ASSESSING THE IMPACT OF UNIVERSITIES IN THE INNOVATION ECOSYSTEM

Incubators, Accelerators, and the Culture of Innovation

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Contents

Executive Summary

The Importance of a Digital Skills Strategy

Digital skills are the foundation of a world-class digital economy. For more than two decades, there has been a great deal of discussion of Canada's critical skills shortage, skill mismatches, and the digital divide. Canada's last comprehensive digital strategy, developed by the Information Highway Advisory Council (IHAC), was instituted over a decade ago (IHAC, 1998). Given the rapid pace of change in technology – and the skills needed to use this technology – Canada requires a new digital strategy.

Digital skills are, arguably, the foundation upon which the other pillars of a national digital strategy are built. While the development of physical infrastructure is an important priority, advanced countries also recognize the need to develop their human skills infrastructure. This ensures the population is able to take full advantage of the physical infrastructure, access the government services and consume digital products and services. Digital skills are critical to companies developing infrastructure, companies requiring skilled workers to achieve their business objectives, companies creating new products and services, as well as small companies striving to rise to the next level. Research and innovation, fundamental to the growth of a world-class digital economy, are dependent on a skilled workforce.

The focus of this project was to review the existing English and French language literature, both Canadian and International, which address the following themes:

- Definitions of specific digital skills, including their similarities and differences;
- Benchmarks used to assess digital skills;
- Strategies related to information and communications technology (ICT) and digital economy skills, including operative definitions, components, and evaluations (if any);
- Taxonomies of stakeholders as well as initiatives documented to promote digital skills, including goals, tactics, and impacts; and,
- Potential models that may serve as a basis for further consultation with relevant stakeholders.

Definitions of Digital Skills

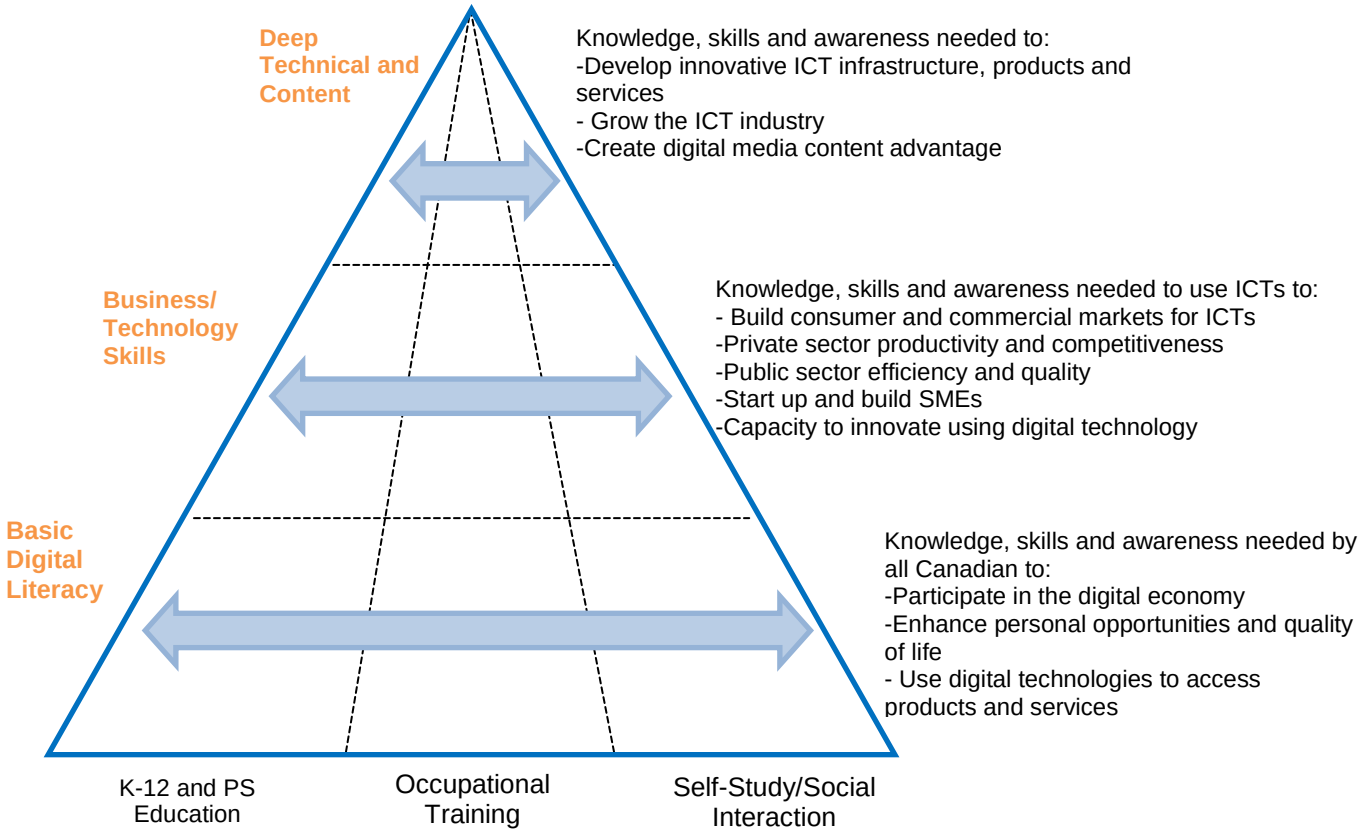
The definitions of "digital skills" and standards for assessing "digital literacy" vary considerably in the academic literature as well as in government and industry reports. The categories of skills also vary – while many differentiate digital literacy from workplace digital skills, business-technology and deep technical skills (typically STEM), some also focus on content creation and entrepreneurial skills.

We suggest that digital skills can be understood at three basic levels.

- Basic Digital Literacy equips Canadians to participate in the digital economy;
- Business/Technology Skills build consumer and commercial markets for ICTs and fuel the capacity to build businesses; and

- “Deep” Technical and Content Skills enable the development of ICT infrastructure, products and services as content. (See Figure 2-2)

Figure 2-2: Levels of Digital Skills



Media Awareness Network, 2010

- Some define digital literacy as low level skills needed to access computers and the internet; others expand the definition to include a wider range of skills; many use digital literacy as the overarching framework for all digital skills, differentiating basic, intermediate, and advanced digital literacy skills.
- Definitions are often in the eye of the beholder – for example, traditional IT manufacturing and service providers are more likely to define skills in ways that meet their employment needs and fit with their perceptions of how the market will develop. Typically, they emphasize STEM and business technology skills. In contrast, digital media, gaming and online companies such as Google are more likely to emphasize the importance of creative and content skills.
- The framing of skills is infrequently linked to specific occupational requirements and more work is required here.
- Most of the research on digital skills is not strongly grounded in evidence concerning the demand for the skills; some of this research is linked to studies of the measurement and assessment of these skills among different populations

- More research is needed to analyse similarities and differences among the definitions and to examine the link between these definitions and empirical evidence of specific needs in the digital economy.

Supply and Demand for Digital Skills

- There is general agreement that there is a skills mismatch – that many jobs in the ICT sector are unfilled while many professionals with high levels of skills are under-employed.
- Labour force projections are seldom precise and are even more challenging within the digital sector. Some have argued that, rather than trying to predict precise demands, creating an agile and adaptive workforce is key.
- Because of differences in the definitions of the sector and occupational categories, measurement is challenging. While the ICT sector, for example, is often conceived of as the providers of hardware, software and services, many studies also include ICT professionals working in end user organizations. Indeed some estimate that there are almost as many ICT professional working outside of ICT companies as inside.
- In addition the definition of the occupational classes presents considerable challenges. Some labour market projections take broad definitions, ranging from deep technology based occupations to technical writers, while others use narrower definitions.
- Lack of digital skills in end user companies has been identified as an impediment to technology adoption, particularly in SMEs.
- Lack of “creative” or content related skills coupled with business skills are another gap.
- Gaps in the available expertise to develop small companies or ideas into successful enterprises have also been identified. There has been considerable discourse about the need to build an entrepreneurial culture to advance innovation.
- Labour force projections are seldom precise and in the digital sector are even more challenging. Some have argued that rather than trying to predict precise demands creating an agile and adaptive workforce is important but considerably more research is needed to understand ICT labour force dynamics and “matching” of the available workforce.
- Many stakeholders have identified a “digital divide” in basic digital literacy based on demographics, socio economic status, geography, etc.
- Some have focused on under-representation of certain segments of the population (women, visible minorities, aboriginal people, and people with disabilities) among workers with digital skills.
- There is also significant evidence of the under-employment of skilled immigrants even in areas where demand for these skills is high.
- While there is extensive academic research exploring some of these issues, there is limited interrogation of the claims about skill gaps or an empirical investigation of perceptions about required skills, available skills and future skill requirements.

- We need a more in-depth and nuanced understanding of the factors affecting career choice and ways to attract and retain more young people and particularly women and aboriginal people in the sector.

Benchmarks to Assess Digital Skills

- Just as the definitions of digital skills vary, so do the approaches to measurement. Many countries which have a digital skills strategy do not have benchmarks; only a handful have concrete goals.
- There is some empirical data which attempts to operationalize definitions and measure performance at the macro-level (e.g., among countries), the meso-level (e.g., among particularly occupational groups or organizations) and the micro-level (e.g., among specific segments of the population)
- Many of the indices being used have not been validated. In fact the limitations with some measures, such as the metrics used to measure basic digital literacy, have been challenged.
- There is evidence of disparities among industrialized countries but also within industrialized countries based on age, gender, geography, ethnicity, socio-economic status, etc., suggesting that reported national averages may hide huge disparities
- Although they are essential, content creation and entrepreneurship skills are often excluded from the taxonomies of digital skills and more attention needs to be paid to measuring these so appropriate targets can be set.
- Consideration should be given to measuring e-learning skills so appropriate targets may be set, given that learning in many disciplines now depends on these skills.
- More research needs to be done to clarify the definitions being used and to compare indices in order to benchmark Canada's progress.

Stakeholders

- Customary stakeholders to be engaged in the development of a digital skills strategy are governments, educational institutions (K-12, colleges, polytechnics, universities, training organizations), employers and other stakeholders (community organizations, libraries, organizations representing specific groups etc.)
- Understanding specific issues and orientation of segments of stakeholders are key – for example, at universities, the perceptions of administrators may differ than those of faculty and those of students. There are huge variations among disciplines, regions and leaders in the adoption of technology, etc. Consequently a detailed and nuanced understanding of these stakeholders and their interests is important.
- Similarly within the corporate sector there are important differences between the perceptions of large ICT providers and content providers, between large organizations and SMEs and between companies which are primarily users of technology.
- There are also a range of stakeholders who have shown interest in the issues around digital skills and specific efforts should be made to include those that represent groups on the have-not side of the digital divide.
- More research is needed to develop a nuanced understanding of differences among stakeholders.

- More work is needed to ensure that the implementation strategy developed to support the digital skills component of the strategy has clear targets, responsibilities and measures of success.

Strategies Related to ICT and Digital Economy Skills

- There is a wide range of digital strategies with varying degrees of specificity in recommendations for the development of digital skills
- Through collaboration with multiple stakeholders and across levels of government, develop a national digital skills strategy which defines needs, defines skill requirements, sets benchmarks and provides a plan of action.
- Ensure a basic level of digital literacy for all Canadians, attending to digital divides based on age, geography, social economic status, gender, etc.
- Provide cradle to grave opportunities to acquire and upgrade skills through a range of formal and informal educational opportunities in partnership with educational institutions, industry, libraries and community organizations.
- A standardized curriculum of digital skills training must be developed and implemented in kindergarten and continue until high school graduation.
- Invest in programs that provide incentives to train and retrain workers.
- Encourage the development of content creation and creative skills.
- Support development of skills needed to promote the adoption of digital technology by SMEs.
- Support development of skills needed to set up small businesses and digital enterprises along with the skills needed to take these to the second stage of development
- Encourage the development of professionals with hybrid skill sets that combine technology and management skills.
- Create experiential learning opportunities, internships, etc.
- Use digital technology in innovative ways to support the development of education and skills in other areas – establish targets for e-learning experiences among post secondary students.
- Dramatically increase the number of science, technology, engineering and mathematics graduates.
- Support further research into real versus perceived needs, taxonomies of skills and forms of measurement, as well as evaluations of programs aimed at promoting digital skills.
- Support collaborative, inter-disciplinary, and cross-sectoral research and learning opportunities at all levels.

Overall Conclusions: Building the Digital Talent Pool and Skills for Tomorrow

The body of literature relevant to digital skills development is extensive – more than 2000 academic articles as well as hundreds of policy papers by governments and other stakeholders address the issue.

Our systematic review of this literature raises as many questions as it answers but our observations include the following:

- There is a high level of consensus on the need for a digital skills strategy as part of an integrated digital strategy.
- There are different definitions of “digital skills” and priorities concerning the focus on basic digital skills, business-technology digital skills or “deep” technology and content skills.
- The focus tends to reflect the orientation of the organization - in some cases, critical skills sets such as content creation and entrepreneurial skills have been neglected even though these are essential.
- While there are many sectors claiming that there are skills shortages or gaps, more precision on the nature of these gaps is needed as well as the factors which influence choices concerning digital skills development both at the basic literacy and advanced levels.
- There continues to be evidence of under-representation among certain groups in the ICT sector as well as evidence that bridging programs and attention to diversity can help address shortages. However, there is limited research on the efficacy of different approaches.
- Clearer definitions must be established with benchmarks at each level.
- There are a wide range of stakeholders who should be engaged in policy development. Beyond the obvious players – government, education, industry and industry associations – community organizations, and libraries.
- Many other jurisdictions have developed comprehensive digital strategies which include digital skills and systematic analysis not just of the strategies but of their efficacy would be useful to inform Canadian efforts in this area.

Introduction

Overview of the Project

Digital skills are the foundation of a world-class digital economy. Not only do they ensure an innovative and effective talent pool, but they also stimulate both economic and social development. Citizens with digital skills drive innovation in both consumer and industrial markets. Canada faces several challenges in terms of developing a comprehensive strategy to increase digital skills and competencies in its population. In part, this challenge is exacerbated by varying definitions of digital skills as well as an unclear understanding of Canada's position on the competitive global stage. Over the past two decades, there has been a great deal of discussion of Canada's critical skills shortage, skill mismatches, and the digital divide. Our proposed paper will review and synthesize the English and French language literature, published both in Canada and internationally, on the spectrum of digital skills needed to fuel Canada's growth.

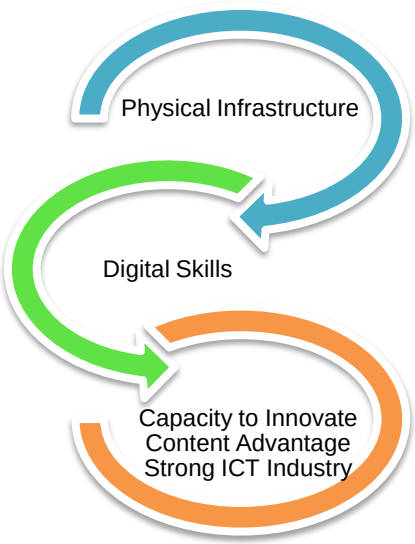
Digital Skills, the Foundation of Our Digital Strategy

In the consultation paper (Government of Canada, 2010), the digital strategy was structured around several inter-related dimensions or themes:

- Capacity to innovate using digital technologies;
- Building a world-class digital infrastructure;
- Growing the information and communications technology industry;
- Creating Canada's digital content advantage (i.e., digital media content); and
- Building digital skills for tomorrow.

Digital skills are the foundation upon which the other four pillars of the strategy rest. The capacity to innovate using digital technologies requires deep technology skills, design and content development skills, and skills associated with the entrepreneurship, innovation and commercialization of technology. Building a world class infrastructure rests on deep technical skills to create it and basic digital literacy to use it. Skills shortages or mismatches have plagued the ICT sector for two decades and an increasingly nuanced understanding of the skills requirements in the sector is emerging. Demands for a range of digital skills exist in not only in the companies that sell technology but also in the companies that use technology. Hence there is a need for virtually all workers to have an understanding of business technology applications; there is a need for people who can develop technology solutions to meet business needs in order to promote adoption and effective use of technology, and there is the need for deep technology skills in both supplier and user companies. Creating Canada's digital content advantage requires technology skills, creative and content related skill and entrepreneurial and management skills. In other words, building human infrastructure and capacity is at least as important as building technological infrastructure in advancing Canada's digital strategy and should, therefore, be addressed in said digital strategy. We have prepared the following figure to visually represent the elements of our proposed digital strategy and how they interconnect.

Figure 1-0: Elements of Canada's Digital Strategy



The deployment of broadband networks across Canada is critical as it enables the use of new digital technologies fuelling innovation and productivity. However, access to infrastructure is only one factor that drives use. Research shows that training and skills development drive technology adoption by consumers and in organizations (Boothby et al., 2010).

Canada has, historically, underinvested in digital technologies and, as a result, has an underdeveloped ICT industry when compared to our key competitors. For example, the size of Canada's ICT sector is less than the Organisation for Economic Co-operation and Development (OECD) average (Government of Canada, 2010). In order to be truly competitive in a global digital economy, Canada has to strengthen its ICT sector. One of the ways in which it can do this is to invest in research, development and technology innovation. Digital skills are integral to utilizing existing technology as well as inventing new technologies. Without a workforce that is digitally literate, Canadian companies will be unable to compete.

At the same time, studies have shown that access to technology and basic skills do not guarantee usage. Factors such as socio-demographics and location of access are important as is social support and technical support during learning (Brandtweiner, 2010). There has been extensive research into the "digital divide" and its dimensions (Crête, 2008; Goode, 2010). In addition extensive research has focused on gender differences in adoption and the factors affecting them (Divjak et al., 2010; Hargittai, 2010).

Studies have also explored the impact of disabilities and access to technology which has shown that people with disabilities tend to have less access to digital technology and use it less often, although there are contributing factors such as socio-economic

status (Caldwell, 1999; Egan et al., 2004; Seymour, 2005; Brotcorne &Valenduc, 2008; Vicente & Lopez, 2010).

Moreover, there is evidence to suggest that different skills development strategies are needed for learners of different ages (Broady et al., 2010). For example, barriers facing older learners include: lack of background knowledge (Dickinson et al., 2005); confusion regarding procedures; fear of the unknown (Hawthorn, 2007); lack of confidence (Marquie, 2002); and lack of the perceived value (Rice et al., 2007).Research on digital literacy among seniors has highlighted that new technologies provide powerful coping mechanisms, intellectual stimulation and increase interpersonal relations for that population (Michel et al., 2009).

Some studies have demonstrated that e-learning systems for skills development are significantly associated with overall job outcomes (Clarke, 2002; Chen, 2010).

Digital skills are, arguably, the foundation of the other pillars of a national digital strategy. While development of physical infrastructure is an important priority, advanced countries also recognize the need to develop their human skills infrastructure to ensure that they have a population that is able to take advantage of the physical infrastructure. Digital skills are crucial for several sets of stakeholders: the government (i.e., providing services and consuming the products provided) as well as companies developing the infrastructure, using it to support their business objectives, creating new products and services and for taking small companies to the next level.

Project Scope

This project has reviewed the existing English and French language literature, from Canada and across the globe, to explore the following themes:

- Definitions of specific digital skills, including their similarities and differences;
- Benchmarks used to assess digital skills;
- Strategies related to ICT and digital economy skills (i.e., digital skills), including operative definitions, components, and evaluations (if any);
- Taxonomies of stakeholders as well as initiatives documented to promote digital skills, including goals, tactics, and impacts; and,
- Potential models that may serve as a basis for further consultation with relevant stakeholders.

Methodology and Approach

Our methodology included textual analysis tools as well as established approaches to meta-analysis. Our corpus is comprised of academic literature as well as ‘grey literature’ – reports produced by governments and industry associations.

Our procedure was structured in the following way:

1. To search the selected databases (Academic Search Premier, CBCA Complete, ProQuest Research Library, and Web of Science) for English language documents, we used the following Boolean search string: (*digital* or *ICT* or *“information*

technology") AND (*skill** or *literac** or *e-skill**). From those results, we created a database of 18,452 non-unique results.

2. To search the selected databases (ProQuest Theses and Factivia) as well as the federated search engine, Google Scholar, we searched for French language documents using the following Boolean search string: (*numérique* or *TIC* or *"technologies numériques"* or *technologies* or *"fracture numérique"* or *"didactique de l'Information"*) AND (*alphabétisation* or *compétence* or *habileté*). From those results, we created a database of 1,892 unique results.
3. We scrubbed the database for both the French and English language documents to remove all duplicate results. This left us with 17,488 unique results
4. After systemically coding these results and eliminating all non-relevant documents for the purposes of this report, we were left with 2,829 unique results. A table and graph representing these findings, by year, is found below.
5. In addition, we searched "grey literature" for relevant documents and examined national strategies for the United Nations Education, Scientific, and Cultural Organization (UNESCO), the European Union, Britain, China, Singapore, Australia, New Zealand, the Asia Pacific Region, the United States and California. We found 81 international, regional, and national reports.
6. We also mined the submissions to the Government of Canada's Digital Economy Consultation to identify stakeholder organizations in Canada who have addressed these topics from a variety of perspectives. We coded and identified 107 documents that were relevant to our report.

The complete bibliography of relevant articles is a separate document.

Table 1-0: Article Search Results Summary

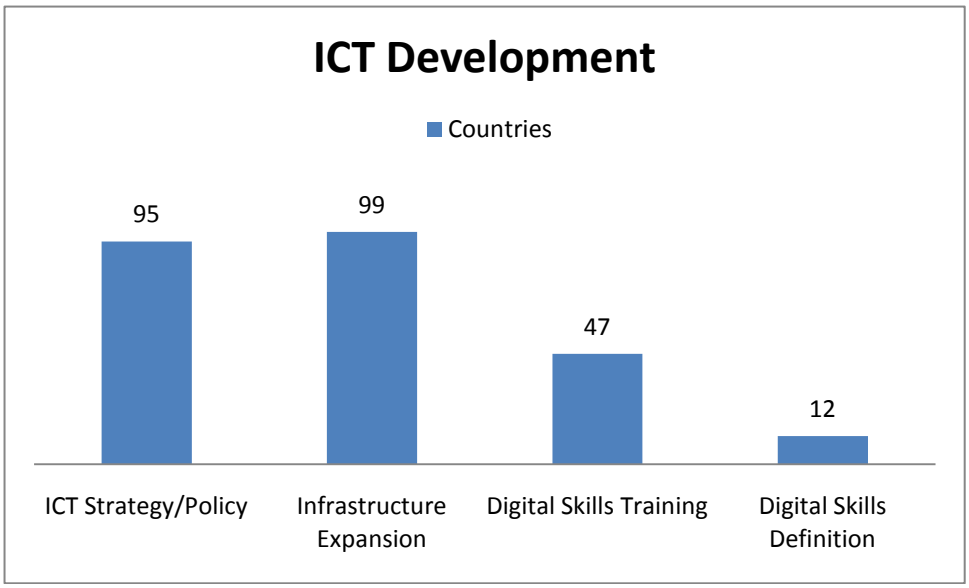
	Total	1980-1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010-2011
Relevant Articles (Total)	2,829	312	88	97	113	112	180	208	324	344	426	387	238
Non-Duplicated Articles (Total)	17,448	3,399	706	837	823	838	1,046	1,177	1,338	1,446	1,681	1,378	887

Definitions of Digital Skills

Overview

While most countries' digital strategies focus primarily on expanding the infrastructure of digital technology, a review of ICT development strategies in 100 countries revealed that a substantial proportion also address digital skills training and digital skills (see Figure 2-0 below, and Appendix 2 for a detailed analysis)

Figure 2-0 Summary of ICT Development Strategies in 100 Countries



* The Global Information Society Watch (APC & Hivos, 2009), the ITU Plenipotentiary Conference Policy statements from the 2006 conference (ITU 2006) and the 2009/10 Digital Review of Asia-Pacific. (Akhtar Arinto, 2009) Additional documentation was included (Doğan, 2005; Uçkan, 2009, Peterson, 2007).

While almost all of the countries reviewed had a national ICT strategy; some were far more comprehensive than others. Most countries were in the process of expanding their infrastructure and nearly half were focused on digital skills training. Many of the countries that lacked training policies had little ICT infrastructure in place. Ten of the 12 countries that had explicitly stated digital skills definitions were in the European Union and, therefore, use the EU's definition. The other two countries with digital skills definitions were the USA and United Kingdom.

In many cases digital skills are essentially defined based on access to digital technology infrastructure. However, researchers have maintained that access to technology is not enough. The investment in digital literacy programs and development may cost ten times as the technological investment to increase digital access (Media Awareness Council, 2010).

Digital skills have been broadly defined as the ability to access, evaluate, manage, integrate, and create information using digital technology (ETS, 2007). Some definitions of digital skills include progressive categories that increase in the level of required

technological expertise and complexity. For example, a range of digital skills might include: basic digital literacy, digital business skills and deep technology/content development skills, which describe highly specialized technical ICT skills (Bresnahan et al., 2002; see also Canadian Coalition for Tomorrow's ICT Skills (CCICT), 2010). The UK digital skills strategy defines digital skills in terms of the required level of complexity and expertise for four categories of workers: technology professionals, content professionals, technology-capable business people, and 'every individual', who has a basic level of digital skills regardless of vocation (Sambell, 2009). Canada's major technology associations define digital literacy, digital management skills and specialized or 'deep' ICT technology skills (see also: CCITC, 2010; ITAC, 2010). The European Commission on e-skills also identifies three areas of focus: ICT practitioner skills, ICT user skills and e-business skills (Ala-Mutka, 2009). Content skills and entrepreneurial/creative skills are rarely recognized as important aspects in the definition of digital skills (E-Skills UK, 2009). California has one of the most comprehensive digital strategies, with six elements: access, manage, integrate, evaluate, create, and communicate (California Emerging Technology Fund (CETF), 2008). Based on our research, we have summarized the categories and definitions of digital skills in Table 2-1.

Table 2-0: Overview of Digital Skills Definition Areas

Skill Area	General Definition
Basic User Skills	Ability to use a computer to do basic office software, access and use websites and use e-mail.
Job Specific User Skills	The ability to effectively use specific hardware and software for in an individual's workplace, such as advanced enterprise systems or graphic design software
Creation Skills	The ability to use ICTs to create new content which can be used and developed by others
Advanced or "Deep" ICT skills	Post-secondary training in developing on a large and small scale ICT technologies, providing the ICT technologies for the rest of society
Digital Citizenship	A more open-ended concept, focusing on an individual's comfort and awareness of living within a digital world.
e-Business Skills	The ability to understand the potential of ICTs in developing and improving a business, government or non-profit agency

Basic Digital Literacy

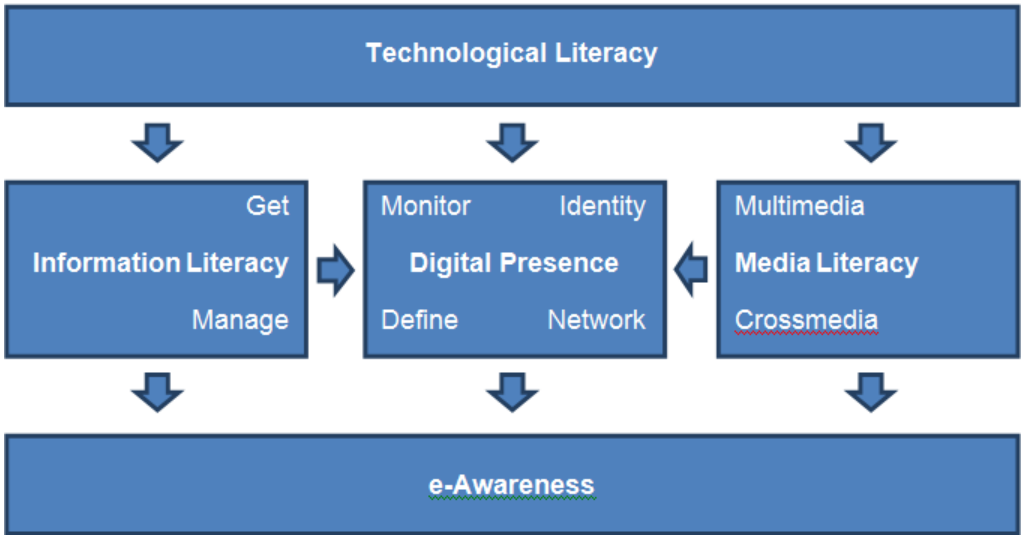
Definitions of basic digital literacy vary (DTI, 2009). According to CCITC, 2010, digital literacy is:

> a skill set that every citizen needs in order to make effective use of digital media. It is the 21st century version of the 19th century's 3Rs – reading, writing and arithmetic. Digital literacy includes understanding of the nature and uses of various digital media and technologies, how to communicate effectively via digital media, creativity, etiquette, safety, health, etc. (ITU, 2006)

Examining the various definitions show two tracks are taken, one type, such as the Canadian Media Awareness Network's (2010), is focused on the intellectual understanding of ICTs on a larger scale. Other definitions, such as that of the EU, break the definition down by job skills, differentiating between those who have basic ICT skills and those who effectively use ICTs to create. Some definitions, such as the UK's, have definitions around basic literacy, content creation and technology in business without discussing ICT professionals.

While great emphasis is placed on the ability to access information, it is also important to ensure that Canadians have the skills to navigate and interpret the information they access (George, 2004). Some academic definitions focus on information literacy in general, rather than emphasizing the cognitive steps of information search and processing, or on the levels of interaction in a digital environment (Sharma & Mokhtar, 2005). Others emphasize media literacy as well as information literacy (Fernandez-Villavicencio, 2010). Some have included protection from cybercrime and cyber-bullying must also be included among essential digital skills. The Ontario Media Development Corporation (OMDC) (2010) maintains that digital literacy should also include knowledge about intellectual property rights, specifically, learning about ethical digital behaviour, and, in particular, a respect for content creators and their right to establish and profit from ownership of their creative works. Others include digital skills among the learning outcomes for skills in the new economy (Lemke, 2003). Issues linked to the multiple translations, definitions and significations of literacy in other languages have been raised. (Le Deuff, 2008). Academic definitions also include advanced a notions of e-competence including technological literacy, media literacy, digital literacy, informational literacy and e- awareness.

Figure 2-1: Digital Literacy Definition



Peña-López, 2009

This definition includes several types of literacy:

- Technological Literacy: The skills to interact with hardware and software

- Informational Literacy: The competences to deal with information, normally by applying Technological Literacy.
- Media Literacy: Skills and competences to deal with several media, make them interact and integrate them in a single output.
- Digital Presence: The digital skills to monitor and establish a digital identity, and the skills to actively define it and use it for interacting with other people digitally
- e-Awareness: The most strategic (even philosophical) stage is the one related with being aware on how the world and our position — as a person, group, firm, institution — varies because of digital technologies (Peña-López, 2009).

The Media Awareness Network (2010) defines that for an individual to be digitally literate that they have three key skills: the ability to use, to understand, and to create using ICT technology. This definition is conceptually similar to many others but there is no single definition of digital literacy that has been agreed upon internationally, and various academics and governmental bodies have established their own definitions, most of which share common characteristics (See Appendix 2 for a more detailed overview of academic definitions of digital literacy). The majority of definitions accept that digital literacy is more than simply the basic computer skills related to basic productivity tasks (i.e., word processing), surfing the Internet or sending email. See table 2-0 for a distillation of the various areas covered by digital skills definitions.

Digital Business/Technology Skills

Beyond digital literacy skills, digital business skills include "the knowledge, skills, and personal qualities to lead and support the effective, competitive use of information technologies" (CCICT, 2010, p. 8). In other words, these are the skills needed to facilitate and support the use of ICT effectively as well as successfully leveraging the benefits from integrating technology with business practices. Integration offers a more in-depth understanding of business management, the performance of vertical markets (i.e., education, financial services, retail) or functions within the organization (i.e., marketing, human resources, accounting). The successful integration of business management skills with ICT also represents a new type of digital skill: the hybrid technology skill set. Research shows that organizations that invest in skills at the same time that they invest in new technology reap greater productivity gains (Boothby et al., 2010).

Professionals who have this skill set are defined in England's digital economy strategy, which describes them as "Technology-capable business people, who understand the strategic implications of technology and have the ability to realise its potential for business innovation, productivity and competitiveness." (E-Skills, 2009). These types of skills are highly sought after and can increase an organization's competitive advantage as hybrid skill sets enable the organization to effectively invest in technology, increase levels of innovation, productivity and, eventually, spur growth. This skill set has been identified as a priority by several of Canada's ICT associations (CCICT, 2010; ITAC, 2010). Also known as T-Shaped Skills (York University, 2010), hybrid or combination technology skills are also becoming increasingly important as traditional ICT careers are being outsourced and globalized (see also: Gantz, 2000; Arellano, 2006; Bancino &

Zevalkink, 2007; Galt, 2007). CCICT (2010) estimates that 45% of ICT professionals are employed outside of the ICT-sector. Reflecting this change, the Information and Communication Technology Council (ICTC) (2010) has estimate a need of 65,000 new hires with hybrid skills by 2017.

Academic research has confirmed a need for boundary spanners between Business and IT (Eckhardt & Rosenkranz, 2010). The European Certification of Informatics Professionals (EUCIP) has defined 21 job profiles and 145 individual skills (Eckhardt and Rosenkranz, 2010).

The adoption of continuous training solutions can play an important role in promoting adoption of ICTs in SMEs (Barba-Sánchez et al., 2007). Building awareness of the potential of ICT to impact the bottom line in the short term and long term is essential.

'Deep' Technical and Content Skills

Traditionally, digital skills have been synonymous with engineering, computer science, engineering, and mathematics. Previous benchmarks for assessing digital skills have included the production of advanced degrees in this area (DTI, 2009). However, the traditional skill sets of ICT professionals are changing; they are becoming more sophisticated, specialized and complex. These professionals "focus deeply on an ICT discipline (like analytics, engineering or security)" (CCICT, 2010, p. 13) and use this knowledge in order to lead the industry in both innovation and increased productivity.

In addition, even in highly technical professions, growing emphasis has been placed on the importance of "soft skills" as well as management skills to be successful. Programs aimed at integrating Internationally Educated Professionals often focus as much on these skills as updating technical knowledge, vocabulary and standards.

While much of the discussion on highly specialized or "deep" ICT skills have previously focused on computer science and engineering degrees and professions, some studies (Polytechnics Canada, 2010) have stressed the importance of retraining technologists and technicians, especially if they are low- to mid-skilled workers.

Creativity and Content Creation

While Canada's consultation on the digital economy paper (Government of Canada, 2010) recognizes the critical importance of digital media content creation, traditional taxonomies rarely emphasize this within broader definitions of digital skills. In contrast, while Singapore was one of the first nations to develop a national educational strategy, it has since broadened its science-driven innovation model to focus more on promoting creative and entrepreneurial activities (Asia Competitiveness Institute (ACI), 2009).

An essential piece in the digital skills puzzle is the role of content creation, design, and design thinking. Various roadmaps for digital skills have paid little attention to these three aspects and how they relate to the acquisition and development of a digital skill set. However, specific stakeholders' – such as game developers, culture industries, and artists – use the creation of digital content as a key indicator of digital skills. For

example, Joseph Crump, Executive Creative Director of Razorfish (Microsoft) describes how creativity drives innovation: “Usability—once fetishized—is now merely the price of entry, like seat belts in a car. Desirability is the new Holy Grail of switched-on brands, from airlines to banks to T-shirt makers. The bar is getting raised everyday for the way an object or an experience looks and feels, its tone of voice, its personality” (Avenue A Razorfish, 2008; 2010).

In other words, growth and prosperity in the economy is linked to innovation, the development of technology and the promotion of co-operation among all stakeholders. Increasing innovation through the use of digital technology to create digital content will increase the need for and encourage skills development as well as creating new jobs (Carte Routiére Technologique (CRT), 2010). As digital innovators and content creators produce digital content for all platforms, they reach both Canadian and global audiences. Most Canadian companies devoted to developing new digital content are SMEs and they face specific challenges when it comes to maintaining the skill-levels necessary for digital transformation. Similarly, due to the constant evolution of the required digital skill set for content creation, pre-determined skill standards cannot be set by a governing body (OMDC, 2010). A proposed solution to this is to create state-of-the-art “living laboratories” to create a network and community of constituents who can come together for “experimentation with high quality leading edge applications and collaborators” (Société des arts technologiques (SAT), 2010, p. 36).

Despite these challenges, content creators are key indicators of a society’s level of creativity, which is necessary for the development of new technologies and new ways of learning, especially in terms of digital literacy and scientific learning. Design and art are now interconnected with technology, engineering, science, and mathematics, further demonstrating the need for a class of creative designers and artists. In other words, “Fostering and supporting the capacities of new media artistic creativity, digital media production skills and innovative design must be a fundamental backbone of the Canadian digital economy strategy” (Ontario College of Art and Design (OCAD), 2010).

The Cultural Human Resources Council (CHRC) in its Digital Media Content Creation Technological Roadmap has set out a general description of the types of skills that will be needed for digital content creation and provides some recommendations for how to ensure that content creators acquire those skills. The skills identified and the skills related to them are:

1. “Soft” skills are those skills that are required for all types of projects or jobs. These are generally learned either through formal or informal workplace training. These can include leading or working within a multidisciplinary team; digital communication skills; and entrepreneurial thinking.
2. “Hard” skills are skills that are required for all types of projects or jobs. These skills are gained through formal education, however, some will be acquired either formally or informally on the job. These include: narrative design for platforms; knowledge of copyright; evaluating and negotiating contracts; finance and project management.
3. Technical skills, however, are specific to the individual job or project being worked on at the moment. Acquired through specialized technical education, there is also a

commitment to keep those skills up-to-date given the rapid pace of change in ICTs. These skills may include: Creating HD or 3D display technology; Recording and editing sound for multi-channel surround sound technology; creating updated control and input interfaces; security and encryption; working knowledge of compression technologies; knowledge of hardware; and a basic knowledge of Web design (i.e., animation, video, programming) (CHRC, 2009, pp. 20-26).

Innovation and Entrepreneurship

Distinct from typical ICT-skills, digital skills that encourage innovation and entrepreneurship are closely linked to those skills related to content creation. Developed in an experiential learning environment, discussions of these skills are – like digital content creation skills – limited. Using the extensive corpus related to the development of general entrepreneurial skills and applying this knowledge to digital skills development, some key characteristics are highlighted. Typically, the literature on general entrepreneurial skill development focuses on the key factors related to the development of a general "entrepreneurial mindset" typically through experiential learning (Sexton & Upton, 1987; Henry et al., 2005). According to Drucker (1985), an individual with the entrepreneurial mindset "shifts economic resources out of an area of lower and into an area of higher productivity and greater yield" (Foster & Lin, 2003, p. 456). Similarly, this mindset can be expanded to focus on strategies to build an organizational culture that is entrepreneurial in nature. Similarly, many pilot projects – such as Ryerson's Digital Media Zone (DMZ) – and incubators to marry entrepreneurial skills to digital innovation have also been developed and deployed. Finally, an entrepreneurial mindset is closely connected to and, when combined with digital or ICT skills, enables organizations to leverage the rapid change of technology and the skills associated with that technology. In other words, change, for an entrepreneur, becomes an opportunity to not only increase productivity but also profit.

e-Learning Skills

Strategies note that digital skill development is not just for ICT professionals, but for every individual in society. As a result, particular attention has been focused on e-learning skills. This was supported by our literature review: hundreds of articles (in both languages) were focused on the use of technology to develop skills at every level of the educational system, for virtually every profession, for every training need; the ultimate goal of which was to facilitate lifelong skill training and development. Technological innovation – specifically social networking platforms such as MySpace and Facebook – has highlighted the potential use of new media in facilitating, enhancing, and encouraging digital skills training. However, as training and skills development becomes linked to digital competence, there is a potential that the skills gap, or digital divide, will widen as not everyone has access, the ability, or the motivation to engage in e-learning opportunities in a quick and efficient way (Brotcorne & Valenduc, 2008). In other words, special care must be taken to ensure that those who lack digital skills do not fall behind. Several benchmarks have been used to ensure that this does not occur as well as several initiatives have been implemented to overcome this divide. For example, e-learning training programs have been audited to ensure that they are effective in developing a core set of skills in a formal educational setting (Davidson & Eliot, 2007).

Training programs have also been developed in order to address individuals who are outside of the formal education system (Unwin et al., 2007; Kadhem & Ala'a Al-Din, 2008), as well as those directed at groups who are most at risk to be disadvantaged due to the digital divide, such as women in low-status, low-skilled professions (Messmer & Schmitz, 2004; Vandenbroeck et al., 2008).

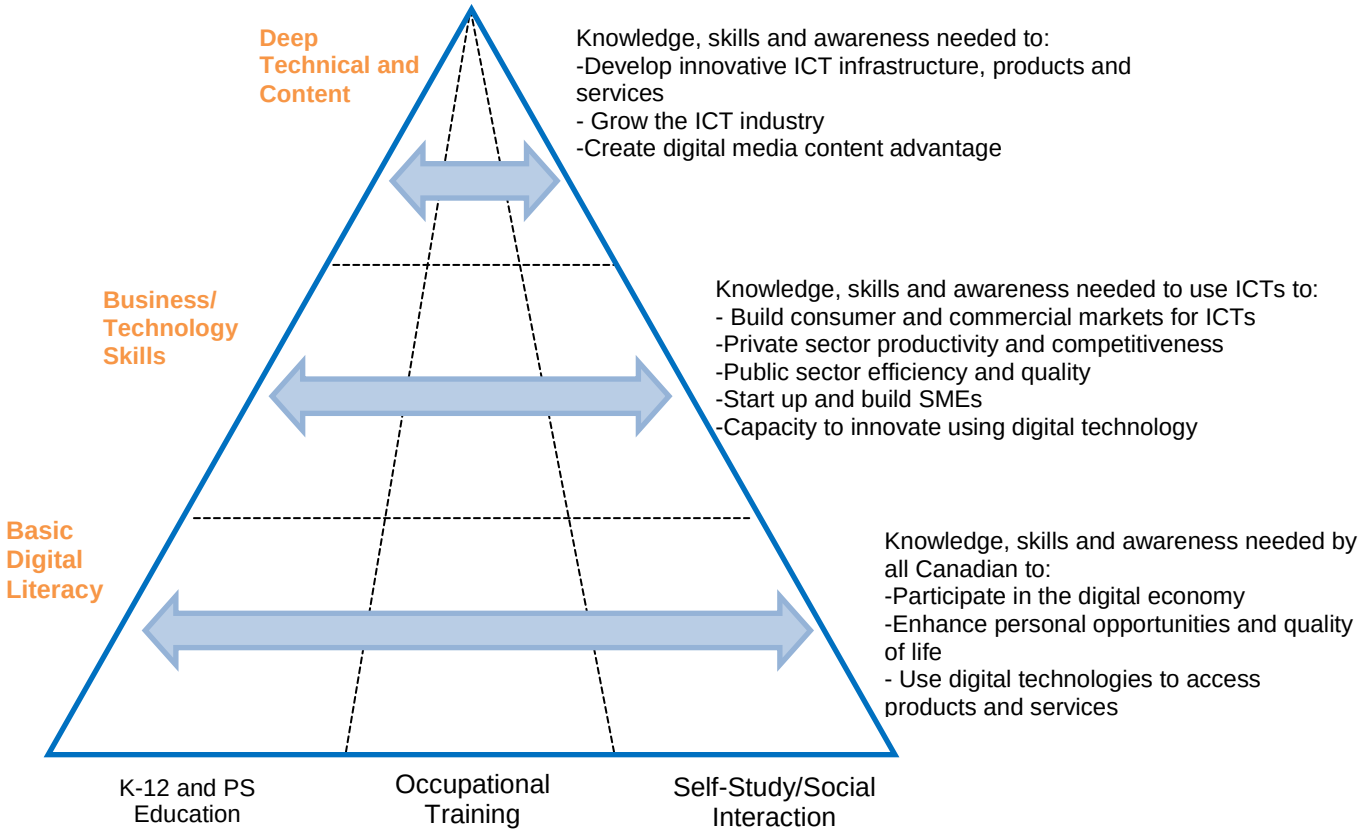
Conclusions and Further Research

The definitions of "digital skills" and standards for assessing "digital literacy" vary considerably in the academic literature as well as in government and industry reports. The categories of skills also vary – while many differentiate digital literacy from workplace digital skills, business-technology and deep technical skills (typically STEM), some also focus on content creation and entrepreneurial skills.

We suggest that digital skills can be understood at three basic levels.

- Basic Digital Literacy equips Canadians to participate in the digital economy;
- Business/Technology Skills build consumer and commercial markets for ICTs and fuel the capacity to build businesses; and
- "Deep" Technical and Content Skills enable the development of ICT infrastructure, products and services as content. (See Figure 2-2)

Figure 2-2: Levels of Digital Skills



Media Awareness Network, 2010

- Some define digital literacy as low level skills needed to access computers and the internet; others expand the definition to include a wider range of skills; many use digital literacy as the overarching framework for all digital skills, differentiating basic, intermediate, and advanced digital literacy skills.
- Definitions are often in the eye of the beholder – for example, traditional IT manufacturing and service providers are more likely to define skills in ways that meet their employment needs and fit with their perceptions of how the market will develop. Typically, they emphasize STEM and business technology skills. In contrast, digital media, gaming and online companies such as Google are more likely to emphasize the importance of creative and content skills.
- The framing of skills is infrequently linked to specific occupational requirements and more work is required here.
- Most of the research on digital skills is not strongly grounded in evidence concerning the demand for the skills; some of this research is linked to studies of the measurement and assessment of these skills among different populations
- More research is needed to analyse similarities and differences among the definitions and to examine the link between these definitions and empirical evidence of specific needs in the digital economy.

Supply and Demand for Digital Skills

Overview

Fundamental to a digital skills strategy is the matching of talent (supply) to employment needs (demand). As the consultation paper on the digital economy (Government of Canada, 2010) noted, the task at hand is: "growing the labour force by reducing barriers; improving the quality of the labour force by supporting skills development; and enhancing labour market efficiency through facilitating labour mobility and adjustment." In Canada, several studies have focused on labour market projections and skill requirements in the ICT sector. ICT organizations continue to claim that there is a skills shortage or, at the very least, a skills mismatch (Valliancourt, 2003; Wolfsan, 2003; ICTC, 2007; Boisvert, 2008; ICTC 2008a). This is exacerbated by a limited investment in ICT training and may contribute to the more general gap in ICT investment between Canada and the US (Centre for the Study of Living Standards (CSLS), 2005). While the ICT sector saw an employment downturn in 2008, organizations are still reporting that they are having difficulty attracting skilled ICT workers.

The academic literature on this subject in Canada is limited or focused on specific dimensions, often with conflicting conclusions. While there have been some large and comprehensive ICT labour market surveys (e.g., Gunderson et al., 2005; Boisvert, 2008), much of the research to date has been fragmented, in part, because of differing definitions, objectives, and conceptual models. Often it is based on surveys of Chief Information Officers (CIOs) in terms of plans to expand their hiring (Canada Newswire, 2010).

Industry, academics and policy makers have commented on the challenges of gathering and analyzing workforce data. Supply, demand and employment data in many sectors is inadequate and in ICT is compounded by the inconsistencies in boundaries and definitions as well as the rapid rate of change. For example, CCICT (2010) argues that the categories defined in the National Occupation Code (NOC) are incomplete and out of date with "information systems analysts" accounting for a large agglomeration of occupations. As well, the categories of ICT-related and hybrid occupations are arbitrary; some sectoral specialists are included while others are ignored. CCICT also identifies other important dimensions of the data including: occupation distribution by industry/sector, gender data, data on internationally educated professionals, supply side data on graduates by program and educational institution as well as mapping to eliminate clusters.

Digital Divides

In addition to the problem of a skills gap or mismatch, attention has focused on the digital skills among of certain groups, such as women, visible minorities, aboriginal people, and people with disabilities. Evidence of a digital divide among individuals, based on geography, gender, age, socio-economic status, disability, and/or education level (Sciades, 2002; Hargittai, 2010).

Much has been written about generational differences in computer skills and use (Tapscott, 2009; Buchanan, 2010). Certainly surveys of internet use have shown significant differences in technology access and use by age. More importantly it reveals distinct differences in the ways in which the technology is used. Younger respondents, for example, are more like to have engaged in content creation activities (developing blogs, posting videos, etc.) than older respondents. At the same time, others have suggested that the notion of younger people being “digital natives” is overstated and that there are significant gaps within age groups in terms of skill levels (Barron, et al., 2009; Hargittai, 2010).

While women are 47% of the Canadian workforce, they are only 29% of ICT workers. Females represent only 9% of engineers and 16.7% of programmers compared to 36.8% of analysts and 60.8% of graphic designers and illustrators (Gunderson et al., 2005). In 2009, 10% of professional engineers in Canada were women (Guay, 2010) and females comprised 17.1% of total undergraduate enrolment in engineering programs, a decline since 2000 (Engineers Canada, 2010). Females dominate some ICT occupational groups such as information science (Gunderson et al., 2005). Some industry associations have maintained that attracting and retaining women in the ICT sector is a key strategy for addressing the skills gap (CCICT, 2010).

Complex factors affect the participation of women in ICT and there are extensive theoretical debates about strategies to change this. Socialization and early education which affect the self efficacy and confidence, the development of preferences and choices. Systemic barriers in schools include pedagogical approaches to science and mathematics which are insufficiently applied and the absence of role models, negative perceptions of computing and related work including the stereotypes and notions that ICT work is programming. Systemic barriers in post-secondary institutions are similar and have been well documented as creating a “chilly climate” for female engineers and computers scientists (Wasburn & Miller, 2006). In addition, there have been barriers identified to finding employment which include closed recruitment processes and narrow definitions of skills and requirements. Within organizations there are issues related to career advancement, access to training, mentoring, exclusion from informal networks, the absence of role models, stereotypes, communication and negotiation styles and work-life balance issues (Cukier et al., 2009). Some literature also considers broader socio-political-cultural forces and practices which form the institutional environment of organizations but these issues receive limited attention (ICTC, 2007). Scholars (Ramsey & McCorduck, 2005) have begun to probe beyond the barriers, and to explore issues related to professional identity in the face of systemic stereotyping, dualism, and devaluation. Many women articulate an interest in 'computing with a purpose' as opposed to 'hacking for hacking's sake.' Females tend to be more interested in the application of technology than “the technical bits” (Rosser, 1990; Grundy, 1996). There are also issues of perceptions – both male and female respondents lack information about the nature of the work, and overwhelmingly perceive it as a masculinized domain—the females mainly see IT courses as boring and difficult (Beekjuyzen et al., 2003; Trauth et al., 2003). Although there have been significant investments in promoting women in technology, participation in computer science and engineering

programs, major pipelines to the ICT industry have actually fallen dramatically in recent years. Retention is also an issue (Engineers Canada, 2010). Related research explores the under-participation of women in technology start-ups and SMEs (Orser et al., 2006).

Given demographic trends, it has been suggested that employment of immigrants could meet the gap in supply over the next decade. The Information Communications Technology Council (ICTC) is projecting that there will be approximately 7,585 new computer science and engineering graduates which will meet 49%-75% of demand. The remaining needs will be filled through immigration with approximately 7,588 immigrants with ICT skills entering Canada annually. In other words, in terms of numbers, supply will meet demand (ICTC, 2008a). Programs have been put in place to increase in the number of Temporary Foreign Worker (TFW) work permits for foreign-trained ICT workers.

However, many still face exclusionary practices – such as failing to recognize international credentials and experience – and discrimination or bias (Bauder, 2003; Arellano, 2006; Esses et al., 2007; Creffier, 2008, Cukier et. al, 2009). In spite of being better educated than Canadian-born workers, immigrants face higher unemployment rates than non-immigrants (Creffier, 2008).

Increasingly, immigrants to Canada are coming from non-traditional countries of origin. While all immigrants are not visible minorities and all visible minorities are not immigrants, there is considerable overlap. Visible minorities are 13% of the workforce but only 10% of ICT workers (ICTC, 2007). Igbaria and Wormley (1992) that African Americans working in the ICT sector received less career support than whites and tended to have lower levels of met expectations and lower levels of career satisfaction than whites. Recent research (Cukier et al, 2009) based on a survey of 7110 mid-career professionals in large ICT firms who have worked in Canada for at least 10 years confirms that gaps persist in Canada and that visible minorities in the ICT sector perceive impediments to their advancement at many levels. This is important because it has implications for the capacity to attract and retain professionals to the sector.

Aboriginal Canadians are also under-represented CCICT (2010) reported that in 2006, Aboriginal Canadians, made up only 1% of that workforce.

Specific Skills Gaps

The shortage of entrepreneurial skills translates into a shortage of professionals who cannot see the big picture, that of the product or service being offered in its totality. Without entrepreneurial skills, professions only look at the technical challenges the product or service presents. Therefore, in order to have a business model that will attract funding, a wide range of nontechnical activities and skills are required which may include: negotiating partnerships, arranging distribution, and securing adequate funding. As with the business technology managers, a combination of creative and business skills is an essential part of entrepreneurial digital skills

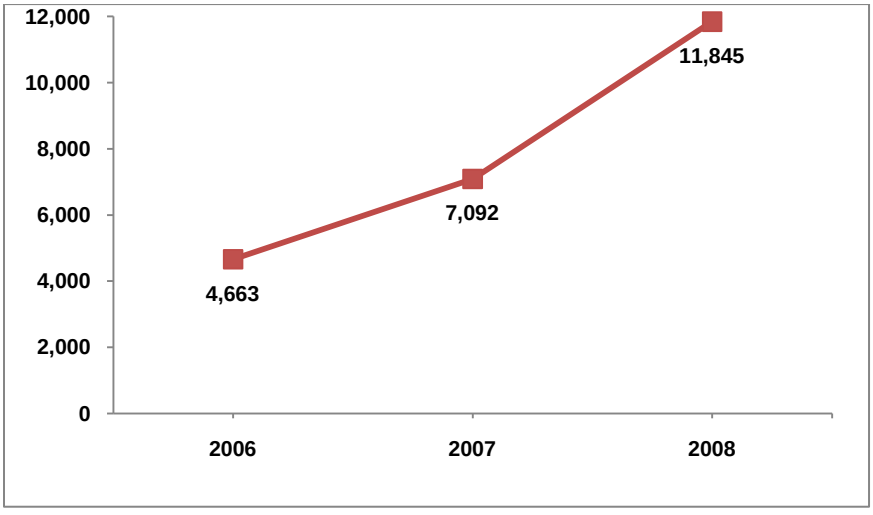
The specific skills defined at a particular point in time also vary (Collett, 2010). For example in 1995 the focus was on engineering and computer science, while several years later the focus shifted to soft skills. A recent projection defined categories of skills including programming or application development, project management, help desk or technical support, networking , security, data centre, web 2.0, telecommunications, business intelligence, collaboration architecture, business acumen and communication skills. A recent consultation led by the CCICT (2010), defined in some detail the learning outcomes and skills required for business technology management graduates to bridge technology and management functions.

Some challenge the notion that digital skills can be defined in a fixed way, asserting that with the frequency of change and redundancy it is difficult to anticipate the skills that will be required in the future.

Temporary Foreign Workers

In order to resolve the issue of the skills gap, the Government of Canada's Temporary Foreign Worker (TFW) initiative enables the temporary entry of foreign workers into several ICT industries. This program has grown over the last several years. As Figure 3-0 below indicates, there has been a jump in the number of temporary work permits issued for ICT-specific occupations from 4,663 in 2006 to 11,845. This represents a 154.02% increase over a three-year period (CCICT, 2010).

Figure 3-0: Number of Temporary Work Permits Issued for ICT-Specific Occupations, 2006-2009



CCICT, 2010

Skills Mismatch

Some suggest that this is a consequence of a skills mismatch, whereby prospective employees have the formal qualifications required of the job but lack the necessary skills and experience that the job requires. For example, while skills shortages are identified, there are, at the same time, a large number of underemployed highly skilled

immigrants (Bauder, 2003; Lysecki, 2006; Creffier, 2008). Some suggest that internationally educated workers face impediments because of the growing demand for "soft skills" and that bridging programs can successfully address these gaps. However, a number of studies (Arellano, 2006; Lysecki, 2006; Esses et al., 2007; Creffier, 2008) also indicate that many workers with foreign credentials face underemployment and deskilling because of cultural and language barriers. Therefore, any strategy that aims to meet the demand for skilled ICT workers must include the implementation of a variety of initiatives that address all of these issues.

Conclusions and Further Research

- There is general agreement that there is a skills mismatch – that many jobs in the ICT sector are unfilled while many professionals with high levels of skills are under-employed.
- Labour force projections are seldom precise and are even more challenging within the digital sector. Some have argued that, rather than trying to predict precise demands, creating an agile and adaptive workforce is key.
- Because of differences in the definitions of the sector and occupational categories, measurement is challenging. While the ICT sector, for example, is often conceived of as the providers of hardware, software and services, many studies also include ICT professionals working in end user organizations. Indeed some estimate that there are almost as many ICT professional working outside of ICT companies as inside.
- In addition the definition of the occupational classes presents considerable challenges. Some labour market projections take broad definitions, ranging from deep technology based occupations to technical writers, while others use narrower definitions.
- Lack of digital skills in end user companies has been identified as an impediment to technology adoption, particularly in SMEs.
- Lack of "creative" or content related skills coupled with business skills are another gap.
- Gaps in the available expertise to develop small companies or ideas into successful enterprises have also been identified. There has been considerable discourse about the need to build an entrepreneurial culture to advance innovation.
- Labour force projections are seldom precise and in the digital sector are even more challenging. Some have argued that rather than trying to predict precise demands creating an agile and adaptive workforce is important but considerably more research is needed to understand ICT labour force dynamics and "matching" of the available workforce.
- Many stakeholders have identified a "digital divide" in basic digital literacy based on demographics, socio economic status, geography, etc.
- Some have focused on under-representation of certain segments of the population (women, visible minorities, aboriginal people, and people with disabilities) among workers with digital skills.
- There is also significant evidence of the under-employment of skilled immigrants even in areas where demand for these skills is high.

- While there is extensive academic research exploring some of these issues, there is limited interrogation of the claims about skill gaps or an empirical investigation of perceptions about required skills, available skills and future skill requirements.
- We need a more in-depth and nuanced understanding of the factors affecting career choice and ways to attract and retain more young people and particularly women and aboriginal people in the sector.

Benchmarks to Assess Digital Skills

Overview

To measure progress on the different dimensions of digital skills, benchmarks have been developed to assess some dimensions of digital skills, particularly basic digital literacy and "deep" ICT skills (DTI, 2009).

Measurement of Digital Literacy

A weakness in the literature concerning ICTs, the digital economy, and digital literacy, is that it does not address concrete ways of measuring digital literacy. The lack of a single, agreed-upon definition of digital literacy hampers attempts to create benchmarks to evaluate levels of digital skills within a population. Instead, there is a focus on levels of access to mobile and broadband technologies, along with frequency of use, rather than determining skills levels within a population (Commission of European Communities, 2009). Some data is available regarding the level of completion of training programs run for private citizens (Morris, 2009), and within companies – which is usually software-specific and very low level of training usefulness – there is no data on the level of knowledge retention from even the most general of training courses (Ala-Mutka, 2009). There have been surveys where people self-report their levels of computer literacy (Ala-Mutka, 2009); however, these have been found to be highly inaccurate (van Dijk, 2006). Ideally digital literacy would be tested by running test in a controlled environment, where a representative cross-section could be tested on a range of knowledge (van Dijk, 2006).

Furthermore, digital literacy is often benchmarked using simple questionnaires that measure usage, or self-reported data. European strategies for developing e-skills often rely on supporting connections with industry, and benchmark based off number of industries connected to broadband and some basic self-reported questions (Aceto et al., 2009, p. 23-26)

This approach has been critiqued as being too narrow – ignoring media competence (Brandtweiner, 2010). Efforts are currently being made by the OECD to gather information globally on digital skills. The Programme for the International Assessment of Adult Competencies (PIAAC) survey will be conducted in 2011 to assess how adults of working age are able to apply their technological competence in workplace and social situations (OECD, 2010) A range of tools based on different assumptions have also been developed to assess technological literacy (Hohfield et al., 2010). Their Standards for Technological Literacy (STL) consisted of six sections: software use and file manipulation, ethics, safety and acceptable use, graphs, presentation and video editing, spreadsheets, browser use and email, word processing and flowcharts (See STL indicators in Appendix 3, Hourcade et al., 2010, Huang et al., 2010).

A report by Statistics Canada (2008) on Internet use rates echoes the international evidence in indicating that digital experience in Canada varies by income, education and age. Essential skills, such as literacy, are also strongly connected with digital

abilities, and improving essential skills will be a key part in assuring that Canadians have adequate digital skills. The Government of Canada's Office of Literacy and Essential Skills (OLES) works with a wide range of partners to improve the literacy and essential skills (LES) of adult Canadians to help them enter succeed and make transitions in the workplace, as well as contributing to their communities and families. The mandate of OLES complements provincial and territorial investments in education and training through research on what works, the development of tools and the promotion of partnerships.

While much of the discussion on digital literacy has been on the skills gap – or mismatch – in the labour force and the need to attract highly skilled talent in order to remain competitive in an information society as well as ensuring that the population attain a key set of skills in order to establish a basic level of digital literacy among all Canadians. Some (eBay & Google, 2010) have defined digital literacy as a knowledge of and basic ability to use the myriad of tools and applications available. However, digital literacy – much like digital skills – cannot be measured simply by measuring usage of ICTs: "True digital literacy implies an ability to find and organize digital information and to communicate, create, and conduct business using online applications and services" (eBay & Google, 2010). Digital literacy, in other words, includes the ability to understand and assess the risks and benefits associated with using specific ICTs and make an informed decision as to whether or not they will use these applications or access digital content. Some studies have defined digital literacy in terms of engagement in online activities including email, e-commerce, downloading documents, looking for information about training, downloading learning content, completing an online course, finding health information, getting information about health lifestyles, obtaining information about a specific disease or getting information about health services (Vincente & Lopez, 2010).

Measurement of Business (MoT)/Technology Skills

A range of benchmarking studies have been undertaken on information literacy as it applies to the work environment noting that in an knowledge-based economy, every organizational member must generate, critically analyse and disseminate knowledge. One study, for example (Heinrichs & Lim, 2010) focused on word and PowerPoint skills. Some studies focus on particular vertical markets – e.g., health infomatics (Hersh et al., 2010)

The European e-Skills Forum defines e-Business skills as "strategic and related in particular to innovation management, rather than technology-management" (Korte et al., 2007). Mitrovic (2010) also describes them as the capabilities needed to exploit modern information systems to build business opportunities, and to enable an organization's efficient and effective performance in the digital economy. There is an overall recognition that technology should be aligned with business strategy in order to enable innovation and open new markets. Therefore, assessment of digital skills in the business environment is not just important for research, but is a business model by which companies can be informed on which digital skills to train and how often in order to maximize profitability (Goodwin, 2006). The Skills Framework for the Information Age

(SFIA) is an effective tool produced to benchmark the skills needed to develop Information Systems (IS) that make use of Information Communication Technologies (ICT) (See also: Dugger, 2001). Its common language and sensible functionality makes it accessible to a wide range of businesses that can harness it as a common framework of reference for the development of HR activities (SIFA, 2010).

The United Kingdom has specific measures associated with programs dealing with the Management of Technology (e-Skills, 2009). These programs recognize the importance of non-technical skills that must compliment technical competence in order to create capable managers of technology. Many post-secondary institutions have begun to offer degree programs that "focus on the unique challenges presented by integrating constantly changing technology into core business functions" (Tynan, 2006). Mallick and Chaudhury (2000) outline the skills necessary for successfully manage technology. They include: the ability to apply analytical techniques; the ability to apply theoretical knowledge; effective communication skills; solving problems on a timely basis; managing risk and uncertainty, handling data gaps and conflict; facility in human relations; achieving implementation; identification of new technological opportunity; and the ability to integrate ICT with the organization's overall business strategy. Individuals in MoT programs should be provided a well-rounded education that includes both intensive technical training and opportunities to develop thinking skills, communication and teamwork skills, and as well as a passion for lifelong learning. Further to the focus of ICT literacy skills in the higher education environment, the ICT Literacy Assessment is a comprehensive test of ICT proficiency developed by Educational Testing Services (ETS); it considers not only knowledge of technology, but the ability to use critical thinking skills (ETS & Academic Consortium, 2005).

Measurement of "Deep Technology" Skills

Internationally, rates of 'deep' technology skills have been historically benchmarked based on the production of advanced degrees in engineering and computer science or by measuring basic digital skills (ACI, 2009). In other word, the measurement of a country's digital skills is reflective of the number of computer scientists and engineers.

The United States of America, for example, uses this narrow method of measurement to assess the level of digital skills and have been preoccupied with the shrinking number of US college students studying computer science and engineering, especially when compared to the growing numbers of Chinese and Indian engineering students. Michael Porter has labeled this drop as "the single greatest threat to American prosperity" (Luftman, 2008). Canada has also seen shrinkages in enrolment into computer science and engineering degrees. Furthermore, we have been unable to raise levels of interest in science, technology, engineering and mathematics. This poses a serious threat to Canada's potential to be a leader in the digital economy (ITAC, 2010). Canada's rating for ICT sectors among OECD nations is mediocre – we are currently ranked 20th in terms of producing graduates with advanced technological degrees, A digital strategy must, therefore, renew interest in the science, technology, engineering, and mathematics (STEM) disciplines and to encourage the pursuit of scientific and technological research. To effectively compete in the 21st century digital economy,

Canada must pursue better outcomes in these areas, especially in promoting opportunities for groups that have been historically underrepresented (i.e., women, visible minorities, aboriginal people, and people with disabilities) in these professions. In order to increase access, in other words, studies have proposed that indicators should be disaggregated to allow under-represented groups to examine measures of participation. Similarly, CCITC (2010) has set a specific target of doubling the number of women in technology.

Other Skill Measurements

As we have seen, content creation and entrepreneurial skills are essential to achieving the lofty goals of the digital economy, yet these are often absent in the taxonomies developed. Where there is a focus on these, the measures are usually tied to outputs – e.g. the production of content or the number of small businesses created. More nuanced analysis is needed to assess how to measure the attitudes, knowledge and skills needed to produce success in these areas.

While it is broadly recognized that digital skills are now foundational to learning in other areas because of the growing emphasis on e-learning, few jurisdictions have concrete measures in this area. We did find several examples of target setting for post secondary students – for example, requiring all graduates to complete at least one on-line course. However, more work needs to be done as this is emerging as a critical area.

Conclusions and Further Research

- Just as the definitions of digital skills vary, so do the approaches to measurement. Many countries which have a digital skills strategy do not have benchmarks; only a handful have concrete goals.
- There is some empirical data which attempts to operationalize definitions and measure performance at the macro-level (e.g., among countries), the meso-level (e.g., among particularly occupational groups or organizations) and the micro-level (e.g., among specific segments of the population)
- Many of the indices being used have not been validated. In fact the limitations with some measures, such as the metrics used to measure basic digital literacy, have been challenged.
- There is evidence of disparities among industrialized countries but also within industrialized countries based on age, gender, geography, ethnicity, socio-economic status, etc., suggesting that reported national averages may hide huge disparities
- Although they are essential, content creation and entrepreneurship skills are often excluded from the taxonomies of digital skills and more attention needs to be paid to measuring these so appropriate targets can be set.
- Consideration should be given to measuring e-learning skills so appropriate targets may be set, given that learning in many disciplines now depends on these skills.
- More research needs to be done to clarify the definitions being used and to compare indices in order to benchmark Canada's progress.

Stakeholders

Overview

The successful execution of any digital strategy requires that multiple stakeholders support and participate in its implementation. Each of these stakeholders has a distinct set of roles and responsibilities and it is only through their collaboration that the goals of a digital strategy can be realized.

Governments

It is not surprising that the countries with the most integrated digital skills strategies tend to be smaller with fewer levels of government involved in the process. In Canada, federalism and the division of powers present a level of complexity that can be daunting. Nevertheless that cannot be a reason for inaction. The federal government needs to work with the provinces (which have responsibility for education) as well as local governments (which often have ties to organizations in the community) in order to develop a shared vision and framework for action.

Education (K-12 and beyond)

Educational stakeholders and business industry stakeholders play several key roles in the successful implementation of digital literacy strategies and the development of a spectrum of formal and information education, training and professional development programs. Formal educational settings (i.e., elementary and secondary schools; universities and colleges) are especially important to ensure that digital skills are not only taught but also practiced in a systemic way from students' entry into the formal education system until their exit. Furthermore, such training reinforces the notion that digital skills training needs to be self-monitored and kept up to date, encouraging lifelong learning and further development of the students' digital literacy capabilities (Canadian Urban Libraries Council (CULC), 2010). Therefore, teachers, teacher aides, and teacher-librarians – both current and future – must have the digital skills to facilitate the development of those skills in their students. Not only must students have training in digital skills throughout their education but they must also be educated in the ethical use of ICT, safety within the digital world, as well as intellectual property rights (i.e., copyright, file sharing/piracy, plagiarism) so that they can use these skills in the most socially responsible manner possible. Universities, polytechnics (Polytechnics Canada, 2010) and community colleges (CETF, 2008) have produced a number of training strategies as well as policies that will directly address the skills gap/mismatch. Private training and professional development organizations also have important roles to play.

Business and Employers

Having long recognized the need for a workforce to be digitally literate, business leaders are another important stakeholder. These leaders have identified a skills gap or mismatch that needs to be rectified so that the economy can remain competitive in a global digital economy. In order to meet these needs, national strategies have been established to ensure that new workers have the skills they need to participate in the

workforce upon entry. Organizations representing large ICT companies have long attended to the issues of digital skills shortages and will continue to provide important insights. In addition, it is important to recognize that the skill requirements of companies, large and small, engaged in content creation may be slightly different than those focused on the development of hardware, software and services. It has also been noted that end user companies employ almost as many ICT professionals as companies providing products and services, yet these organizations and the associations representing various vertical markets (retail, banking, manufacturing, etc.) have been largely silent on the digital skills question. Given the importance of digital skills to the adoption of digital technologies (enabling innovation, building digital markets etc.) is also important to engage them to better understand their needs. Particular attention should be focused on Small and Medium Enterprises (SMEs) as under-adoption of the technology in this sector has been identified as a critical issue to economic growth and job creation. Access to skills would seem to be as much of a factor as access to capital and more attention should be directed to them.

Other Stakeholders

The consultation processes in Canada and other countries has also surfaced a wide range of other stakeholders with an interest in developing digital skills. Professional organizations for engineers, librarians, game makers, writers, content producers, publishers, programmers, artists, and others have significant interests in this discussion. At the level of basic literacy skills, there are a wide range of community organizations that play an active role and have expertise that is highly relevant. Public libraries in Canada and elsewhere have provided “hubs” where access to technology and skills development can take place particularly for vulnerable segments of the population. In addition, organizations serving particular constituencies – women, immigrants, aboriginal people and persons with disabilities – need to be engaged in discussions about developing basic digital skills, business-technology skills needed for employment as well as improving representation in professions requiring “deep” technology and content development skills.

Quebec

To date the engagement of Quebec based organizations in the digital strategy has been limited and there is less French language research than one might expect. More representation from is important because of specific needs for French-language training and content.

Defining Roles and Responsibilities

For almost two decades governments have developed strategies for the ICT sectors, for the “information highway”, for innovation and for the digital economy. Many of these strategies have had grand visions but have not fully achieved their goals. Plans remain words on paper without ensuring the buy in of the players needed to implement the strategies, without the specific targets and accountabilities needed to ensure action. Consequently, attention to stakeholder engagement is critical. In Canada, this is particularly complex because of the multi-jurisdictional, multi-stakeholder nature of the issue of developing digital skills. Limited research has focused on the implementation

gap as it applies in this context although there is extensive research on the development of educational policy and strategies generally.

The challenge facing governments that seek to implement a digital strategy is to bring each of these shareholders in-line with "a shared vision, common definition of ICT digital literacy, and with 'buy-in' for the proposed continuum for digital literacy aligned to assessments, standards and certification" (CETF, 2008, p. 8). The chart below reproduces the CETF's (2008) matrix of stakeholder and their roles which was informed by a review of international best practices.

Table 4-0: Matrix of Multiple Stakeholders

	State Level	Local Entities	K-12, Colleges, and Universities	Business and Other Key Stakeholders	Individuals
21st Century Economy	Adopt policies in support of an *ICT Digital Literacy Roadmap for Success* that meet globally recognized standards	Adopt ICT digital literacy skills framework for education and workforce	Develop a *California Performance Skills Framework* for K-20 education	Lead strategic alliances to support economic policies based on a ICT digital literacy foundation	Demonstrate a willingness to seek training for employment in ICT related jobs
	Provide an ICT literacy vision and needed leadership Conduct ICT literacy census	Initiate local projects based on existing best ICT practices	Work with government, K-12, and industry to develop ICT skills competencies needed for the workforce and high school exit	Provide up to date meaningful statistics and benchmarks to track and reduce the skills	Be flexible in employment opportunities
	Require standardized skills, certifications, and assessments	Build public-private sector partnerships	Infuse digital literacy into teacher education curriculum and professional development	Seed models of innovation	Use technology in the home
21st Century Learning and Workforce	Adopt an ICT Digital Literacy definition and elements based on global standards	Add ICT literacy to school board education exit requirements based on ISTE-NETS standards	Align assessments and certifications to global standards with supporting diagnostics and curriculum	Increase decentralized workforce training by initiating pilot projects in digital literacy with local entities	Be willing to engage in digital literacy skills acquisition and lifelong learning
	Encourage a citizenry mindset of	Develop teacher qualifications for mastery of ICT	Require digital literacy competencies	Promote the job training in ICT digital literacy	Show ambition to learn new methods and

	lifelong learning	digital literacy	for teacher credentials	skills	ICT related skills
	Enhance understanding of statewide qualification structures to facilitate workforce opportunity and mobility	Increase ICT training and certification opportunities for workforce development	Incorporate digital literacy competencies into vocational training Adopt ICT digital literacy requirements for high school exit requirements	Seed pilot projects	Recognize the need for continuous improvement and self-assessment in digital literacy capabilities
21st Century Citizenry	Promote a digitally literate 21st century citizenry	Recognize ICT skills for professional and vocational training	Promote lifelong learning and e-learning	Foster dialogue with diverse stakeholders	Foster the use of ICT in social environments and family groups.
	Advance e-government and ICT applications for health, environment and e-learning	Provide incentives for retraining employees		Collaborate with Government on a Public Awareness Effort	Participate in e-learning at home, in libraries and community centres
	Provide equal opportunities by supporting policies that eliminate the digital divide	Encourage underrepresented groups to acquire digital literacy skills (i.e., women, long-term unemployed, the disabled)	Require ADA compliance for assistive devices, software design and curriculum	Work with local entities to train the long term unemployed and other target groups in key e-skills for business	Apply digital literacy skills to access health, e-government, banking, and to support a healthy environment
	Support universal access to broadband technologies			Establish a statewide pool of digitally literate workers	

CETF, 2008, p. 9

Conclusions and Further Research

- Customary stakeholders to be engaged in the development of a digital skills strategy are governments, educational institutions (K-12, colleges, polytechnics, universities, training organizations), employers and other stakeholders (community organizations, libraries, organizations representing specific groups etc.)
- Understanding specific issues and orientation of segments of stakeholders are key – for example, at universities, the perceptions of administrators may differ than those of faculty and those of students. There are huge variations among disciplines, regions and leaders in the adoption of technology, etc. Consequently a detailed and nuanced understanding of these stakeholders and their interests is important.
- Similarly within the corporate sector there are important differences between the perceptions of large ICT providers and content providers, between large

organizations and SMEs and between companies which are primarily users of technology.

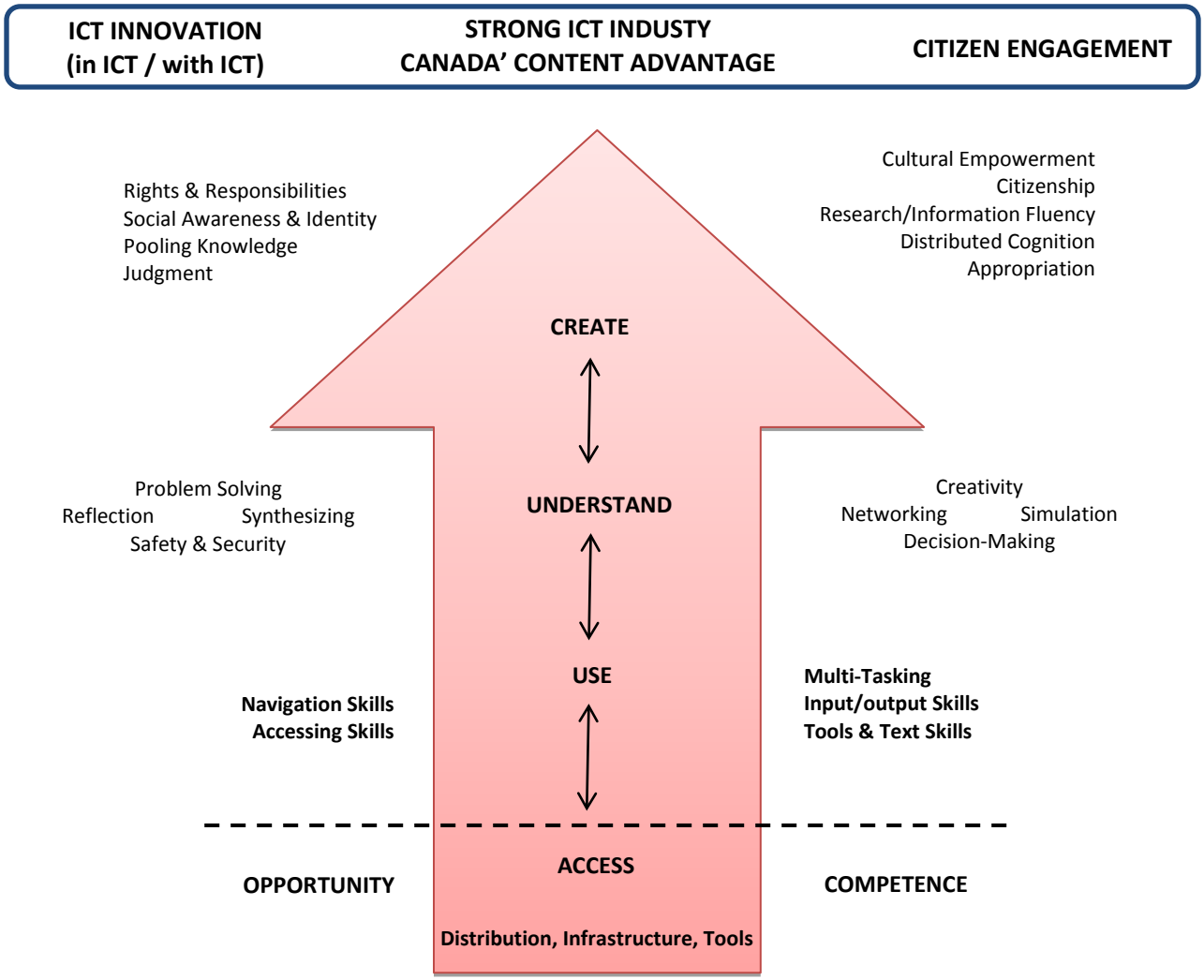
- There are also a range of stakeholders who have shown interest in the issues around digital skills and specific efforts should be made to include those that represent groups on the have-not side of the digital divide.
- More research is needed to develop a nuanced understanding of differences among stakeholders.
- More work is needed to ensure that the implementation strategy developed to support the digital skills component of the strategy has clear targets, responsibilities and measures of success.

Strategies Related to ICT and Digital Economy Skills

Overview

As noted above, there is a broad assumption that "if we build it they will come" that underpins many digital strategies around the world. Certainly there is evidence that infrastructure is a key driver of ICT adoption and the development of digital skills. Figure 5-0 below demonstrates that access to infrastructure is only the foundation of a digitally literate population.

Figure 5-0: The Relationship between Technology Infrastructure and Digital Literacy Training

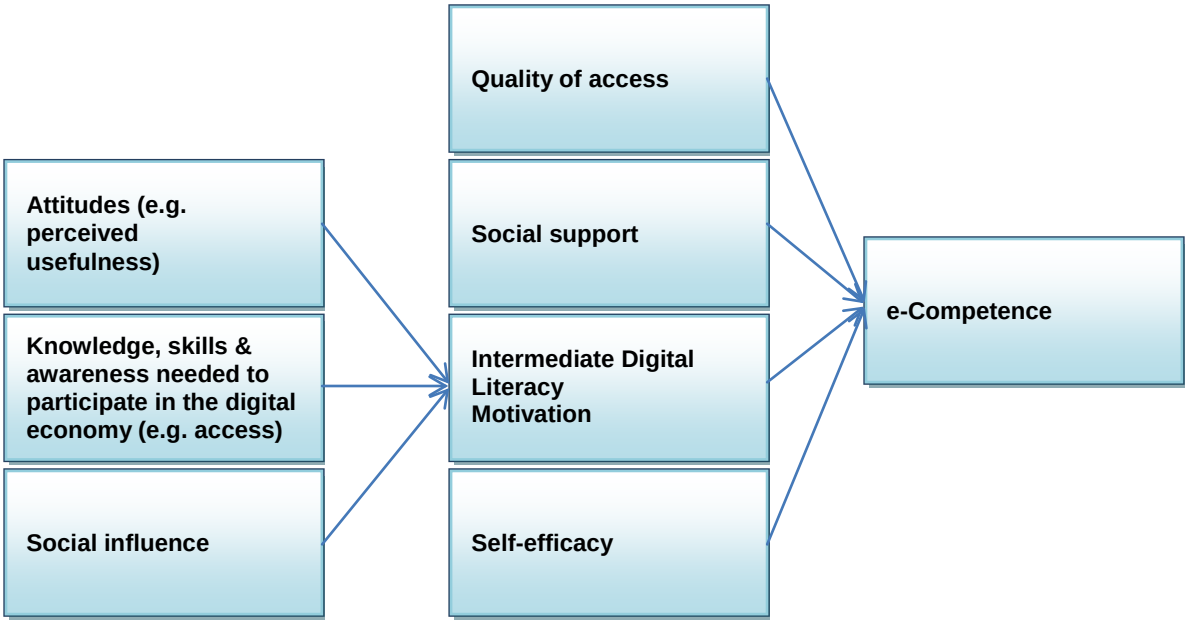


Media Awareness Network, 2010

Factors Affecting the Development of Digital Skills

Research has been undertaken to explore the interactions among factors likely to influence the development of digital skills or what Brandtweiner et al. (2010) describe as e-competence. Their model, adapted from other technology adoption models (TAMs) suggests that attitudes (e.g., perceived usefulness), objective hurdles (e.g., access) and social influence affect motivation. Motivation, along with self-efficacy, quality of access and social support, in turn, affect e-competence (see Figure 5-1). This research has significant implications for the development of effective strategies to develop digital skills in Canada.

Figure 5-1: Determinates of e-Competence



Brandtweiner et al., 2010, p. 817

More research is needed on the role of social support, especially distinguishing between problem solving assistance (technical support) and affective support (CRISP, 2000).

Similarly, models have been developed that attempt to explain the choice of ICT careers. For example, Besecke and Reilly (2006) suggest a range of factors affect choices of STEM careers. They identified personality variables (math and science aptitude, need for achievement, academic performance, self esteem, gendered self-concept); parental family variables (supportive of choices, absence of discouragement of non-traditional career choice); and transforming experience (mentors and role models, enriching opportunities, exposure to a range of career choices). But little of this has been empirically tested and there is scant research evaluating the impact of interventions aimed at encouraging STEM career choices.

Initiatives to Promote the Development of Digital Skills

A plethora of initiatives have been introduced over the past twenty years, aimed at understanding barriers and developing programs at various stages in the ICT career pipeline. These include:

- Promoting ICT education choices (for all students, but particularly women); Ensuring all graduates possess the ICT skills needed to succeed;
- Developing educational programs aimed to help individuals with both managerial and technical skills meet industry needs;
- Utilizing skilled talent to the fullest (especially immigrants).

Canada has a key competitive advantage as an attractive and receptive place for the best and brightest to come from all parts of the world. But we are not doing as well as we should to integrate immigrants into our ICT companies, particularly SMEs – which have limited resources. We need to vigorously pursue integration programs to address the following issues:

- Develop skills to promote innovation and the commercialization of technology in order to fuel the development of SMEs and to accelerate the adoption of technology in vertical markets;
- 'Upskilling' employees in all sectors as users of technology, particularly in SMEs;
- Providing ICT skills development for workers in transition, particularly employees returning to the workforce and employees changing careers and industries.

Specific roadmaps to skills have been included among them the Sectoral Council Program (SCP), Focus on Information Technology (FIT) (ICTC 2008a; 2008b), and Cultural Human Resources Council (CHRC) Technology Road Maps (CHRC, 2009).

Using technology to develop skills for example discuss the importance of exploring new approaches to pedagogy including games (Doshi, 2006; Markey et al., 2008; Annetta et al., 2010: Beavis et al., 2010; Chang & Kim, 2010; Hsu & Wang, 2010) and the notion of cultivating new literacies through gaming literacy, the use of which has been associated with "accelerating learning, increasing motivation and supporting the development of higher order cognitive thinking skills" (De Freitas & Jarvis, 2007). Recent research has also focused on using avatars and virtual environments, (Falloon, 2009; Padiotis & Mikropouls, 2010; Lee & Fang, 2010; Savin-Baden, et al., 2010). Online and blended learning is also the subject of extensive research (So & Bonk, 2010). For example, some countries have established standards to ensure that all university students take at least a portion of their curriculum online. Other studies focus on the use of social media to support learning (Smythe & Neufeld, 2010) and mobile learning. Studies have also examined the adoption of technology among instructors (Soffer & Eshet-Alkalai, 2009) noting variances by faculty and discipline.

There are also a plethora of initiatives aimed at attracting and retaining under-represented groups in the industry (ICTC, 2007). Many ICT companies have undertaken targeted outreach to immigrants and visible minorities. In Canada, many large ICT companies are federal contractors or federally regulated and so have well-developed reporting mechanisms for groups designated under Employment Equity legislation

(visible minorities, women, aboriginal people, people with disabilities). Large ICT companies have been at the forefront of advocating “the business case for diversity” (Cukier et al., 2008).

Once they are recruited, companies have a range of programs aimed at supporting under-represented groups in the workplace. Some companies offer mentoring programs, language and communications skills programs on site, and affinity networks to support women, immigrants, aboriginal people and others. Some companies have policies on diversity in the supply chain and have adopted voluntary codes of conduct (Cukier et al., 2009). Evaluations of best practices in the sector have been undertaken (CATAWIT Forum, 2009) but rigorous empirical research is lacking.

Similarly, extensive attention has been focused on various mentoring and support programs (ICTC, 2009). While empirical data on the impact of these programs is limited but there are some promising practices

Finally, and most challenging, are initiatives aimed at shaping societal views. Hireanimmigrant.com for example, is a campaign aimed at challenging assumptions and stereotypes. Large companies can use their spheres of influence to help shape the media representations of under-represented groups and to use their purchasing power (Cukier et al., 2009).

Recommendations from Canadian Stakeholders

A review of industry positions on digital skills suggests that there is consensus on the importance of addressing technological competencies. A number of stakeholders have proposed that the Canadian Government needs to work with international organizations, like OECD and the ITU, in order to establish international standards related to digital skills. Furthermore, research needs to be done to assess the effectiveness of teaching and learning practices that use technological interventions to assess the usefulness of these new tools in these areas of learning. As many of these technological intermediaries (i.e., social networking) are fairly recent additions to the digital toolkit, we cannot know how effective they will be in the educational context (both informal and formal and across a number of curriculums). Similarly, as these new technologies are still in their infancy, an emphasis on Internet safety must be part of the digital literacy curriculum for young persons (i.e., cyberbullying, protection from predators, and privacy). This new emphasis ensures that not only will future generations have the digital skills necessary to succeed but also that they will be able to evaluate the risks and rewards associated with the information society and the digital world (University of Toronto, 2010).

Canadian Research Alliance for Community Innovation and Networking (CRACIN) argue that the community plays an important role in fostering digital literacy. Specifically:

> that community networks and other community-based organizations provide both technological and social infrastructures for ICT access, adoption and use. Community networks also act as important sources of local economic

> development and innovation. Through training programs, for example, they help ensure that all Canadians, particularly those most at risk of being left behind, have the necessary skills to participate in the networked economy. (Sinclair et al., 2006, p.7-43)

Providing service to over 100,000 people daily, Canada's network of 3,500 community technology centres helps its clients to successfully incorporate ICT into their lives (Sinclair et al., 2006, c. 8) in a cost-effective way (Ekos Research Associates, 2004). Staffed by volunteers and a variety of young facilitators, these community centres offer training on:

- Job search;
- Software;
- Technology literacy programs
- Access to community services; and,
- Opportunities for cultural integration.

Furthermore, these centres often build relationships with several private and public sector organizations to provide services and experienced staff. This benefit is two-fold. Not only do thousands of people (particularly youths) gain job experience while acquiring digital skills. This program is especially concerned with bridging the digital divide.

Increased innovation and productivity are an often touted benefit of increasing a population's digital literacy. Since the community facilitates the development of digital literacy, those involved in such programs can leverage the networking opportunities in order to develop new business relationships. Furthermore, with input from a variety of technical experts, academics, and policy makers, the development of a nation's digital strategy occurs on at the macro-level. However, it is at the local level that these strategies are adapted and implemented in a way that best benefits the local constituency's needs and wants. In other words, while national strategies to increase infrastructure and access have the possibility of facilitating the proliferation of digital literacy to a population, it is the community that transforms that possibility into reality. As the community plays an integral role in the success of fostering digital skills, those developing the national digital strategy must not only be aware of its importance but also to ensure that their policy reflects the importance of the local.

Furthermore, when it comes to skills training and development, a distinction is often made between hard and soft skills. The former are usually acquired through formal training or education; the latter are learned on the job. Hard skills, it should be noted, include technical skills and can be applied in a general or in a more specialized manner (OMDC, 2010).

An important part of a national digital economy policy is that provisions be made – such as the Temporary Foreign Worker Program – to ensure that Canada continues to have access to qualified ICT workers, especially those who have management-level knowledge and expertise. By accepting foreign training and accreditation, Canada

increases its desirability against a country that requires retraining or recertification for all immigrants.

The Canadian Film Centre (CFC)'s Media Lab was established to develop a starting point in policy development for digital media. Developing creative talent, supporting the development of digital media producing organizations, and creating numerous projects, the Media Lab quickly established itself as a content creation hub, focusing on the use of new ICTs to create a variety of media content. Since it was established the Media Lab has sought to advance digital entrepreneurship in a number of ways, including implementing their Interactive Art & Entertainment Programme (IAEP). This program combats the shortage of creative talent in the industry by combining the technological and business skills needed to succeed. In addition, the IAEP provides these entrepreneurs with the opportunity to build prototypes of their product. Upon finishing the program, 50% of those involved started their own business; eventually, half of these start-ups become successful SMEs with up to five additional employees (CFC Media Lab, 2010). As well as supporting new talent, the IAEP has also instituted a number of programs for traditional media professionals to develop their own ability to be entrepreneurial and to increase their level of innovation. These programs to develop digital literacy are also meant to spur innovation and to encourage creative risk taking in order to remain on the cutting edge of content creation. Together, these initiatives have attempted to cast Canada as a leader in digital media content creation which, in turn, increases the reputation of other industries.

Table 5-0: Strategies proposed by Canadian stakeholders

Aim:	Examples:	Sources:
Develop a national digital skills strategy for Canada	Includes plans for action as well as strategies regarding the collection of metrics, benchmarks, and data about all aspects of the digital labour market	ITAC, 2010
Ensure digital inclusion/Increase access for under-represented groups	Promote enrolment into post-secondary education or training programs for lower socio-economic groups	Polytechnics Canada, 2010
	Establish scholarships and graduate research fellowships to encourage high-achieving students	CARL, 2010
		Réseau ACTION TI, 2010
	Expand and support a system to acknowledge foreign credentials	AUCC, 2010
		Engineers Canada, 2010
	Remove barriers that prevent foreign workers with the necessary education, training, and experience from working	CIAIC, 2010
	Attract immigrants by providing newcomer orientation and integration programs that include some form of ICT training	CULC, 2010
		CARL, 2010
	Increasing the visibility and participation of women in ICT-related and technical careers through mentorship and training programs	AUCC, 2010
		Engineers Canada, 2010
	Double female enrolments to high value programs by 2017	ITAC, 2010
	Educate, inform, and assist Aboriginal youth into educational programs in science, technology, and engineering	AUCC, 2010
		Engineers Canada, 2010
	Adaptive technology and different skill training to increase access	CNIB, 2010

	for disabled individuals	CARL, 2010
	Increase access to the infrastructure needed to develop and use digital skills by providing computer and Internet access at libraries and through Internet Community Access Centres (CACs) and free wireless Internet zones	CULC, 2010
		Réseau des SADC du Québec, 2010
	Subsidies (i.e. vouchers, tax incentives, etc.) to ensure that everyone has access to technology that has core digital education tools	Microsoft Canada, 2010
	Government action to ensure that by 2015 90% of residents and organizations have a fixed Internet connection of 100 Mbps or more and firm commitment to ensure that the remaining see the quality of their Internet connection improve considerably.	CEFRIO, 2010
Invest in programs for training and re-training workers	Expand existing (Canada Social Transfer program, specialized HRDC training) and develop new training programs	Polytechnics Canada, 2010
	By 2017, increase total number of digital economy college and university seats by 20%	ITAC, 2010
	Promote STEM literacy through a national campaign; improve performance in producing science and engineering graduates moving from our current OECD to top 5 by 2016	ITAC, 2010
	Work experience to provide youth with both the job experience and skills training necessary to succeed	Sinclair et al., 2006
	Prioritize regularly updating current training programs to ensure accurate development of competencies.	Réseau ACTION TI, 2010
		APFTQ, 2010
	Encourage flexible learning environment (time and location) to enable workers to undergo trainings to stay abreast of latest technology.	RFAVQ, 2010
		Barbot et al., 2006
Endorse proven training service providers	For those training service providers (i.e., universities, colleges, and polytechnics) that have a proven track record when it comes to training or retraining workers should be publically endorsed by the government in order to increase their visibility as well as their expertise in ICT skills training	Polytechnics Canada, 2010
Establish common industry standards and definitions	Support programs that promote common industry standards for training outcomes for specific competencies in close consultation with the industry.	CIAIC, 2010
Encourage and fund digital content creation	Digital content creation drives consumers to adopt new technologies which have driven the development of new technologies as well as the skills to use these technologies	CRT, 2010
		OMDC, 2010
	Nurture the creation and development of digital content using new ICT technology in order to make Canada a leader in the area of digital content creation	CFC Media Lab, 2010
	Technology and art/design are inextricably connected; need to foster creative skills in the use of ICTs to create content	OCAD, 2010
		ADISQ, 2010
Ensure SMEs keep up with changes in digital skills	Develop programs so that SMEs can keep up with changes in digital skills so that they can remain competitive against larger organizations that have the time and money to constantly retrain its workforce to keep pace with evolving skill requirements	OMDC, 2010
	Engage in knowledge co-creation; focusing on current issues engages and educates employees to support future innovation	York University, 2010
	Using tax incentives and online skills development to update skills	CARL, 2010
Commit to the pursuit of continuous	In order to keep up with the evolution of digital technology and the speed of the global marketplace	Engineers Canada, 2010
		RFAVQ, 2010

professional development and lifelong learning	Ensure that digital skills and literacy programs are included in both formal and informal education streams	CULC, 2010
	Ensure that every individual in the workforce remains proficient in digital skills, regardless of vocation	Microsoft Canada, 2010
Support collaboration	Support collaborative, inter-disciplinary, and cross-sectoral research and learning opportunities at all levels of government, industry, educational institutions, trade associations, and sector councils in order to develop critical thinking, analytical and digital skills	AUCC, 2010
		Polytechnics Canada, 2010
		Microsoft Canada, 2010
	Create state-of-the-art "living laboratories" to create a network and community of users and developers	SAT, 2010
	Create a skills marketplace to drive market agility and innovation	ITAC, 2010
	Target and match governmental funds with private sector commitments to build regional centres of excellence to develop digital skills	CFC Media Lab, 2010
	Build both formal and informal collaborative networks which builds trust and to increase the level of technical, creative, and business knowledge among their members	CFC, Media Lab, 2010
	Create a "creativity transfer fund" to support faculty and student research at polytechnics	Polytechnics Canada, 2010
	Research collaboration and the need for multi- and inter-disciplinary education	Barbot et al., 2006
Develop programs to increase digital skills	Develop a national internship program which will address the labour shortage facing some reasons while also addressing the skills gap between the skill sets of new graduates and those skills required by the industry	ICTC, 2010
	Invest in knowledge transfer programs, mentorships, and apprenticeships to facilitate continued digital skills training	Canadian Conference of the Arts, 2010
		ACPFT, 2010
	Use digital games to develop educational content	Canadian Federation for the Humanities and Social Sciences, 2010
	Placement programs provide opportunities for mentoring new talent, bridging the digital divide as well as guaranteeing succession planning	ACPTF, 2010
	Support and drive collaboration among research institutes, post-secondary educational institutes as well as the public and private sector to connect education with industry and to ensure that training produces job-ready workers	Polytechnics Canada, 2010
		CARL, 2010
	Aggressively build awareness, supports, incentives and partnerships to drive change (i.e., infrastructure in place to deliver training may be prohibitively expensive).	ITCT, 2010
Support early education opportunities	Develop a foundation of math and science skills to facilitate later education in computer science, engineering, science, and mathematics	Microsoft Canada, 2010
	Use technology to facilitate a more dynamic, personalized learning environment that takes student's needs and individual characteristics into account	Microsoft Canada, 2010
	To promote lifelong learning, make digital skills acquisition a priority from primary school onwards	ITCT, 2010
		eBay & Google, 2010

Conclusions and Further Research

- There is a wide range of digital strategies with varying degrees of specificity in recommendations for the development of digital skills
- Through collaboration with multiple stakeholders and across levels of government, develop a national digital skills strategy which defines needs, defines skill requirements, sets benchmarks and provides a plan of action.
- Ensure a basic level of digital literacy for all Canadians, attending to digital divides based on age, geography, social economic status, gender, etc.
- Provide cradle to grave opportunities to acquire and upgrade skills through a range of formal and informal educational opportunities in partnership with educational institutions, industry, libraries and community organizations.
- A standardized curriculum of digital skills training must be developed and implemented in kindergarten and continue until high school graduation.
- Invest in programs that provide incentives to train and retrain workers.
- Encourage the development of content creation and creative skills.
- Support development of skills needed to promote the adoption of digital technology by SMEs.
- Support development of skills needed to set up small businesses and digital enterprises along with the skills needed to take these to the second stage of development
- Encourage the development of professionals with hybrid skill sets that combine technology and management skills.
- Create experiential learning opportunities, internships, etc.
- Use digital technology in innovative ways to support the development of education and skills in other areas – establish targets for e-learning experiences among post secondary students.
- Dramatically increase the number of science, technology, engineering and mathematics graduates.
- Support further research into real versus perceived needs, taxonomies of skills and forms of measurement, as well as evaluations of programs aimed at promoting digital skills.
- Support collaborative, inter-disciplinary, and cross-sectoral research and learning opportunities at all levels.

Overall Conclusions: Building the Digital Talent Pool and Skills for Tomorrow

The body of literature relevant to digital skills development is extensive – more than 2000 academic articles as well as hundreds of policy papers by governments and other stakeholders address the issue.

Our systematic review of this literature raises as many questions as it answers but our observations include the following:

- There is a high level of consensus on the need for a digital skills strategy as part of an integrated digital strategy.
- There are different definitions of “digital skills” and priorities concerning the focus on basic digital skills, business-technology digital skills or “deep” technology and content skills.
- The focus tends to reflect the orientation of the organization - in some cases, critical skills sets such as content creation and entrepreneurial skills have been neglected even though these are essential.
- While there are many sectors claiming that there are skills shortages or gaps, more precision on the nature of these gaps is needed as well as the factors which influence choices concerning digital skills development both at the basic literacy and advanced levels.
- There continues to be evidence of under-representation among certain groups in the ICT sector as well as evidence that bridging programs and attention to diversity can help address shortages. However, there is limited research on the efficacy of different approaches.
- Clearer definitions must be established with benchmarks at each level.
- There are a wide range of stakeholders who should be engaged in policy development. Beyond the obvious players – government, education, industry and industry associations – community organizations, and libraries.
- Many other jurisdictions have developed comprehensive digital strategies which include digital skills and systematic analysis not just of the strategies but of their efficacy would be useful to inform Canadian efforts in this area.

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Appendix 1: ICT and Digital Skills Strategies by Country

Country	ICT Strategy/Policy	Infrastructure Expansion	Digital Skills Training	Digital Skills Definition
Afghanistan	Yes	Yes	No	No
Algeria	Yes	Yes	Yes	No
Argentina	Yes	Yes	Yes	No
Australia	Yes	Yes	Yes	No
Azerbaijan	Yes	Yes	No	No
Bangladesh	Yes	Yes	No	No
Benin	Yes	Yes	No	No
Bhutan	Yes	Yes	No	No
Botswana	Yes	Yes	No	No
Bosnia and Herzegovina	Yes	Yes	Yes	No
Brazil	Yes	Yes	No	No
Brunei Darussalam	Yes	Yes	Yes	No
Bulgaria	Yes	Yes	Yes	EU
Burkina Faso	Yes	Yes	No	no
Burundi	Yes	Yes	No	no
Cambodia	Yes	Yes	No	No
Cameroon	Yes	Yes	Yes	No
Central African Republic	Yes	Yes	No	No
Chad	Yes	Yes	No	No
Chile	Yes	Yes	No	No
China	Yes	Yes	Yes	No
Colombia	Yes	Yes	No	No
Congo	Yes	Yes	No	No
Cuba	Yes	Yes	Yes	No
Croatia	Yes	Yes	Yes	No
Cyprus	Yes	Yes	Yes	EU
Dominican Republic	Yes	Yes	Yes	No
Ecuador	Yes	Yes	No	No
Egypt	Yes	Yes	Yes	No
El Salvador	Yes	Yes	No	No
Ethiopia	Yes	Yes	Yes	No
France	Yes	Yes	Yes	EU
Gabon	Yes	Yes	No	No
Gambia	Yes	Yes	No	No
Germany	Yes	Yes	Yes	EU
Greece	Yes	Yes	Yes	EU
Honduras	Yes	Yes	No	No
Iceland	Yes	Yes	Yes	No
India	Yes	Yes	No	No
Indonesia	Yes	Yes	No	No
Iran	Yes	Yes	No	No
Italy	Yes	Yes	Yes	EU
Jamaica	Yes	Yes	Yes	No
Japan	Yes	Yes	Yes	No
Jordan	Yes	Yes	No	No
Kazakhstan	Yes	Yes	No	No
Kenya	Yes	Yes	No	No
Kiribati	Yes	Yes	No	No
Korea	Yes	Yes	Yes	No
Kuwait	Yes	Yes	Yes	No
Kyrgyz Republic	Yes	Yes	No	No
Lao	No	Yes	No	No

Country	ICT Strategy/Policy	Infrastructure Expansion	Digital Skills Training	Digital Skills Definition
Lebanon	Yes	Yes	Yes	No
Macau	Yes	Yes	No	No
Malawi	Yes	Yes	No	No
Malaysia	Yes	Yes	No	No
Maldives	Yes	Yes	Yes	No
Mali	Yes	Yes	No	No
Malta	Yes	Yes	Yes	EU
Mexico	No	Yes	No	No
Mongolia	Yes	Yes	No	No
Morocco	Yes	Yes	Yes	No
Myanmar	Yes	Yes	Yes	No
Namibia	Yes	Yes	No	No
Nepal	Yes	Yes	No	No
Netherlands	Yes	Yes	Yes	EU
New Zealand	Yes	Yes	Yes	No
Nigeria	Yes	Yes	No	No
Pakistan	Yes	Yes	No	No
Paraguay	No	No	No	No
Philippines	Yes	Yes	Yes	No
Romania	Yes	Yes	Yes	EU
Rwanda	Yes	Yes	Yes	No
Saudi Arabia	Yes	Yes	Yes	No
Singapore	Yes	Yes	Yes	No
Somalia	No	Yes	No	No
South Africa	Yes	Yes	Yes	No
Spain	Yes	Yes	Yes	EU
Sri-Lanka	Yes	Yes	Yes	No
Suriname	Yes	Yes	No	No
Switzerland	Yes	Yes	No	No
Syrian Arab Republic	Yes	Yes	No	No
Taiwan	Yes	Yes	Yes	No
Tajikistan	No	Yes	No	No
Tanzania	Yes	Yes	No	No
Thailand	Yes	Yes	Yes	No
Timor Leste	Yes	Yes	No	No
Trinidad & Tobago	Yes	Yes	Yes	No
Tunisia	Yes	Yes	Yes	No
Turkey*	Yes	Yes	No	No
Uganda	Yes	Yes	No	No
United Arab Emirates**	Yes	Yes	No	No
United Kingdom***	Yes	Yes	Yes	Yes
Uganda	Yes	Yes	No	No
Uruguay	Yes	Yes	Yes	No
USA	Yes	Yes	Yes	Yes
Uzbekistan	Yes	Yes	No	No
Viet Nam	Yes	Yes	Yes	No
Zambi	Yes	Yes	No	No
Zimbabwe	Yes	Yes	No	No

*Doğan, 2005; Uçkan, 2009
** Peterson, 2007
***E-Skills UK, 2009

Appendix 2: Academic Definitions of Digital Skills

Region	Definition of Digital Skills/Literacy	Ways of Measuring of Digital Skills/Literacy	Source
International	Technological Literacy: The skills to interact with hardware and software		Ala-Mutka, 2009; Peña-López, 2009; Media Awareness Network, 2010
	Informational Literacy: The competencies to deal with information, normally by means of ICTs (applying Technological Literacy). This is in two stages: how to get (relevant) information, and how to manage that information.		
	Media Literacy: Skills and competences to deal with several media make them interact and integrate them in a single output. A lower level, multimedia, where interaction would be more mechanical, and a higher one, cross media, where interaction and integration respond not to technical possibilities but to a strategic design, building an ecosystem of different media (and not a simple multimedia output)		
	Digital Presence: Is centred in the person. These are the digital skills to monitor and establish a digital identity, and the skills to actively define it and use it for networking or interacting with other people digitally		
	e-Awareness: The most strategic (even philosophical) stage is the one related with being aware on how the world and our position — as a person, group, firm, institution — varies because of digital technologies		
United States and International	Digital Literacy: what the most basic ITC user should know about computers, software and basic communication technologies. This level is not vocationally oriented but serves as a common knowledge base upon which more advanced computer and communication skills can be developed. Tasks at this level could include: cellular telephone usage, turning the computer on and off safely, saving files, using e-mail, using a web browser, and very basic word processing.		Ala-Mutka, 2009
	Digital Proficiency: average office worker with average computer and communication skills whose skills include moderate levels of word processing, spreadsheets, presentation software, e-mail, Internet usage, cellular telephony and cellular applications and very basic troubleshooting and cell phone maintenance.		
	Digital Competency: The initial ICT specialist skills needed to work as an ICT professional		
	Digital Expertise: The highest degree of ICT knowledge and skills necessary for any given profession.		

Intellectual Process of Information Use Definitions			
Region	**Definition of Digital Skills/Literacy**	**Ways of Measuring of Digital Skills/Literacy**	**Source**
East and South East Asia and International	Recognises the nature and extent of information needed	• Defines and articulates the need for information • Identifies a variety of information sources • Understands the purpose, scope and appropriateness of a variety of information sources and resources • Knows and considers the costs and benefits of obtaining the needed information	Sharma, 2008; Ala-Mutka, 2009
	Accesses the needed information effectively and efficiently	• Selects the most appropriate investigative methods or information • retrieval systems for finding the needed information • Constructs and uses well-planned search strategies • Retrieves information using a variety of methods	
	Evaluates information and its sources critically and incorporates selected information into own knowledge base and value system	• Assesses the information obtained • Summarises main ideas extracted from the information obtained • Articulates and applies initial criteria for evaluating information and its sources • Validates understanding and interpretation of information through discourse with other individuals, subject area experts and practitioners • Determines if the initial query should be revised	
	Strives for excellence in information seeking and knowledge generation	• Understands bias and authority issues when obtaining information • Recognises the differences between accurate and inaccurate information, reliable and unreliable information • Continues to seek and revise search strategies and methods until the information need is aptly and accurately met	
	Uses information appropriately and creatively	• Generates main ideas to construct new concepts • Compares new information with prior information to determine value-addedness, contradictions and other unique characteristics • Applies new and prior information to the planning and construction of new knowledge or product • Reassesses and revises the development process for the new knowledge or product • Communicates the new knowledge or product effectively to others	
	Understands many of the economic, legal and social issues surrounding the use of information, and demonstrates ethical and legal access and use of information	• Adheres to laws, regulations, institutional policies and etiquette related to the access and use of information sources • Acknowledges the use of information sources in communicating new knowledge or product that is generated • Honours and acknowledges the ownership of information	
	Contributes positively to the learning community and the society, and recognises the importance of information in a society	• Recognises and respects differing opinions in discussions as well as print and non-print information sources • Proactively seeks to understand different perspectives in order to have an informed opinion • Shares knowledge and collaborates with others to generate new ideas or products that benefit the learning community and the society	

Region	Definition of Digital Skills/Literacy	Ways of Measuring of Digital Skills/Literacy	Source
Global	(i) The definition of the information task, (ii) The formulation of strategies to search for information, (iii) Strategies for the location of and access to information, (iv) The use of acquired information, (v) The synthesis of knowledge from prior and current information, and (vi) The evaluation of the information process.		Sharma, 2008
	(i) The initiation or perception of an information need, (ii) The selection of a topic for further investigation, (iii) The exploration of the required information in order to have a better understanding of the topic, (iv) The formulation of the specific information need, (v) The collection of relevant information, and (vi) the information search closure.		
	(i) The information technology conception, (ii) The information sources conception, (iii) The information process conception, (iv) The information control conception, (v) The knowledge construction conception, (vi) The knowledge extension conception, and (vii) The wisdom conception.		

Appendix 3: ST²L Indicators

Level	The student can:
I. Essential Operational Skills	1. Use help functions within an application for assistance 2. Respond appropriately to information presented in dialog box (e.g., replace a file dialog) 3. Select correct printer 4. Use print preview 5. Change page orientation between landscape and portrait 6. Print a specific page range 7. Demonstrate practical keyboarding skills 8. Identify and locate the standard menu bar 9. Toggle between two open software applications 10. Create a new file 11. Locate and open a specific file 12. Rename a file 13. Move a file to a different location 14. Search for specific files 15. Use "Save As…" to change the name of a working file 16. Use "Save As…" to save a file to a different location
II. Constructing and Demonstrating Knowledge	1. Select the best device to complete a given task, such as digital cameras, scanners and external storage devices 2. Select appropriate uses for word processing software 3. Use the ordered and unordered list features of a word processor 4. Use the table creation feature of a word processor 5. Insert a hyperlink into a document 6. Insert an image into a document 7. Set page margins within a word processing document 8. Adjust line spacing within a word processing document 9. Insert an object using the drawing tools feature of a word processor 10. Edit images within software using cropping 11. Edit images within software using resizing 12. Edit images within software using rotating 13. Edit images within software using brightness/contrast 14. Edit images within software using duplicating 15. Select appropriate uses for Web browser software 16. Identify a Web browser 17. Identify and use the address bar in a Web browser 18. Identify and use the back function in a Web browser 19. Identify and use the Refresh function in a Web browser 20. Identify and use the bookmarks/favourites elements in a Web browser
III. Communication and Collaboration	1. Use e-mail to send a message 2. Use e-mail to receive/open a message 3. Use e-mail to forward a message 4. Use e-mail to reply to a message 5. Use e-mail to add attachments to a message 6. Select appropriate uses for presentation software 7. Create new slides within presentation software 8. Enter content within presentation software 9. Play a slide show within presentation software 10. Perform basic digital video editing by removing a section of video 11. Perform basic digital video editing by adding narration 12. Perform basic digital video editing by adding music

	13. Insert an edited video clip into presentation software
IV. Independent Learning	1. Perform Web searches that produce relevant results 2. Use the advanced search features of search engines (e.g., Boolean, date limits, language, etc.) 3. Access information through online resources including encyclopedias, libraries, education and government websites, and electronic catalogs (a.k.a. card catalogs) 4. Evaluate Internet sites for accuracy 5. Select appropriate uses for graphic organizer software 6. Create flowcharts as a learning strategy 7. Create concept maps as a learning strategy 8. Select appropriate uses for spreadsheet software 9. Enter data into a spreadsheet 10. Format data in a spreadsheet 11. Delete data in a spreadsheet 12. Use spreadsheets to compute basic formulas 13. Use spreadsheets to create a graph 14. Import and export data (e.g., copying and pasting from spreadsheet to presentation software)
V. Ethical, Legal, and Safety Issues	1. Differentiate between appropriate and inappropriate use of school computers (acceptable use policy) 2. Use and appropriately cite electronic references 3. Understand and follow copyright laws pertaining to software and/or Internet resources, including duplicating and/or plagiarizing text and media files 4. Identify an appropriate procedure to follow when a peer is using the computer inappropriately 5. Identify an appropriate procedure to follow when inappropriate content is encountered on a computer 6. Display an awareness of potentially inappropriate language while using technology 7. Display an awareness of potentially inappropriate media use in regards to technology 8. Display an awareness that technology is in a state of continual change/advancement 9. Identify security risks that are involved with giving out personal information (e.g., fake eBay sign-in to steal password) 10. Understand that there is no guarantee of privacy on a network 11. Recognize and report potential online predators (e.g., strangers asking inappropriate questions) 12. Recognize the risks of downloading files and documents 13. Recognize the permanency of electronic data 14. Maintain password security 15. Understand the need for virus scans, pop-up blockers, spyware blockers, firewalls and filters

Hohlfeld et al., 2010, pp. 387-389