Diversity and the Skills Shortage in the Canadian Information and Communications Technology Sector: A Critical Interrogation of Discourse

Wendy Cukier
Ryerson University, Toronto, Ontario
Margaret Yap
Ryerson University, Toronto, Ontario
Mark Holmes
Ryerson University, Toronto, Ontario
Sara Rodrigues
Ryerson University, Toronto, Ontario

Abstract

For more than a decade, companies in the Information and Communications Technology (ICT) Sector have discussed the problem of the skills shortage and the need to develop the ICT labour pipeline. Some companies have linked diversity to the labour skills shortage, suggesting that increasing the participation of under-represented groups—particularly women and immigrants—would help offset the declining enrolments in computer science and engineering (considered the principal pipeline to the ICT profession).

This paper will draw on several data sources to interrogate some of the assumptions about the "shortage" as well as the "ICT profession" and the role of diversity. Specifically it will draw on three sets of data—the discourses concerning the ICT labour shortage, data on the Canadian ICT labour market and results of focus groups and interviews with ICT managers through the Information Communications Technology Council of Canada.

The principal conclusions of the paper are that there is a gap between the discourse of the labour shortage and the data on the labour shortage. Rather than an absolute shortage of ICT workers, there seems to be a skills gap resulting from a mismatch between some current requirements and available talent; underutilization of available talent and, in some cases, a gap between actual and perceived requirements. In particular, narrow definitions of the ICT profession and entry points serve as an unintended barrier to the full participation of women. We propose an integrated strategy to address the full range of entry points to the pipeline. While attracting more women to Computer Science and Engineering remains important, we also need a critical evaluation of the scope of the ICT profession, the actual nature of the job requirements and the qualifications needed.

Keywords

Information Communications Technology, Diversity, Women in Technology

Background

With rapid technological change, globalization, the growing demand for skills and education, and an aging workforce, companies in every sector have been signalling concerns about labour shortages. This is particularly acute in the ICT sector as enrolments in core disciplines such as Computer Science and Engineering which feed the labour supply "pipeline" have declined significantly. The demands in the sector are by no means homogenous—the companies affected range from small manufacturers of hardware to some of the largest telecommunications carriers in the country, such as Bell Canada Enterprises. Further complicating the picture are competing definitions of "ICT professional" as well as the fact that many individuals work in ICT functions within end-user companies in other sectors such as finance, retail, manufacturing, etc. Consequently, assessing supply and demand in the sector is challenging. In spite of this, many companies, associations and governments in Canada and elsewhere have suggested that increasing diversity within the ICT labour force is one strategy which will ameliorate the perceived shortage. In particular, increasing the participation of women is the focus of this paper. The under-employment of women has significant implications for the Canadian economy. If women were employed at the same rate and level as men it

would produce 1.6 million extra workers along with $168 billion in added income (RBC, 2005).

Considerable research confirms that in spite of the advances women have made in the workforce, gaps associated with gender remain in employment levels, income and satisfaction (Frenette and Coulombe, 2007). While many overt forms of discrimination have been reduced, there are still systemic barriers that limit access to positions with more power and social prestige, and to higher rewards and resources (Jacobs, 1995; O'Leary and Ickovics, 1992; Reskin and Ross, 1992; Shenhav and Haberfeld, 1992). It is also acknowledged that both women and visible minorities are often excluded from the informal networks that are important in career progress (Powell, 1993; Wajcman, 1996). The concept of the "glass ceiling" concept emerged in the 1980s to reflect the many barriers that preclude women from making progress in the management hierarchy (Morrison and Von Glinow, 1997; Davidson and Burke, 1994; Wajcman, 1996). While progress has been made the problem persists. Although there are important differences, many analyses of barriers to immigrant workers and visible minorities follow a similar logic (Yap, et. al, 2008).

The complex factors affecting the participation of women in the ICT sector can be understood through a number of lenses. Many studies, for example, examine the barriers (and relevant interventions) in a linear fashion. For example, factors identified include socialization and early education, systemic barriers in schools, negative perceptions of computing and related work, systemic barriers in post-secondary institutions, barriers within organizations (including recruitment, promotion and other human resources strategies, exclusion from informal networks, the absence of role models, stereotypes, communication and negotiation styles, self-efficacy and individual choice, competing priorities, etc. Some literature also considers broader socio-political-cultural forces and practices which form the institutional environment of organizations but these issues receive limited attention.

Much of the research makes reference to the issues outlined above and their part in shaping expectations of the workplace, yet few studies examine the institutional environment of organizations. This environment is shaped by such carriers of values as media and government regulations. The organizational relevance of the broader societal discourse as a part of the firm's institutional environment has, with varying degrees of explicitness, been acknowledged in the organization theory literature (e.g. Meyer and Scott, 1983; Czarniawska-Joerges and Joerges, 1988; Walsham, 1993). Organizations tend to conform to their institutional environments (DiMaggio and Powell, 1984) but as Meyer and Scott (1983) note, the link between societal macro level and firm behaviour is poorly understood. The media is one cultural carrier; government policy is another that affects this environment.

The literature abounds with case studies and examples of practices aimed at promoting women in technology fields. However, there has been little evaluation of these initiatives (Cukier and Chauncey, 2004) In fact, at the same time the these programs have expanded, overall enrolment in Computer Science and Engineering programs has plummeted and the decline in female enrolment has been faster than the decline in male enrolment. The percentage of women in IT and Computer Science disciplines at universities is also declining at a time when their participation in other disciplines is increasing. While female enrolment in many technical disciplines has declined in recent years, Computer Science is the only discipline where the percentage of women is lower than it was in 1992-1993. In contrast, females now dominate some disciplines such as business administration (COU, 2007). There is also limited systematic evaluation of the impact of practices aimed at promoting women and visible minorities in management although there is extensive discussion of leading and best practices.

Research Questions

Our study builds on our previous empirical work examining diversity in the workplace from an organizational and individual perspective, and links it to the broader socio-political-cultural environment of organizations. The study explores five inter-related questions including:

1. What is the public discourse regarding the ICT labour market shortage in Canada?
2. What is the empirical evidence regarding the ICT labour market shortage?
3. What is the participation of women in the ICT sector?
4. What are the barriers to participation by women in the ICT sector in Canada?
5. What strategies may be employed to increase the "pipelines" to the sector?

Methodology

This study combines several forms of data collection using a variety of techniques:

1) Discourse on the ICT skills shortage was collected using a key word search of ("skills shortage" AND "information technology" OR "information and communications technology" AND Canada). Using this search term, we collected 1203 texts during the 1986-2008 period from a variety of online sources including Proquest, CBCA and the internet. Several bibliographic databases (CBCA, Dow Jones Interactive, Proquest) as well as Google Scholar were queried using standardized search terms ("Information Technology" AND Shortage AND Skills OR Worker). A wide range of industry and government reports, press releases, speeches and articles were collected along with some academic articles. The documents were supplemented with papers and conference proceedings. The documents were analysed with a focus on four themes:

a. Definitions of "IT Professional" or "IT Worker";
b. Types of "IT Professionals" or "IT Workers";
c. Skills needed for IT Professionals or IT workers;
d. Qualifications required for IT professionals or IT workers.

2) Statistical analyses of labour force demographics. Drawing on the labour market survey of the Information and Communications Technology Council (ICTC) we examine the empirical data concerning the ICT labour force and representation of women and minority groups.

3) A review of the literature concerning barriers to participation and initiatives to address them.

4) A series of focus group consultations with Information Communications Technology Employers through the Information Communications Technology Council (ICTC) January 2006–May 2008.

Discourse and the ICT Skills Shortage

The ways in which professions consolidate their power and status have been studied in a variety of contexts (MacDonald, 1995; Meyer, 1994) but little attention has been paid to the process of institutionalizing the IT profession. In other sectors there is evidence of the emergence of norms which are invisible and taken for granted, yet very powerful. As Meyer (1994) notes, "organizations are rewarded for conforming to the requirements generated by such actors irrespective of whether they support improved performance" (p.248). There are many examples of qualifications assumed to be important (for example, height requirements for police officers) which may become institutionalized and present unintended barriers to certain segments of the population. These become forms of systemic discrimination (Ontario Human Rights Commission, 1999). For this reason, the discourse or "talk" about the ICT skills shortage and some of the implicit assumptions which underlie it are significant.

For more than ten years, employers in the ICT sector have been talking about the skills shortage in Canada. In 1997, the US Office of Technology Policy released a report which maintained that US employers would face "tough international competition" for IT workers, and demand to fill IT jobs would continue to outpace the supply, highlighted as a "crisis" by the media:

> [...]More than 95,000 new computer scientists, engineers, systems analysts and programmers will be needed each year until at least 2005 in the United States alone […] the largest job growth will be in the field of systems analysts […] The number of computer scientists and engineers also are expected to grow […] the number of computer programmer positions are expected to grow at a much slower rate until 2005 […] The shortage was reported to be global and would affect not only computer and software industries but also manufacturing and services, transportation, health care, education, and government (Kaliciak, 1997).

Shortly afterward, IT organizations in Canada launched a similar study. A survey of just over 100 companies by the Canadian Advanced Technology Association and Angus Reid Group (CATA, 1997) appears to have been the foundation of many of the calls for expanding engineering and computer science programs. The headlines throughout the period cited a finding of the report: "Canadian advanced technology businesses (88%) believe they face a skills shortage. Many jobs remain open because of this shortage"(Chevreau, 1997). In fact, a closer look at the data indicated that of those surveyed, half (54%) indicated they have had positions open for 3 months. Of those, 1/3 (34%) said the skills shortage was very serious. In other words, only 1/6 of companies surveyed actually indicated that the skills shortage was very serious.

It is not surprising, for example, that John Roth, former president of Nortel, and an engineer, defined the problem as a shortage of engineers, mathematicians and computer scientists:

> [...] We're facing a serious capacity issue in our universities. The problem is not that we don't have enough students who want to become engineers and scientists and computer programmers. It's that we don't have the capacity in the technological departments of our universities to meet the demand [...] Our sustained growth and on-going success in a competitive global marketplace require large numbers of new Canadian graduates in computer science, electrical and computer engineering, physics, and mathematics. These graduates are our most important resource. Their talent, fresh ideas, and technical expertise enable us to maintain our competitiveness (Roth, 1998).

As a result of the advocacy efforts led by Roth and others in the sector, the Ontario Government "doubled the pipeline," creating twice as many spaces for Engineering and Computer Science students. Subsequently, the ITAC sponsored a survey of Ontario-based user and supplier. It concluded that in 2001 Ontario actually had a surplus of 24, 531 IT qualified professionals; however, in 2002, Ontario will have a "gap" of 9,900 qualified IT professionals, and in 2003 it will have a gap of approximately 3,700 qualified IT professionals. It concluded that "clearly some skills are in greater demand than others"(ITAC and IDC, 2002). The Canadian Advanced Technology Alliance (CATA) and the Information Technology Association of Canada (ITAC) were the leading organizations that pushed the government to invest more heavily in "doubling the pipeline" and creating more spaces for computer science and engineering students. The Access to Opportunities Program (ATOP) funnelled $150 million over three years into Ontario universities to address the skills shortage in IT. The initiative focused primarily on computer science and electrical engineering and other programming related programs. There was no consideration of other disciplines or attention paid to the gender dimensions of these fields (Ontario Ministry of Education and Training, 1998). The result, however, was overcapacity in universities and a decline in enrolments in these disciplines over the next 10 years, in part, as a result of the dot.com bubble bursting in 2000 (Panko, 2008).

Ironically, three years later, there was evidence of the professional associations redefining the nature of IT worker which is in short supply. In the study undertaken by IDC Canada, it is clear that the definition of IT worker is much broader than the definition promoted by ITAC and CATA four years earlier, and in addition to workers in the Information and Communications Technology (ICT) Sector (the providers of technology) it includes workers in IS departments within end-user companies. For this study IDC defines an IT worker very broadly, as "anyone doing work conceiving of, developing, planning, implementing, operating, or maintaining information technology as his or her primary work […] They may be trained in mathematics, computer science, electrical engineering, business, social science, physics, chemistry, communications, and other formal education disciplines that include learning about computing at different levels of theory and application" (IDC, 2001). After the crash, the CATA issued a release once again focusing on the critical IT skills shortage. However, storyline appeared to have changed and the problem redefined. "Doubling the pipeline" for Computer Scientists and Engineers, it seems, had not addressed the skills shortage:

> Technological skills are not the only need. When Industry Canada first became interested in the software industry in 1987, it assumed that the industry's biggest problem was a lack of programmers. Software execs said that while it certainly was hard to find enough good ones, the real problem was finding sales and marketing people. When I put the question to the CEOs who serve on the CATA Alliance board today, I get the same answer, 'Marketers are harder to find than engineers' (CATA, 2001).

However, in 2007, the ICT industry associations once again sounded the alarm bells.

> A new survey shows that a growing shortage of IT skills has put upward pressure on salaries as employers choose experienced workers over graduates….a continuation of what [IT World Canada] calls a 'sobering trend' will hurt economic growth and productivity 'across all industries' (CBC, 2007).

Industry banded together, once again, to create another Council to encourage more students to enter the ICT sector. Once again there is a call for more computer scientists and engineers:

> The competitiveness of Canadian enterprise relies more and more on our access to information and communications technologies. Those technologies, in turn, rely on the highly trained people that create them, run them and push them into new areas of economic life. A growing

> and increasingly serious shortage in Canada's information technology talent pool, however, is putting that connection at risk. As IT skills 'shortages' become skills 'emergencies,' the situation is becoming Canada's greatest human capital challenge. (Boisvert, 2008)

Boisvert, President of Bell Ontario, is leading a coalition of employers lobbying the government to address the ICT skills shortage.

Empirical Data

Labour force projections are a difficult call to make, but the evidence on the ICT skills shortage are somewhat contradictory owing in part to issues of definition and perhaps, in part, to the tendency to over-simplify the results of empirical analysis. The Information and Communications Technology Council (ICTC), working with Statistics Canada, has tracked supply and demand for ICT workers for more than 5 years. The latest study, (ICTC, 2008) maintains that between 2008-2015, it is expected that there will be demand for 127,700-181,000 additional ICT workers, or 16,000-27,000 per year owing to growth in demand and a surge in retirements. Of these 93% are expected to be in occupations typically defined as core ICT positions. On the other hand, the ICTC is projecting that there will be approximately 7,585 new computer science and engineering graduates who 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, supply should meet demand. (ICTC, 2008)

The study acknowledges that there is a gap between the specific skills required and skills available. For example, freshly minted computer science graduates cannot immediately fill positions vacated by retiring professionals with 40 years experience. Similarly, many of the immigrants with the ICT qualifications are not being employed in the sector.

What specific roles and skills sets does this data indicate are needed in the ICT sector? This is where the analysis becomes interesting and, in some respects, is most at variance with the dominant discourse described above. The range of ICT positions varies considerably from highly technical roles to hybrid roles, such as business analysts, in which the ability to bridge technology and business functions is essential. This is consistent with early suggestions that the ICT profession is broad. Denning (2001a), for example, has reflected on the changing nature of the profession and suggests that there are over 40 organized professional groups in computing and information technologies and that interdisciplinary studies are growing. He proposes a redefinition of the profession to include what he terms "IT specific disciplines", "IT intensive disciplines", and "IT supportive occupations" (See Table 1).

Table 1: The Evolution of the IT Profession

IT-Specific Disciplines	IT-Intensive Disciplines	IT-Supportive Occupations
Artificial intelligence	Aerospace engineering	Computer technician
Computer science	Bioinformatics	Help desk technician
Computer engineering	Cognitive science	Network technician
Computational science	Digital library science	Professional IT trainer
Database engineering	E-commerce	Security specialist
Computer graphics	Financial services	System administrator
Human-computer interaction	Genetic engineering	Web services designer
Network engineering	Information science	Web identity designer
Operating systems	Information systems	Database administrator
Performance engineering	Public policy and privacy	
Robotics	Instructional design	
Scientific computing	Knowledge engineering	
Software architecture	Management information systems	
Software engineering	Multimedia design	
System security	Telecommunications	
	Transportation	

Consistent with the argument made by Denning, industry data show that the shape of the Information Technology Profession in Canada has changed and that the skills it demands are multi-disciplinary. Non-technical and soft skills-based positions will be increasingly important. Technical competence will not be sufficient (Wolfson, 2003). A total of 27 different segments have been defined

in the IT workplace (Gunderson, Jacobs, and Vaillancourt, 2005). Moreover, a study of critical skill shortages suggests that the skill sets in short supply are not primarily the core technology skills but business skills and communications skills. (See Table 2) As Carole Stephenson, former president of Lucent Canada, said, "the soft skills are hard" (Brody et. al., 2002).

Table 1: Skills Reported by Employers (Gunderson et al., 2005)

	Very important	Somewhat important	Less important	Not required
Personal Skills	53.6%	31.2%	10.8%	4.3%
General IT Skills	31.4%	27%	20.6%	20.9%
Business Skills	23.3%	23.7%	15.7%	29.3%

This raises some questions about the definition of "ICT professional" as well as the often exclusive emphasis on computer science and engineering graduates in discussions of the ICT pipeline (Cukier, Devine and Shortt, 2002). We discuss this further below. In many cases, the demand for communications and business skills has allowed non-engineers and computer scientists to enter and excel in the industry. Consequently, we suggest that the supply of IT professionals for Canada comes from several sources:

- Canadian university graduates in computer science and engineering;
- Canadian university graduates in allied disciplines, e.g. management, informatics;
- International students graduating in computer science and engineering;
- New immigrants with IT training and experience;
- Employees moving from other functional areas.

Solving the skills shortage, then, requires considering the full range of entry points. University enrolments in computer science have declined compared to enrolments in other disciplines, a trend which is causing significant concern to employers (De Guzman, 2006). In Canada, enrolments in the combined category of mathematics, computer and information sciences grew from 19,996 in 1992-1993 consistently until 2001-2002 when they hit 29,856. During the last five years, they have fallen to 22,567 in 2004-2005, the last year for which there is data. In contrast, enrolments in other programs, such as business have grown by over 40% during the same period (COU, 2007). What is striking is that female enrolments have fallen faster than male enrolments, from a high of 23% in 2001-2002 to just over 15% in 2004-2005. During this same time, female enrolments in undergraduate business are almost 50%.

Participation of Women and Under-represented Groups

A comparison of the ICTC employment data with the population shows that, at least at the macro level, a number of groups are under-represented generally and in particular segments. For example, while women are 47% of the Canadian workforce, they are only 29% of ICT workers. Immigrants are 20% of the workforce but only 5% of ICT workers. Visible minorities are 13% of the workforce but only 10% of ICT workers. If these imbalances were addressed, the result would be almost a doubling of the workforce.

It is particularly important to note the variation in demographics by job category. 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. Females dominate some ICT occupational groups such as information science (Gunderson et al., 2005). Between 1990 and 2002, employment growth in all other industries was nearly twice as high for women than for men. In ICT industries, though, employment growth for women was only two-thirds that of men (Vaillancourt, 2003). We also know that the unemployment rate of immigrants is more than three times as high as for other people in Ontario in spite of the fact that they have higher levels of education.

Barriers to Participation

Research on the barriers to participation in ICT careers faced by women and visible minorities notes that impediments to full participation in the Canadian workforce persist. In spite of advances, gaps remain in employment levels, income and satisfaction associated with gender, and immigrant status, and more specifically visible minority status. While many overt forms of discrimination have

been reduced, there are still systemic barriers that limit access to positions with more power and social prestige, and to higher rewards and resources.

Complex factors affect the participation of women in ICT including socialization and early education which affect self-efficacy and confidence and 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 "nerd" stereotypes, and notions that ICT work is programming. Systemic barriers in post-secondary institutions are similar and it has been well documented that they create a "chilly climate" for female engineering and computers science students. 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. Some literature also considers broader socio-political-cultural forces and practices which form the institutional environment of organizations but these issues receive limited attention. (For a summary of these see ICTC, 2007).

Some scholars (Ramsey and McCorduck, 2005) probe beyond the barriers and explore issues related to professional identity in the face of systemic stereotyping, dualism, and devaluation. Computer science or engineering are not more "difficult" than professions in which women have achieved parity, such as the medical, law and business fields. However, females in North America are more attracted to disciplines with "social purposes". Many women articulate an interest in "computing with a purpose" as opposed to "hacking for hacking's sake" and are more interested in the application of technology than "the technical bits" (Rosser, 1990; Grundy, 1996). There are also issues of perceptions: in a study be Neilson et. al (2003), the authors found that both male and female survey respondents lack information about the nature of the work, and overwhelmingly perceive IT as a masculinized domain. In particular, the females mainly see IT courses as boring and difficult (Neilson et. al, 2003). We speculate that when the sector was growing, many females enrolled as a route to a secure profession, rather than out of love of computers. This may explain why retention rates for females are lower than for males.

At the same time, it is important to recognize that the under-representation of women in engineering and computer science disciplines is not the only metric for assessing women's participation in the information systems profession. The ICT profession is much broader than computer science and engineering and women's participation in many segments remains high. Institutional theory shows that qualifications not related to performance may become institutionalized and we believe that some assumptions about the experience (Canadian) and qualifications (Canadian degree in Computer Science or Engineering) needed to do the job of an ICT professional need to be further explored. There is evidence that industry, government and academe shape the institutionalization of the discourse around the IT profession and the skills shortage. Given that the leaders in the profession are often men who are computer scientists and engineers (like Roth and Boisvert) it is not surprising that they tend to reinforce the definition of Information Systems Professional as computer scientist or engineer. However, the result may be that the conceptualization of or definition of the profession itself serves to reinforce the exclusion and marginalization of women entering the profession from other disciplines. The focus on the technology bits (rather than its applications) also may reinforce negative stereotypes of the IS profession which are known to discourage women from entering the field. Finally, the approach often devalues skills associated with females (the soft skills) in spite of the empirical evidence of their importance. (ICTC, 2007)

Discursive Practices: Another Barrier?

While we do not doubt the existence of a skills gap or mismatch, some attention needs to be focused on the discourse associated with the profession which may in part explain the apparent gap between the espoused labour needs for the ICT sector associations and leaders compared to some of the data on the job and skill requirements. Further exploration of this is critical.

Some hi-tech companies, dominated by computer scientists and engineers, perpetrate the practice of hiring in their own image and do not match skill sets to job requirements. Microsoft, for example, recognized this and adopted new approaches to recruitment in an effort to open the doors.

Despite clear evidence that graduates of many technology-related disciplines have the necessary skills and do succeed in the sector, there is clear bias towards hiring from traditional (and also male-dominated) disciplines. It is important to consider the roles of actors and the ways in which their messages are institutionalized through a variety of "carriers" as well as the potential consequences (See Table 3).

Table 3: Actors and Discursive Practices

Actor	Carriers	Examples of Discursive Practices Related to the IT Profession	Unintended Consequences
Government	Programs	Expanded funding for Computer Science, Engineering and some IT Management	Privilege male dominated disciplines
Industry and Professional Associations	Advocacy	Promotion of "doubling the pipeline" focused on Canadian Computer Science and Engineering	Privilege Canadian male dominated disciplines
	Programs	CIPS "Women in IT" focus on Computer Science and Engineering	Reinforce negative stereotypes
Employers	Hiring practices	Job Descriptions and Recruitment (full time and student) focus on Computer Science and Engineering Focus on Canadian credentials and experience	Privilege Canadian male dominated disciplines
	Programs	Define Women in IT as Women in Computer Science and Engineering	Reinforce negative stereotypes
	Research	Centre for Telecommunications defines "interdisciplinary" as computer scientist and engineers working together	Privilege male dominated disciplines
Granting Councils	Programs	Natural Sciences and Engineering Research Council versus Social Sciences and Humanities Research Council relative funds, success levels	Privilege male dominated disciplines
		Canada Research Chairs focus on science and engineering	Privilege male dominated disciplines
Educators	Hiring Practices	Shift to Computer Science and Engineering for IT Schools	Privilege male dominated disciplines
	Admission Requirements	Emphasis on Mathematics over other Skills	Reinforce negative stereotypes
	Programs	Define Women in IT as Women in Computer Science and Engineering	Reinforce negative stereotypes

Further work is needed to explore the interactions between the stakeholders but it would seem that the discourse regarding the IT skills shortage was shaped by interactions between a number of players including industry and industry associations (by no means homogeneous), the media, government, and educational institutions (in both their educating in research functions.

There are also complex interests among these stakeholders: the government funds education, and industry sponsors educational programs and research, etc. which means that a multi-layered strategy engaging a range of stakeholders is key to enacting sustainable change. Discursive practices are reinforced by existing structures in industry, associations and academe which are dominated by men, computer scientists and engineers who continue to reinforce these definitions in spite of the gap with the reality. These practices tend to exclude and marginalize women who are under-represented in engineering and computer science but better represented in other disciplines. While it is critically important to continue to attract females to study computer science and engineering, it is equally important to ensure that multiple paths are available and respected and that narrow definitions are not systemic barriers to their participation in IT professions.

Promoting Participation of Women in the Canadian ICT Workforce

Complex problems require complex solutions and addressing the issues of under-representation of women in the ICT sector requires collaboration work among a variety of stakeholders to develop integrated multi-layered solutions. Better data and more research on current practices will help advance our understanding of processes for developing strategies which "fit" in particular contexts.

"Best practices" which are innovative, make a difference, have a sustainable effect, and can be replicated and applied in other contexts need to be further explored.

There is little doubt that two of the critical factors in successful diversity programs are senior management support on the one hand and measurement on the other (Catalyst and the Diversity Institute, 2007). In Canada, federally regulated ICTs, principally those in telecommunications, are obligated to track and report on diversity. However, we see many global and Canadian companies making explicit commitments to diversity as a strategic direction. A number of hi-tech organizations sponsor outreach, role modelling and summer computer camps aimed at attracting girls as young as 8-10 to the industry. These programs are based on a recognition that attitudes and preferences which shape choices are formed early on. Companies are also providing support to teachers and guidance counsellors. A list of more than 40 programs aimed at attracting girls to ICT careers can be accessed via ICTC (2007). Once they are recruited, companies have a range of programs aimed at supporting under-represented groups in the workplace with impressive results. For example, telecommunications services provider TELUS increased the representation of women in senior management roles from 7% to 30% within a three-year period (ICTC, 2007). Finally, and most challenging, are initiatives aimed at shaping societal views. Attending to the representation of women both generally and in technology in particular is a challenge, but also an important part of positively influencing the socialization of girls and women (ICTC, 2007).

We have reviewed in some detail the current discussion of the ICT labour shortage in Canada, the empirical data concerning the shortage and have suggested ways in which addressing diversity in a systematic way can contribute to expanding the pipelines feeding the ICT profession. We have also suggested that an area for further investigation lies in the definitions and assumptions used to frame the discussion and self reflection on the assumptions underpinning the discussion of the ICT labour shortage.

An important contribution of our study is to suggest the development of an "ecological model" which considers the complex interactions among individual factors, group factors, organizational factors and societal factors which shape choices, create barriers and facilitate opportunities. We propose this model in order to address one of the major gaps which have been identified in the literature to date on diversity—that is, the relative lack of research exploring the institutional environment of organizations or the larger socio-political-cultural context of organizations. While many interventions have been developed which address organizational barriers to women in the ICT sector, we suggest that the broader societal issues—for example, the socialization of girls, the absence of role models, representations in the media etc. are particularly significant in shaping the expectations of young women. At the same time, the very way in which the ICT sector is conceived and defined can, in itself, be a significant barrier. We suggest that some of the practices associated with the institutionalization of the "IT profession" also present barriers to the participation of women.

Given the increasingly multidisciplinary nature of the IT industry and the demand for a workforce with a broad range of skills sets, preliminary research has suggested that there may be a discrepancy between skill requirements for IT jobs and qualifications sought by employers. Narrow constructions of the IT professional and the IT discipline may have significance for recruitment and retention strategies, for example, the assumption that a degree in computer science or engineering is a prerequisite for a position in project management. The notion that computer science, engineering and mathematics are the only entry routes to the IT profession may, in the same way, have unintended consequences for women. In addition, the (mis)representation of the IT Profession in this way reinforces the stereotypes of it as a "technocentric" profession rather than one with broader appeal that requires diverse knowledge and skill sets. More study is needed to explore the ways in which our definition of "IT professional", the occupational categories, skill requirements, education and admission requirements may present unintended barriers to the full participation of women and to consider the multiple pathways to the ICT profession.

References

Brody, L., W. Cukier, K.Grant, M. Holland, C. Middleton, and Shortt, D. (2002). *Innovation Nation: Canadian Entrepreneurs from Java to Jurassic Park.* Toronto, Wiley & Sons.

Catalyst and The Diversity Institute, Ryerson University (2007). *Career Advancement in Corporate Canada: A Focus on Visible Minorities.*Toronto, Catalyst and Ryerson University.

CBC (2007). “Survey reveals “sobering” IT skills shortage”, CBC News, July 16, viewed October 29, 2008, http://www.cbc.ca/technology/story/2007/07/16/skills-shortage.html
COU (2007). Council of Ontario Universities. Enrolment Statistics by Discipline.
Cukier, W. (2003). “Constructing the IT Skills Shortage in Canada”, SIGCPR/SIGMIS 2003, Philadelphia.
Cukier, W., & Chauncey, C. (2004). “Women in information technology initiatives in Canada: Towards fact-based evaluation.”, AMCIS, NYC.
Cukier, W., I. Devine & D. Shortt, (2002). “Gender and Information Technology” *Journal of Information Systems Education (JISE)*, 13(1): 7-15.
Czarniawska-Joerges, B., & Joerges, B. (1988). “How to control things with words: Organizational talk and control”. *Management Communications Quarterly, 2*(2): 170-193.
Davidson, M.J., & Burke, R.J. (Eds.), *Women in Management* (1-10). London: Paul Chapman.
Denning, P. (2001). *When IT becomes a Profession*, in The Invisible Future, NY, McGraw Hill.
DiMaggio, P. & Walter, P. (1984), "The iron cage revisited: institutional isomorphism and collective rationality in organizational fields", *American Sociological Review,* 48: 147-60.
Frenette & Coulombe. (2007). Has Higher Education among Young Women Substantially Reduced the Gender Gap in Employment and Earning? Ottawa: Statistics Canada. 978-0-0662-46217-0.
Grundy, A.F. (1996). *Women and Computers*. Exeter: Intellect Books.
Gunderson, M., Jacobs, L., & Vaillancourt, F. (2005). *The information technology (IT) labour market in Canada.* Ottawa: Software Human Resource Council (SHRC).
Information and Communications Technology Council (ICTC) (2007). *Diversity: The Competitive Edge*. Ottawa, ICTC.
Information and Communications Technology Council (ICTC) (2008). *Outlook for the Information and Communications Technology Labour Market*, Ottawa, ICTC.
Information Technology Association of Canada (ITAC), & International Data Corporation (IDC). (2002). *Meeting the skills and needs of Ontario’s technology sector.* Toronto, Ontario.
Jacobs, J.A. (1995). Women’s entry into management. In J.A. Jacobs, (Ed.),*Gender Inequality at Work,* 152-77, Thousand Oaks, CA, Sage Publications.
MacDonald, K.M. (1995). *The Sociology of the Professions*. London: Sage.
Meyer, J.M. (1994). "Social Environments and Organizational Accounting", in R.W. Scott and J. W. Meyer, eds. *Institutional Environments and Organizations*. Thousand Oaks: Sage
Meyer, J.W. & Scott, R. (Eds.). (1983). *Organizational Environments: Ritual and Rationality*. Newbury Park, CA, Sage.
Morrison, M.A., Von Glinow, M.A. (1997). Women and minorities in management. In R.P. Vecchio, (Ed.). *Leadership: Understanding the Dynamics of Power and Influence in Organizations,* 521-541. Chicago, IL, University of Notre Dame Press.
O’Leary, V.E., & Ickovics, J.R. (1992). Cracking the glass ceiling In U. Sekaran, F.T.L. Leong (Eds.), *Womanpower: Managing in Times of Demographic Turbulence,* 7-30. Newbury Park, CA, Sage.
Ontario Human Rights Commission (1999). *Guide to the Human Rights Code*. Toronto: OHC. Viewed October 29, 2008, <http://www.ohrc.on.ca/English/publications/hr-code-guide.pdf>.
Ontario Ministry of Education and Training. (1998). *Access to opportunities program: Thousands of new student spaces to be created.* Viewed July 2, 2005, <www.edu.gov.on.ca/eng/document/nr/98.05/tech.html>.
Panko, R. (2008). “ IT employment prospects: beyond the dotcom bubble”, *EJIS,* 17(3).
Powell, G. (1993). *Women and Men in Management* (2nd ed.). Newbury Park, Sage.
Ramsey, N., & McCorduck, P. (2005). *Where are the women in information technology? Preliminary report of literature search and interviews*. Colorado, NCWIT.
Reskin, B.F., & Ross, C.E. (1992). Jobs, authority, and earnings among managers: the continuing significance of the sex. *Work and Occupations*, 19(4): 342-65.
Rosser, S. (1990). *Female Friendly Science: Applying Women's Study Methods and Theories to attract Students.* New York, Pergamon Press. DC, 2
Roth, J. (1998) “University Capacity Halting the High-Tech Engine”. Waterloo, Gazette. Viewed November,2008,http://communications.uwaterloo.ca/Gazette/1998/apr01/nortel.doc>.
Royal Bank of Canada (RBC). (2005). The Diversity Advantage. Toronto: RBC. Viewed on October 29, 2008, <http://www.rbc.com/newsroom/pdf/20051020diversity.pdf>
Shenhav, Y., & Haberfeld, Y. (1992). Organizational demography and inequality. *Social Forces,* 71(1): 123-43.
Software Human Resource Council. (SHRC) (2005). *A Strategy For Increasing the Participation of Under-represented Groups in the IT Sector*. Ottawa: Software Human Resource Council.
Vaillancourt, C. (2003). *A Profile of Employment in Computer and Telecommunications Industries*. Ottawa: Statistics Canada.
Wajcman, J. (1996). Desperately seeking differences: is management style gendered? *British*
Walsham, G. (1993). *Interpreting information systems in organizations*. New York, John Wiley and Sons.

Wolfson, W. G. (2003). *Analysis of labour force survey data for the IT occupations*. Ottawa, SHRC.
Yap, M. Cukier, W. Holmes, M., Hannan, C. (2008) *Career Advancement for Visible Minorities in Canadian ICT Companies.* Working Paper. The Diversity Institute. Ryerson University.