses, and then only as upper-year electives (CBC News 2015).² The “hit-and-miss feel of computer science education” (CBC News 2015) in Canada is also due to the lack of federal or province-wide computer science curricula, meaning that some eager teachers may begin to teach coding, for example, but there is no institutionalized priority to train students or their teachers.

The question of training teachers to be effective sources of digital literacy for students has been hotly debated. Erstad et al (2015) cite Davis (2013) that technological innovations and teaching methods have ‘followed a co-evolutionary progression of constant change’ – and that teachers are crucial agents of such change. Vivian, Falkner, and Falkner (2014) point out that innovative computer science curricula implemented in the United Kingdom, Australia, and New Zealand

² According to Wendy Powley, researcher and lecturer in computing and education at Queen's University.

have been struggling with implementation – not least of which was due to the unpreparedness of teachers to teach the new curricula.

Vivian, Falkner, and Falkner (2014) point out that the rapid implementation of digital literacy curricula in New Zealand, Australia, and the United Kingdom has given rise to concerns about teachers' digital skills and preparedness. Sancho Gil and Petry (2016) argue that teaching plays a large role in promoting digital competences in secondary school, as do the backgrounds and educational views of teachers. They state that the “teaching culture and organisation of schools” ought to be challenged in order to successfully promote digital competence among students.

A large scale international study of secondary schools by the International Computer and Information Literacy Study, conducted by the International Association of Educational Achievement, found that most teachers did use ICT in their teaching practice at least weekly, usually for simple tasks (Fraillon in Erstad et al 2015). This, argue Erstad et al, corresponds with other studies that document “difficulty among most teachers with using the full potential of new technologies,” and findings that teachers often use technology in ways which are not necessarily innovative. They suggest that innovative ways of using technology would be not only to teach digital skills but also understand how digital technologies have changed the nature of learning, teaching, and knowledge itself. Erstad et al cite Kereliuk's 2013 review which suggests three areas of 21st Century learning: “foundational knowledge, meta knowledge, and humanistic knowledge,” each of which interacts with technology in different ways (2015).

A republished resignation letter by a professor at a university in Colombia (Jimenez 2012) argued that the cacophony of the digital had caused digital natives to lose “the ability to concentrate, to be introspective, quiet” and expressed the professor's disappointment with his students' compromised ability to learn. Interestingly, intergenerational conflicts such as these are increasingly referenced in the pedagogic literature.

Fernandez-Cruz and Fernandez-Diaz's 2016 study breaks down the digital skills of teachers in Spain, finding that the generational divide between teachers and students raises questions about teachers' competencies. Cruz and Diaz found that in Spain, the majority of teachers were over 40 years old (2016). Interestingly, Cruz and Diaz break down generations into distinct

groups, defined by their exposure to ever-evolving digital technologies. The crucial groups are Generation Y (1977-94), who witness the emergence of now-common digital technologies; Generation Z, ‘digital natives’ who were born in the late 1990s-2000s, in a world defined by digital technology; and Generation Alpha, born after 2010, who will likely be early adopters of digital tech and are considered to be the most tech-savvy. It is Generation Z and A that are the targets of current K-12 education – and assumptions about their exposure to technology hold true in developed countries.

Fernandez-Cruz and Diaz (2016) point out various models of digital competencies for teachers themselves have been published by NGOs and governments: ‘the Department of Education of Victoria, Australia; the International Society for Technology in Education in the USA and Canada; the Enlaces (learning networks) Project of the Chilean Ministry of Education; the North Carolina Department of Public Instruction; the UNESCO ICT Competency Framework for Teachers.’ The UNESCO framework was applied in Spain in late 2000s, and aimed at getting teachers to incorporate ICT skills and resources throughout their teaching practice as a whole. UNESCO identified three ICT competence levels for teachers, which resemble other typologies of digital literacy, particular Media Smarts’ “Use, Understand, Create.” The first level, technological literacy, implies understanding digital technologies and integrating them in to the curriculum. The second incorporates use of these competences into problem-solving skills. The third, knowledge creation, require teachers to produce and leverage new knowledge using digital competences (UNESCO in Fernandez, 2016). In Fernandez-Cruz and Diaz’s findings, teacher training was rather low: 46% of polled teachers in Spain had poor skills, while just under 40% had average skills (2016). Older teachers had poorer ICT skills, while Generation Y teachers and those who taught STEM courses had the best profile.

MediaSmarts (2015) offers a Digital Literacy Framework for Canadian Schools, calling for holistic programming which fosters “a gradual release of responsibility towards independent practice by youth – working *with* youth in building resilience, finding solutions and promoting positive engagement with technology.” This model is framed on Manitoba’s *Continuum Model for Literacy with ICT*, which sees the role of teachers simply as facilitators to ICT training, allowing students to become increasingly autonomous.

Resources for Canadian teachers to teach digital literacy (or learn it themselves) are sparse and seemingly based on the voluntary participation of teachers. EduGAINS is a hub for Ontario Ministry of Education resources for teachers and educators, which includes a **set of tools** for elementary teachers to teach coding. If the website is an indicator of the level of these resources, we can infer that they are not a priority. In the US, similar educational resources and studies about STEM education have been developed through studies by the National Science Foundation, the Association for Computing Machinery and universities, a comprehensive list of which is found at the **website** of Outlier Research & Evaluation at the University of Chicago.

Digital Literacy Outside of the Classroom

There is evidently increasing consensus that digital literacy training must take place outside of school as well, particularly to those generations that did not grow up with digital technologies and whose occupations may soon require a higher level of digital skills than before. Sweden's Digital Agenda for 2011, "ICT for Everyone," underscores the need to develop digital skills in the workplace. However, there is no consensus on methods to retrain or upskill older workers who are already part of the workforce, and as mentioned earlier such training is rarely paid for in lower-wage positions. Lawton Smith in found a 2009 study in England a lack of coherent training response to the changing workplace.

Currently, much of digital learning already takes place outside of formal education structures. The Economist (2017, "Established education") notes the rise of private education providers offering these skills – a burgeoning field given the lack of attention in formal education. However, they question whether private educational venues can provide standardized skill sets, positing digital badges as a potential way to offer credentials to their students. Raish and Rimland (2016) find that digital badges are viewed positively by employers, as a form of micro-credentials which would offer employers a more specific set of skills held by applicants – or in short, their digital literacy. These and other forms of 'nanodegrees' offered by workplaces themselves can act as crucial credentialing tools for constantly upskilling workers. Microsoft offers its own course, Microsoft Digital Literacy, which appears to be widely used in private and public settings. Another encouraging upskilling practice by the Singapore Council for Skills,

Innovation, and Productivity is the giving out of monetary credits to citizens who can use them to enrol in various ICT (and other) courses at public and private institutions.

A positive practice from Canada is ABC Life Literacy, a non-profit that created an 'ABC Internet Matters' workbook to help older Canadians without digital literacy skills, and organized several workshops teaching its content. ABC launched a 2014 initiative called UPskill, which connected employers who were seeking to train their employees with expert trainers; among the essential skills taught within the initiative was computer use.

After-school training is also increasingly common as well— in fact, Google For Education (2014) found that Black and Hispanic K-12 students were more likely than their Caucasian peers to learn digital skills primarily from such training, which correlates to the fact that they're less likely to have internet access at home. Amiri's 2009 study of the effects of promoting digital literacy (and access) among children of low economic status found that it could increase academic performance as well as self-confidence.

Matzat and Sadowski (2012) find that simply learning at home by one's self can increase digital skills, and call for further research into the DIY approach. Ferro et al (2011) corroborate this, finding that self-learning is "at least as important as formal face-to-face training courses in the process of basic IT skills acquisition." However, this is dependent on access. Eynon and Geniets (2016) find that young people who do not have digital access at home are far less likely to self-learn by 'playing around' with technology given the restrictions of using internet in public spaces.

The ICTC (2016, "Innovation...") suggests that coding camps and other organizations that provide short-term targeted training are an efficient method of quickly upskilling workers – they yield high success rates and demonstrate to employers the ability and motivation to keep learning. However, ICTC notes that these organizations tend to have high entry costs. A US study done by Course Report in 2016 found that private boot camps are indeed efficient at raising the incomes of their graduates – most significantly for previously low-skilled workers (Stewart 2016). However, the average cost of a ~3-month camp was rather high: \$12,147 USD (ibid). The most

popular courses were web and mobile development, UX design, and data science, and Course Report noted the rise of cybersecurity courses in the past year as well.

Some digital literacy training is targeted specifically at teachers. Hobbs and Coiro (2016), who created a Digital Literacy Institute at the University of Rhode Island for K-12 teachers and other educators, use a collaborative and dyadic model where ‘everyone learns from everyone’. Vivian, Falkner, and Falkner (2014) suggest that Massive Open Online Courses (MOOCs) might actually be a scalable solution to train teachers for teaching digital curricula.

Massive Open Online Courses (MOOCs) have become an increasingly popular learning tool due to their accessibility, though their role in digital literacy training has not been very deeply examined. Although MOOCs are much cheaper to develop and participate in than traditional university degrees, it appears that the probability of MOOCs responding to structural barriers is unlikely. As Steffens (2015) points out, women, those from developing countries, and the unemployed are far less likely to participate in MOOCs – indeed, most participants already hold university degrees. However, in some countries, the government has teamed up with MOOC platforms to link job seekers with further education – France with Open Classrooms and Saudi Arabia with edX, for example (Gaskell 2016) – something which is undoubtedly less costly than retraining programs. More research on the effects of these partnerships has yet to be done.

There have been a wide variety of written-about attempts to increase digital literacy among non-students and workers as a response to poverty and underemployment. Lindsay (2004) finds that digital literacy is crucially lacking among job-seekers, especially those who are low-skilled or long-term unemployed, and that this hampers their ability to search for jobs using the internet. Lindsay suggests community-based ICT centres where the unemployed could efficiently access labour market information as a possible response. A report on a pilot digital literacy program for low-income office workers in Bangalore, India, Ratan et al (2009) finds that sustained access to computers and digital habituation offered concrete results. Office workers were able to improve digital literacy, English proficiency, and build confidence and the desire to learn. Thomas (2014) speaks to the successful empowerment of communities in the Communist Indian state of Kerala via digital literacy initiatives. He ascribes the success of a program which brought free and open-access software and training to secondary schools in Kerala to the

sociopolitical environment of 'grassroots democracy', as well as integration with women's empowerment projects.

THEME 4: BRIDGING THE DIGITAL [LITERACY] DIVIDE

The digital divide: From access to literacy?

As with digital literacy, definitions the digital divide and how to conceptualize it vary, and often include several levels of consideration. The first level is access to the digital, most often the internet. For many people, merely accessing quality internet in an efficient way remains a struggle. Kang (2016) documents five million US families without internet at home, whose children struggle to keep up with increasingly digitized curricula. Statistic Canada's Internet Use Survey found that 80.8% of Canadian households had internet access in 2012 (Statistics Canada 2013). While a 2015 Ipsos study found that 9% of Canadians had no internet access at home. In Canada, the most significant divide in terms of access to internet is urban/rural, with communities facing the most exclusion in terms of broadband development policy (McMahon et al, 2011).

There are also obvious gaps in access between countries. Antonelli (2003) talks about the emergence of a *global* digital divide given that ICT-driven economies rely on capital and skilled labour to be productive and competitive. He argues that this is likely to exacerbate asymmetries between actors in the global economy. Quibria et al (2003) found that income, education, and infrastructure were the most important factors in the divide in their study of Asia. They suggest that ICT developments could easily play a large positive role in developing counties, as long as their governments focus on building social and human capital and basic infrastructure.

Helsper and Eynon (2013) argue that the digital divide and digital literacy literature rarely intersected until recently, and our research corroborates this. According to Seifer (2016), the digital divide can stem from lack of infrastructure or lack of access due to cost, low levels education and literacy, special needs or disabilities, or other barriers. Seifer (2016) provides two robust definitions for digital equity and inclusion. Digital equity is what ensures full participation of all members of a community in digital technologies. Digital inclusion she defines as the

activities that make this possible, citing five key elements:

1. Affordable, robust broadband Internet service;
2. Internet-enabled devices that meet the needs of the user;
3. Access to digital literacy training;
4. Quality technical support; and
5. Applications and online content designed to enable and encourage self-sufficiency, participation, and collaboration” (2016).

Robinson et al (2015), in their wide-ranging study, argue that digital inequality has “a broad range of individual-level and macro-level domains, including life course, gender, race, and class, as well as health care, politics, economic activity, and social capital.” They argue that as technology develops, so do forms of digital exclusion, identifying first-levels gaps in access, as well as second-level inequalities in digital engagement. Alam and Imran (2014) consider digital literacy a “third level digital divide” which must be addressed by high quality and accessible education and training. Crucially, Robinson et al (2015) point out that digital divides are embedded in social, economic, and cultural contexts, and necessarily intersect with categories of race, class, gender, age, and so on. Gaps can be both reinforced as well as exacerbated by digital proliferation – and some would argue that they could also be broken down if properly addressed (see for example Iqbal 2014).

Increasingly, however, the digital divide literature has begun to focus not only on equitable access to the digital but also on whether or not users have the skills to navigate the digital to their benefit. Digital equity in the form of full access and participation is seen as a precondition for digital literacy, which would serve to more fully break down digital divides. Though the literature has recognized the multidimensionality of the digital divide for more than a decade (see Bertot 2003), policymakers are just now catching up.

Park and Kim (2014) find that in South Korea, which has very high broadband penetration rates, policies to address second-order digital gaps in terms of skills have not been as prevalent or successful. They argue that policy must respond to the ‘lags’ that rapidly developing digital technologies bring about and focus on long-term consequences of such lags. South Korea is

currently piloting a Software Education curriculum to develop “computational thinking, coding skills, and creative expression through software” in all levels of education from elementary to postsecondary (Kyung Eun Park, 2016). Preliminary findings suggest that focusing on equity in education policy is crucial for the success of such a program (Ibid). Van Deurson and van Dijk (2010) also argue that existing social inequalities could very quickly become worse due to the manner in which digital technologies change much faster than literacy.

As Iqbal (2014) puts it, the literature seeks to understand the range of factors that shape and enable a person’s ability to access and use ICT. For Iqbal (2014), digital equity enables the ‘positive face of digital literacy’, where digitization and technological proliferation benefits all sectors of society.

Negative face of digital literacy	Positive face of digital literacy
Restricted access to learning technologies (Eshet-Alkalai and Aydin 2009; Gudmundsdottir and Broke-Utne 2010)	Pervasive access to learning technologies and digital literacy opportunity (Marsh 2010; Russell and Stafford 2004)
Low digital literacy attainment resulting in social exclusion (Zheng and Walsham 2008)	Nurturing and sustaining an inclusive approach to digital literacy in the classroom (Hague 2010)
Poor access to digital educational resources (Madden, Ford, and Miller 2007)	Extensive access to digital educational resources (Madden, Ford, and Miller 2007; Sparrowhawk 2007)
Low information intensity in the classroom due to limited online access (Hargittai and Shafer 2006)	High information intensity in the classroom due to real time online access (Hargittai and Shafer 2006)
Isolating digital literacy to specific classes that results in inequality, lower esteem, and stereotyping	Integrated approach towards digital literacy in all subject areas
Inequity in the teaching pedagogies that are instrumental to digital literacy exclusion (Gillen et al. 2008; Resta, Solomon, and Allen 2003)	Teaching pedagogies instrumental to facilitating equity in digital literacy (Gillen et al. 2008; Resta, Solomon, and Allen 2003)
Limited technologies infrastructure in schools and classrooms (Loveless 1996; Susan and Dianne 2004)	Immersive technological infrastructure in schools and classrooms (Loveless 1996; Susan and Dianne 2004)

Figure 3. Iqbal, Javed, et al. (2014).

With his concept of the ‘two faces of digital literacy’ Iqbal argues that growing attention paid to digital literacy could exacerbate existing divides. Reddick et al (2000) foresee that the digital

divide will continue to mimic other patterns of differential levels of access, based on “social class, generation, gender and value factors (perceived need and interest).” Age is an important factor in the digital divide, with older people increasingly disengaged from the digital (Olphert and Damodaran 2013; Park and Nam 2014). However, engagement of the elderly (65+) in digital literacy practices is focused more on social inclusion than it is on the labour market as many have reached retirement age.

Rodino-Colocino (2006) describes the mid-2000s critical turn in digital divide literature. At the time, authors argued that digital divide literature was often technologically deterministic, positing technology as a solution the ‘structural problems that surround the digital divide’. The critical turn began to look past access and look at the role of literacy in addressing these structural problems. Indeed, it appears that contemporary literature on the need to teach digital literacy presupposes that technology itself, without adequate policy, cannot solve structural exclusions. Rodino-Colocino’s skepticism about ‘digital skills’, however, still rings true. She argues that much of the literature about upskilling to remain relevant to the modern labour market focuses on the individual worker’s responsibility to do so (2006). As examined, the prohibitive costs of private courses and lack of on-the-job training continue to pose structural barriers to workers who must learn digital skills to survive in the labour market.

Green and Kryszczuk’s 2015 study on the digital divide in Poland found a decreasing digital divide between economic classes, but also found that having a PC and internet access at home did not have a strong positive correlation with income. In other words, digital access and proficiency had less predictive power about someone’s future income than did education and occupational status, suggesting that improving access and literacy alone might not be able to address existing socioeconomic divides.

Gendered Dynamics

Although PIAAC scores routinely mark men and women at the same levels of literacy, women are underrepresented in post-secondary STEM disciplines, among graduates, and in STEM/ICT professions. In the US, women in STEM and computer science professions make up just less than 30% of the total (Google, 2014), while their computer science participation has been

decreasing since the 1980s. In Canada, women are about 23–25% of those in ICT professions, which is lower than EU countries and the US (ICTC, 2016b). Women are also more likely leave the STEM profession – a US study cited working conditions and work-life integration as the top cited reasons for switching industries (ibid). Interestingly, the ratio of women in private boot camps (for coding, programming, developing, etc.) in the U.S. is 43% – much higher than female attendance in university-level computer science (Eggleston, 2016). Research into drivers of this higher ratio has not been done to date, but suggests that the gender gap in formal education is not driven by women’s lack of interest in tech. Gender gaps in digital technology tend to vary, however, and are lower in countries with more gender equality as a whole and where women are a large part of the workforce, pointing to ‘social and economic macrostructures’ which create and sustain digital inequalities (Robinson et al 2015).

However, it hasn’t always been the case that women’s enrollment in tech was low – since hitting a peak of 36% enrollment in the mid-1980s, it has been dropping steadily for reasons that have not yet been entirely established. Incidentally, female enrollment and graduation in computer science has continued dropping in the 2000–2012 period in Australia, New Zealand, South Korea, and the United States (MacDonald 2017).

What Happened To Women in Computer Science?

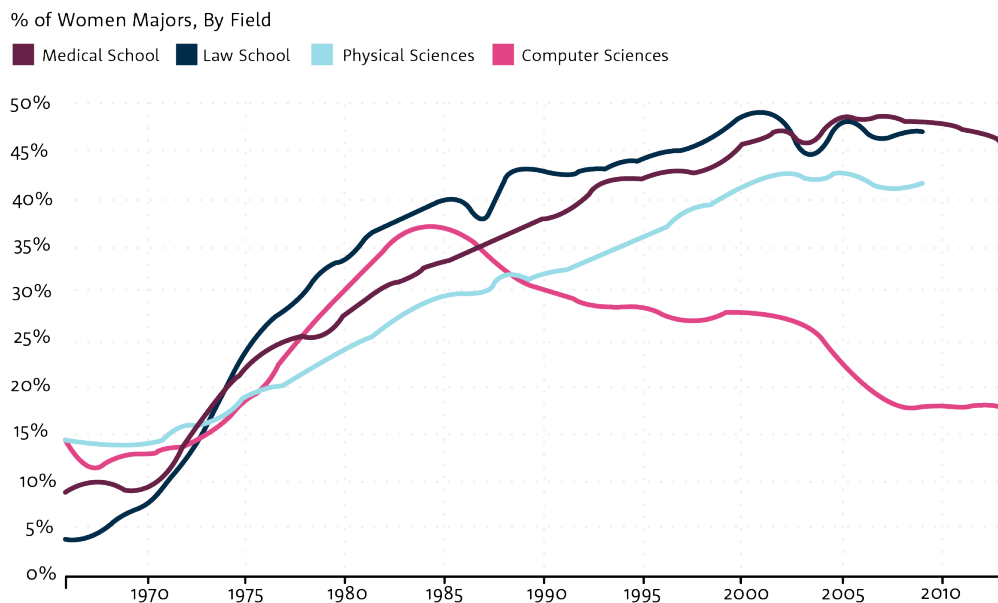


Figure 4. US women's enrollment in STEM fields (Henn 2014)

Some posit that it is linked to the rise of personal computers, which were marketed almost exclusively to men and boys – one study found that parents were more likely to buy a PC for their male child, even “when their girls were really interested in computers” (Henn 2014). Given that to this day, many digital skills such as coding and programming are self-taught and excel when a student has access to a computer to ‘tinker around’ with, we can guess that the lack of PCs may have decreased both interest and skill among girls.

Reasons for lack of enrollment seem to be embedded in culture, rather than in strict structural barriers. Google’s 2014 US study found that factors such as socioeconomic background and objectively measured proficiency had far less to do with young women choosing to study computer science than did social encouragement (from family and peers, self-perceived proficiency, academic exposure to computer science courses, and perception of career success. ICTC (2016a) suggests that computer science and STEM courses in high school must be promoted especially among young women.

Given that social encouragement plays such a great role in women entering this field, studies have considered the social dynamics that prevent such encouragement from being widespread. Several recent studies by a group of psychologists (Bian et al 2017; Cimpian and Leslie 2017; Cimpian et al 2016; Leslie et al 2015) have found that gender stereotypes shape ideas about intellectual ability and career aspirations at a very early age. According to Bian et al, women’s discouragement in pursuing STEM is shaped by social conditioning where girls are considered to be less naturally intelligent (“brilliant”) than boys. They find that these stereotypes shape the interests of children as early as age 6, dissuading girls from undertaking interests, and later intellectual activities, which are thought to require high levels of brilliance. Their findings were constant across race, ethnicity, and socioeconomic status (2017). An earlier 2015 study (Leslie et al) found that women are underrepresented in disciplines which are considered to require ‘brilliance’ – innate talent rather than diligence – because of stereotypes that women are less likely to possess this form of talent.

Cimpian et al (2016) link early mathematics experiences with the gender gap in STEM which follows girls to high school, post-secondary education, and eventual career paths. Early math achievements, according to the authors, predict “changes in mathematics confidence and

interest during elementary and middle grades” and “influence girls’ emerging views of mathematics and their mathematical abilities” (2016). Their study found that teachers were more likely rate girls’ math skills lower than similarly performing boys, that teachers and society had lower expectations of girls, and that teachers’ underrating of girls relative to boys was prevalent among high- and low-performing girls alike. These disparities led to clear gender gaps by the first grade.

Cimpian and Leslie 2017 suggest that girls can be ‘inoculated’ against the harmful effects of such stereotypes by ‘early and consistent exposure’ to successful female role models, to emphasis on learning and effort rather than on brilliance, and even the equitable distribution of household labour in home. Similarly, Google’s 2014 study found that young women’s self-perception of their own abilities was crucial in their pursuing computer science. A recent Government of Canada campaign called “Chose Science” seeks to encourage girls’ interest in STEM via a social media campaign, providing material for home science projects and experiments, and forefronting women in STEM professions (MacDonald, 2017).

Globally, best practices are abundant. In rural India, a Google campaign called “Helping Women Get Online” aimed at training women to use digital technology to improve their lives or even earn income has proven a success (Dhillon, 2016). Digitized e-commerce opened the door to female entrepreneurship in Kenya (Freedman 2016), jiving with findings by Accenture that doubling the pace at which women are trained in digital fluency would hasten the arrival of gender equality in developed and developing nations alike (Vertical News 2016).

Rural, remote, and indigenous communities in Canada

Early initiatives tackling Canada’s digital divide focused specifically on affordable public access to internet as well as the skills needed to use it effectively (Graham and Hanna, 2011); this remains the case in rural and remote communities. These programs focused on youth as well as on connecting rural Canada to infrastructure. Reports noted that what was crucial was access to the “means of using what the infrastructure enables,” though no national inclusion strategy was adopted as of 2008. Graham and Hanna assess that Canada’s early digital programs saw

technologies themselves as primary agents of change, and focused on their value to economic markets, failing to consider the need to transform socioeconomic structures and markets.

Canada's digital divide has tended to mirror the fault lines caused by its vast landmass and cultural history: there is a strong urban/rural divide which has excluded indigenous communities, low income families, and Francophones. Developing infrastructure has been crucial to addressing the inclusion of remote communities (which are often indigenous), where costs are high both to build and access broadband services (Howard et al 2010). Howard et al trace two early government policies, Gathering Strength and Connecting Canadians, which sought to offer internet to indigenous communities in local libraries and schools, and funding indigenous content. There were also two policy programs aimed at Francophones, which funded French content and bilingual government resources online (ibid 2010).

The OECD's PIAAC scores found that cognitive skills in Ontario are significantly different across urban and rural areas - literacy, numeracy and problem solving in technology-rich environments (PS-TRE) are lowest in Northern Ontario (Essential Skills Ontario 2014). Northern Ontario also has the highest percentage of Aboriginal population in Ontario (13%), and PS-TRE scores for Aboriginal and Francophone populations dip lower than the region's average. In Eastern Ontario, however, Aboriginal scores are not lower than average. Across Ontario, PS-TRE scores of immigrants are lower than average, while those of youth are higher across the board.

The ICTC (2016b) study identifies women, indigenous communities, and youth living in poverty as untapped resources that could help address the skills gap were they provided with education and training. MediaSmarts notes that indigenous communities face specific barriers to digital access and literacy based not only on their often rural/remote locations but also by existing literacy challenges and 'unique cultural context.' Canada could potentially learn from Australian programs specifically designed for Indigenous communities and schools (2015). The CRTC's recent ruling that broadband internet access is a basic service (Kupfer, 2016) was accompanied by government funding to bring high-speed internet to rural and remote communities in the next 4 years. Howard et al (2010) argue that while access is important, it is also crucial to create content relevant to rural and remote communities in order to foster their inclusion.

While exclusion of indigenous populations in ICT and STEM careers is clear (ICTC [2016b] found that the enrolment and graduation rates of indigenous people are only 3% in ICT and 3.7% in STEM), indigenous communities are increasingly taking broadband development into their own hands. McMahon et al (2011) look at locally driven broadband development initiatives by indigenous communities, arguing that Canada's broadband approach must be reconceived. Currently, they argue, plans to address the digital divide begin from centralized government institutions rather than in consultation with the communities in question. The authors put forth a 'First Mile' approach which would "re-frame solutions to the 'digital divide' in ways that support community-based involvement, control, and ownership," thus reasserting the autonomy of First Nations. They add that human capital and lack of training contributes to the inability of some communities to manage their own broadband infrastructure, suggesting that strengthening digital literacy training would empower community-centered digital development.

A later study (McMahon et al 2015) documents how a Mohawk community's data management work and use of digital tools supports autonomy and self-government in education. Similarly, Gibson et al (2012) find that the indigenous community in Fort Severn has used ICT tools efficiently in order to deliver services and benefit work and daily life. A study of ICT use in Northern Ontario (Walmark et al 2012) found that digital divides *among* indigenous groups were smaller than in the general population, suggesting a more democratic dispersal of technology, which echoes previously cited work about holistic and community-based approaches to ICT. A promising study by Carpenter et al (2012) found that women in remote and rural indigenous communities are active users of ICT and use it primarily for social communication and for the preservation of culture and history.

Poverty and racialized/visible minorities

Despite few studies done in Canada that focus specifically on the intersections between digital exclusion, race and minority status, and poverty, it is a reasonable assumption that such patterns mimic structural exclusions in the United States. In 2016, Google for Education found that diversity gaps in computer science courses in K-12 education were caused by structural and social barriers such as a lack of access and exposure. Black students were less likely to attend schools which offered computer science courses; Black and Hispanic students were less likely to

have computer access at home. Lack of disaggregated data in Canada about race or ethnicity makes it difficult to assess the situation with certainty, however. Interestingly, while there have been no large-scale government programs in Canada focusing on digital exclusions, private programs such as Actua, Ladies Learning Code, and Covenant House have focused specifically on excluded youth, which addresses the issue of access as well as literacy

Digital literacy and integration

Alam and Imran (2014) draw on work that foregrounds access to information as the crucial barrier to social inclusion for immigrants and newcomers, linking digital inclusion with social inclusion. They draw on a mid-2000s Canadian study that claimed that the causes of social exclusion of newcomers were linked to an inability to efficiently access information about basic needs, arguing that information itself is a crucial form of social capital. Alam and Imran also argue that cognitive factors and capability to utilize access, such as digital literacy and ability to use technology competently, are key to social inclusion. Most poignantly, their findings are that “digital exclusion can stall the process of social inclusion and the process of the refugee migrants’ integration into the wider community” (2014).

Initiatives in the UK (CodeYourFuture) and Netherlands (HackYourFuture) seek to teach refugee newcomers coding skills in order to hasten their entry into the labour market. They are run particularly by volunteers from the tech community, in the absence of government programming (Reynolds, 2016). Work by Alam and Imran (2014) finds that digital literacy (presupposing access) can lead to greater integration into host communities. They cite Caidi and Allard (2005), who find that social exclusion of refugee newcomers is partly due to a lack of information about basic needs, including employment, housing, education, and health. Information (Johnson, 2003) is a form of social capital, which further spurs social inclusion. Gilhooly and Lee (2014) did a similar study on the role of digital literacy on refugee resettlement, corroborating findings that it boosted social connectedness and inclusion.

EMERGING RESEARCH QUESTIONS

Based on this scan of literature on digital literacy, we can identify several areas where further research is necessary. Research is needed to:

1. Adequately understand the state of digital literacy in Canada, beyond the public school system; this would include mapping all existing public and private programs.
2. Understand the digital skills gaps in the Canadian economy with more precision (rectify disagreements between studies).
3. Quantify and examine the digital divide in Canada particularly in terms of race.
4. Explore how digital literacy can be taught to older populations, in particular about cost-effective re-training programs in digital skills for older workers.
5. Precisely identify digital skills needed for various sectors of the economy and occupations.
6. Examine the links between computational thinking and other cognitive factors and digital literacy.

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APPENDIX A: KEY RESEARCH INSTITUTIONS + RESEARCHERS

Last Name	First Name	Title	Organization	Selected Expertise
Belshaw	Doug	Consultant	Literacies	Digital Literacy
Benade	Leon	Director of Research and Senior Lecturer	School of Education, AUT University, Auckland, New Zealand	Educational Research
Bhatt	Ibrar	Senior Research Associate	University of Lancaster	Digital Literacy
Brown	Cheryl	Senior Lecturer	Centre for Innovation in Learning and Teaching, University of Cape Town	Digital Literacy and Education
Coiro	Julie	Associate Professor of Reading	School of Education at the University of Rhode Island	Digital Literacy and Education
Coombs	Antony	Academic Adviser, Technology-Enhanced Learning	University of Greenwich	Digital Literacy and Education
Creutzberg	Tijs	Senior Associate	Innovation Policy Lab	Public policy, public administration and strategy in the areas of research, innovation and economic development.
Flanagan	Jennifer	CEO	Actua	Digital Literacy
Gourlay	Lesley	Head of Department of Culture,	UCL	Education and technology

		Communication and Media		
Haight	Michael	PhD Candidate	Sociology Dept, The University of Western Ontario	Digital Inclusion: Technology Use and Non-use in Canada's Digital Economy
Hinrichsen	Juliet	Senior Lecturer	University of Greenwich	Digital Literacy and Education
Hobbs	Renee	Founder and Director of the Media Education Lab	Harrington School of Communication and Media	Digital Literacy
Jane	Tallim	Executive Director	MediaSmarts	Digital Literacy
Lea	Mary Rosalind	Reader in Academic and Digital Literacies	Institute of Educational Technology, Open University, UK	Digital Literacy and Education
Oliver	Martin	Professor in Education and Technology	UCL	Technology in Higher Ed
Wing	Jeanette	VP of Research	Microsoft	Computational thinking

APPENDIX B: ANNOTATED BIBLIOGRAPHY

Canada

1. Canadian Science Policy Conference. (2015). "Why Canada needs a national digital literacy strategy." Summary of Panel on Digital Literacy: What is going to make the real difference? organized by Actua. http://sciencepolicy.ca/sites/default/files/digital_literacy_-_why_canada_needs_a_national_digital_literacy_strategy.pdf
 - Brief report on a 2015 discussing the fact that the Canadian education system is failing to provide their students with digital literacy skills (and lagging behind OECD)

countries). The panel's recommendations are the creation of a federal digital literacy strategy, provincial curricula informed by this strategy, professional training for teachers in teaching the new curricula, inclusion of girls, indigenous youth, and youth living in poverty, and opportunities for youth innovation.

2. Colledge, Mike, and Michael Haight. (2016). "The risk of building infrastructure without building digital literacy." *The Globe and Mail*. <http://www.theglobeandmail.com/report-on-business/rob-commentary/the-risk-of-building-infrastructure-without-building-digital-literacy/article32043633/>
 - Looks at the perils of Canada's innovation agenda if it fails to address the growing skills gap in Canadian digital users and workers. Encourages not only fostering digital infrastructure such as expanding rural broadband but increasing skills and knowledge of digital consumers.
3. Council of Canadian Academics. (2015). *Some assembly required: STEM skills and Canada's economic productivity*. Retrieved from <http://www.scienceadvice.ca/uploads/ENG/AssessmentsPublicationsNewsReleases/STEM/STEMFullReportEn.pdf>
 - This study contradicts the findings from ICTC's studies, claiming that there is no evidence of a STEM skills gap across Canada. However, they recommend long-term strategies to nurture both foundational and advanced STEM skills, as well as recruiting women and First Nations, and attracting immigrants.
4. Depow, Jeremy. (n.d). "Thoughts on the Global Race for Digital Skills." *Canada's Digital Policy Forum*. <http://cdpf.ca/publications/#>
 - Depow argues that Canada imposes high hurdles in employers' search for global talent and that this adds to Canada's declining STEM performance. He argues for a consistent national approach that prioritizes the digital skills needed to participate in the digital economy – in particular education – and for the funding of private digital literacy boot camps and organizations.
5. Government of Ontario. (2015). "Seizing Global Opportunities: Ontario's Innovation Agenda." <https://www.ontario.ca/page/seizing-global-opportunities-ontarios-innovation-agenda>
 - Frequently cited by ICTC reports. Talks about the 'spectrum of skills' and how post-secondary educations can give students the full range of skills needed for innovation – however it doesn't reference digital skills, 21C skills, or literacy.
6. Howard, P., Busch, L., & Sheets, P. (2010). Comparing digital divides: Internet access and social inequality in Canada and the United States. *Canadian Journal of Communications* 35, pp. 109-128. <http://www.ryerson.ca/~cmiddlet/cc8987/readings/2192-5865-1-PB.pdf>
 - A wide-ranging and useful text on the roots of Canada's digital divide.
7. ICTC. (2010). "Digital Literacy: Canada's Productivity Opportunity."
 - Includes several key recommendations, including creating 'a standardized system to measure Digital Literacy in its workforce.'
8. Industry Canada. (2010). "Digital Literacy and Essential Skills." *Ontario Literacy Coalition*. <https://www.ic.gc.ca/eic/site/o28.nsf/eng/00328.html>

- Includes digital literacy in a broader adult literacy strategy and discusses workforce training.
9. Institute for Competitiveness and Prosperity. (2016). “Collaborating for growth: Opportunities for Ontario.” Annual Report 15. http://www.competeprosper.ca/uploads/2016_AR15_Final.pdf
 - Identifies a prosperity gap between Ontario and peered economies; linked to a lack of productivity in general. Finds that a skills gap may threaten Ontario’s competitive advantage, and that training in emerging technologies and digital literacy should be instated or increased in the workplace and in formal education. Points out the shortage of technical expertise among the labour force as a growing concern.
 10. Ipsos. (2015). “One in Ten (9%) Canadians Do Not Have Internet Access at Home.” <http://www.ipsos-na.com/news-polls/pressrelease.aspx?id=7086>
 - News release of the results of a study which offers an interesting look at the numbers behind Canadian participation in the digital economy and the digital divide in Canada.
 11. Let’s Talk Science and Amgen Canada. (2014). “Spotlight on Science Learning: Shaping Tomorrow’s Workforce: What do Canada’s teens think about their futures?” http://www.letstalkscience.ca/images/Research/Spotlight/LTS_Spotlight_on_Science_Learning_2014_EN.pdf
 - Includes interesting recommendations about a multi-stakeholder discussion related to STEM talent development.
 12. Lets’ Talk Science and Amgen Canada. (2013). “Spotlight on Learning: The High Cost of Dropping Science and Math.” <http://www.letstalkscience.ca/images/Research/2013/SpotlightOnScienceLearning-2013.pdf>
 - Includes great statistics on what secondary school students [don’t]study and why; includes a career opportunity matrix that identifies jobs and trades that require STEM skills and literacy.
 13. Media Smarts. (2015). Mapping Digital Literacy Policy and Practice in the Canadian Education Landscape. <http://mediasmarts.ca/sites/mediasmarts/files/publication-report/full/mapping-digital-literacy.pdf>
 - Looks to be the only organization that has published any similar look at digital literacy policy across Canada – focuses on primary education and youth and provides an overview of provincial curricula.
 14. Media Smarts. (2015). Young Canadians in a Wired World Phase III: Experts or Amateurs? Gauging Young Canadians’ Digital Literacy Skills. http://mediasmarts.ca/sites/mediasmarts/files/pdfs/publication-report/full/YCWWIII_Experts_or_Amateurs.pdf
 - One of the only studies to father data on young Canadians’ digital skills.
 15. Media Smarts. (2010). Digital Literacy in Canada: From Inclusion to Transformation. <http://mediasmarts.ca/sites/mediasmarts/files/pdfs/publication-report/full/digitalliteracypaper.pdf>
 - This study links Canada’s lagging digital economy and the failure to develop a digital literacy/skills strategy on a national level.

16. Reddick, Andrew, et al. (2000). “The Dual Digital Divide: The Information Highway in Canada.” Canadian Cataloguing and Publication Data.
<http://publications.gc.ca/collections/Collection/RH4-5-2000E.pdf>
 - A look into how the digital divide used to be considered as primarily an issue of access to technology, esp. household use of the internet and cost, but also begins to consider the second-order divide: that of literacy. The study foresees that the digital divide will continue to mimic other patterns of differential levels of access, based on “social class, generation, gender and value factors (perceived need and interest).” Would be interesting to see if this prediction holds true – for ex. the gender gap appear to be diminishing at a faster rate.
17. UBC. “Canada and digital literacies.” Digital Literacies blog, Course ETEC 540: Text Technologies: The Changing Spaces of Reading and Writing.
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 - a. Overview of main concepts, definitions, and uses of digital literacy. Teaching tool for a UBC course.
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http://en.copian.ca/library/research/digi_es_can_workplace/digi_es_can_workplace.pdf
 - Tracks the shift in concern about the digital divide to the digital-skills and cognitive skills divide. Includes tables of varying definitions of digital literacy and skills.
19. ACM Europe. (2017). “ACM Europe: Informatics education report: Digital literacy.” Association of Computing Machinery. <http://europe.acm.org/iereport/digital-literacy.html>
 - Recommends that digital literacy should indeed be a required part of the education of all Europeans but doesn’t define what its components are.
20. Benade, Leon. (2014). “Knowledge and Educational Research in the Context of ‘Twenty-First Century Learning’.” European Educational Research Journal 13(3).
 - Benade discusses how the discourses of 21stC learning and the knowledge economy intersect in educational research. He suggests the need for a paradigm shift in education (which is currently a modernist, industrial-age model) towards a radically future-oriented education model, which would assume an economy where all forms of work are highly skilled. He emphasizes lifelong learning and 21stC skills not as static but as a form of knowledge which equips learners with the thinking skills to adapt of complex and uncertain futures.
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 - Discusses the “Computational Thinking (CT) movement rather than digital literacy – or conflates the two. Echoes Wing (2006), who argues that “computational thinking needs to be viewed as a core cognitive skill, not as the province of experts and specialists.”

The digital economy

22. Asliturk, E., Cameron, A., & Faisal, S. (2016). Skills in the Digital Economy: Where Canada Stands and the Way Forward. Information and Communications Technology Council. Retrieved from <http://www.ictc-ctic.ca/wp-content/uploads/2016/05/Skills-in-the-Digital-Economy-Where-Canada-Stands-and-the-Way-Forward-.pdf>
 - One of the crucial ICTC studies, identifying skills required to succeed in the digital economy. Quantifies Canada's skills gap and introduces set of recommendations.
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 - Includes a breakdown of levels of digital skills and what they comprise.

Best Practices

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