An Historical Outline of Computing and IT Occupations: Canada and Abroad, 1940s-1980s

WANE Working Paper #6

Tracey Adams, PhD
Workforce Aging in the New Economy
University of Western Ontario
London, ON CANADA

WORKFORCE AGING IN THE NEW ECONOMY

www.wane.ca

Workforce Aging in the New Economy

A Comparative Study of Information Technology Employment

WORKFORCE AGING In The NEW ECONOMY (W.A.N.E.) explores the relationships among workforce aging, employment growth in information technology (IT) labour markets, and the transformation of employment relations in the new economy. This work involves a multi-dsciplinary, cross-national comparison of IT employment and workforce aging in Canada, the United States, the European Union, and Australia.

Principal Investigator:
Julie McMullin, Ph.D.

Project Manager:
Terri Tomchick, MA

Workforce Aging in the New Economy
The University of Western Ontario
Social Sciences Centre, Room 3207
London, Ontario CANADA
N6A 5C2
t: 519-611-2111 x.81236
f: 519-661-3200
e: wane@uwo.ca

We gratefully acknowledge the Social Sciences and Humanities Research Council of Canada; the Faculty of Social Sciences; University of Western Ontario; and Research Western for their support of this project.

An Historical Outline of Computing and IT Occupations:
Canada and Abroad, 1940s-1980s
WANE Working Paper #6

Tracey Adams, PhD
Workforce Aging in the New Economy
University of Western Ontario
London, ON CANADA

Abstract

Central to the WANE project is the exploration of the nature of employment and workers' experiences in IT occupations. Key initial questions have focussed on identifying the nature and scope of IT occupations, the contexts in which IT employment occurs, the factors that shape employment, training, and career advancement, as well as the significance of gender, age and race. Answers to all of these questions have an historical component. To attain a full understanding of the nature of, and key issues surrounding, IT employment, it is necessary to review the history of IT, and especially computing, occupations. The purpose of this paper is to provide a brief history of the rise of computing, and to consider the changing nature of computing work. While the emphasis of the paper is on developments in Canada, these cannot be separated from developments elsewhere, and hence the paper also considers the history of computing in the United States and, to a lesser extent, the United Kingdom.

February 2004

Acknowledgement

I would like to thank Rob Downie and Erin Demaiter for their research assistance, and Julie McMullin for her guidance on this research.

Introduction

The rapid expansion of work in the field of 'information technology' began after the Second World War with the invention of the modern computer and the rapid technological advances in computing that followed in successive decades. This paper first reviews the events surrounding the birth of the electronic computer in the late 1940s and considers the people and organizations that shaped its development. The paper then outlines changes in computer employment over time. Lastly, the paper considers the experiences of women, and the significance of age and ethnicity to IT employment in the past. While professional, educational and organizational developments within the field of computing were prominent in the period between 1945 and 1985, these topics will be mentioned only briefly in the present paper; instead, they will form the basis for a follow-up WANE working paper on professionalization within IT occupations.

The Rise of the Computer

The first modern-day computers were built in the late 1940s. There are at least two central social events and trends that encouraged developments in computing at this time: the Second World War, and advances in science and technology that made complex calculations increasingly necessary and facilitated the development of machinery to perform them. First, the Second World War was a key catalyst in the development of computing technology. Before the war, many mechanical calculators or 'computers' – literally machinery used in making mathematical computations – had been built. These were in high demand during the war, as were those people who could run and program them. These mechanical devices, though, were inherently limited in terms of their scope and speed; hence, there was a push for innovation to create more advanced machinery, and especially to explore electronic computing technology. The United States military came to realize that "there were scientific problems of high military priority for whose acceptable solution the development of large-scale, fast machines was essential" (Rees, 1987, p. 833; see also Vardalas, 2001, p. 277). For instance, the U.S. army had to prepare complex ballistic firing tables so that "artillery men [could] accurately aim their weapons" (Williams, 1985a, p. 30). Such a large volume of tables were required that the army funded research into computer development. The U.S. Navy's reliance on radar and navigational tables also enhanced its need to do complex calculations for which machinery was needed. As a result, the military and U.S. government funded and supported a number of research projects, many of which were university-based, aimed at creating an electronic computer. The British government had similar needs, and also furthered research in computer technology through its efforts to break the German military's secret message codes (Williams, 1985b).

Demand for computer technology did not decrease after the war: the U.S. and other allied governments believed it was important to continue to develop military technology, particularly as the Cold War got underway. Advances in atomic (i.e. nuclear) energy during and immediately after the war also raised the demand for machinery that could perform complex calculations. Thus, government demand funded and fuelled the development of computing, playing "a critical role in the early support of research and development of ... computing machines" (Rees, 1987, p. 833).

Second, technological advance in the field of computing was encouraged by changes within university science. Here, a variety of scientists in areas such as applied mathematics, astronomy, physics and other disciplines were working on problems requiring complex mathematical computations (Croarken, 1992; Williams, 1994). At the same time, advances in physics, mathematics, and engineering ensured that there were personnel, who had the capacity to make innovations in this area. Hence, if research in computing technology was largely encouraged by government funding and support, it was physically generated by teams of physicists, engineers, mathematicians, and other scientists working in university facilities to create computer technology, for themselves, their university communities, and for government sponsors. These university-based researchers worked with some degree of co-operation, and the plans, successes and failures of one group of researchers were fairly well-known to others working in the field (Croarken, 1992; Griffith, 1994; Williams, 1986).

In the years immediately following the Second World War, work developing electronic computers was intense. It was being carried out at, at least, four university locations – two in England, and two in the United States; research was undertaken in Canada at the University of Toronto, as well. To some extent, it is difficult to identify the very 'first' computer as there is disagreement amongst computer historians over what precisely 'counts.' The first electronic computing machine, the ENIAC, was created by John Mauchly (a physicist) and Presper Eckert (an engineer) at the University of Pennsylvania in 1946.[1] However, this machine lacked "stored program" capability, and therefore, is generally not accorded the title of "first" computer. Later in 1946, Mauchley and Eckert left the University of Pennsylvania to further their research in computing, creating the Universal Automatic Computer (or UNIVAC) – a machine that became synonymous with 'computer' in the 1950s (IEEE, 1996). The other main contenders in the race to create the first computer included John von Neumann's team at Princeton[2], a group at Cambridge working under physicist Maurice Wilkes, and a group at the University of Manchester that was highly influenced by mathematician, Douglass Hartree (who moved to Cambridge in 1946). All four groups were in contact with each other and the U.K. groups' efforts were particularly influenced by a visit to, and exchange of ideas with, their American counterparts (Croarken, 1992; Williams, 1986).

The title of first computer seems to go to the Manchester team who in 1948 created a prototype machine, "Baby" (IEEE, 1996). This prototype was very limited – apparently it could only subtract, and hence there were limits to the computation it could do and the amount of data it could handle (Earl of Halsbury, 1959). A full scale machine, the Manchester Mark I, was constructed later. The second computer – or the first "large-scale, fully functional, stored-program electronic digital computer" – was the one completed by Wilkes and colleagues at the Mathematical Laboratory at Cambridge in 1949: it was named EDSAC (IEEE, 1996).

Contemporaneous with these efforts is a lesser-known campaign by a handful of scientists at the University of Toronto (U of T) to create a computer. Around 1946, a Computer Committee was formed with representation from mathematics, physics, and engineering. This group researched the feasibility and requirements for building a computer, and in 1947-8 gained funding from the Canadian Defence Research Board (DRB) and the National Research Council (NRC) to do so. The Canadian military, like its counterparts in other nations during the post-war years, was impressed with the key role that science and technology played in the war, and, as a result, was eager to expand Canadian research and development (Vardalas, 2001, p. 15-16). The DRB was created by the Canadian government to encourage research useful to the armed forces. The value of computing technology soon became clear to the DRB (by 1947), and hence it was willing to join the NRC (who needed enhanced computation facilities for its atomic energy research program) in funding the activities of the U of T computer group (Vardalas, 2001; Williams, 1994; Griffith, 1994).[3] It was understood that after the computer was built, the Canadian government, military, and the atomic energy commission would have immediate access to it, as would other interested university-based scientists.[4]

A proto-type of a computer, the UTEC (U of T Electronic Computer), was built by the U of T team, led by physicist C.C. Gotleib and electrical engineering graduate student Joseph Kates, in 1951. The computer was still in an experimental phase, and it was never fully developed (Williams, 1994). Indeed, work on the University of Toronto computer halted shortly after the British successes. The atomic energy researchers affiliated with the NRC were particularly impatient for an electronic computer they could use. When they discovered that a copy of the Manchester computer, built by Ferranti Ltd in the UK, was available for purchase, they urged the University of Toronto team to use their funding to buy a computer, rather than develop one (Vardalas, 2001; Griffith, 1994).[5] The development team was quite reluctant to give up their dream of building their own computer, but they eventually agreed to use much of their funding to purchase the Ferranti computer, after much pressure from the funding agencies, and with the promise that additional funds would be set aside to continue their own work. While some additional research was conducted, it never resulted in a full-fledged U of T computer. The Ferranti computer, FERUT (FERranti, U of T), arrived in 1952 – without instructions or a programming manual. The focus of the computer group at the University of Toronto quickly changed from building their own computer, to maintaining, running and programming the FERUT.

The U of T computer became very useful to scientists around the university and to government organizations. The machine was extremely difficult to use, maintain and program – physicist J.N.P. Hume took over many of the main programming duties (along with mathematician B.H. 'Trixie' Worsley) – but it was nonetheless invaluable (Hume, 1994). Indeed immediately upon its installation, the Canadian government used FERUT to aid it in making calculations for the construction of the St. Lawrence Seaway; the path the seaway would take through international waters was then being negotiated with the United States. Lacking access to similar equipment to make the required calculations, the Americans "were essentially forced to accept the Canadian plans" (Williams, 1985c, 1994, p. 11). According to technology historian John Vardalas, the efforts to build UTEC and the experience gained in using FERUT "accelerated development of the capacity to design software and make innovative use of the computer" in Canada and enabled the University of Toronto to "become an important training centre and innovation pole in the application of computers" (Vardalas, 2001, p. 41; see also Williams, 1994, p. 8). Moreover, the U of T facilities encouraged the use of computers elsewhere in Canada, as both the University of Alberta and the University of Saskatchewan made arrangements for remote access to FERUT through a teletype machine in the late 1950s (Griffiths, 1994; Smillie, 1996).

Establishment of a computer industry

From these initial developments, the computer industry was established in the 1950s. This was particularly the case in the United States. There was a continued need for computers within U.S. government departments. Not only did military establishments seek computers and encourage research in computer-related areas, other government offices did as well. The value of a computer for areas such as the U.S. Census was obvious, and the Census bureau was among the first organizations to commission a computer from Mauchley and Eckert, after their initial success. Quick to see the possibilities, IBM and Remington-Rand (manufacturer of the UNIVAC) also jumped into the market of researching, generating and selling computers. Gradually other business saw their potential. Large organizations that needed to process large numbers of customers and monetary transactions (like banks and insurance companies) were amongst the first to embrace the new technology. The value of computers was also evident in the postal service, and the airline industry, amongst others. However, at first, few computers were being made; development time was long and there were few people with the requisite skills. In very little time, however, IBM established itself as a leader in the industry, originally producing two distinct lines of computers for two different types of customers: one for business, the other for university and scientific users. They merged their two different lines in 1964 (IEEE, 1996). IBM had an extensive reach and became a world-wide leader in this area.

The computer industry was slower to develop in the United Kingdom and in Canada. In the U.K. the early leading contender was the Ferranti Corporation; however, computers were only a small part of their business, and a part that computer historians argue was not well managed (Vardalas, 1994). While a computing industry was established in Britain, it was one that computing leaders characterized as 'slow' to develop, and labelled the "computer non-industry" (Earl of Halsbury, 1959, 1991, p. 273). The fledgling computer industry in Canada, in the 1950s, was small, and concentrated in a few small firms and foreign subsidiaries. Notable amongst the former was a computer consulting firm established by many of the central scientists involved in the creation of the UTEC, led by Josef Kates.[6] Another key firm was a Canadian subsidiary of Ferranti U.K. This company has received some scholarly attention because of its promising innovations that many feel could have – but did not – generate an indigenous computer industry. Ferranti Canada received a large contract from the Canadian Navy to create a computer system that would enable ships to ascertain the locations of other ships, and to communicate information from ship to ship about the environment, the location of enemy ships, and so forth (Vardalas, 1994). The Navy hoped that this innovative technology would improve its international standing, and be coveted (and purchased) by its allies. However, the young Canadian scientists and engineers at Ferranti Canada had only limited success: the system they created was somewhat prone to failure (due to the vacuum tube technology used), and other countries were not interested in buying it. Amongst Ferranti Canada's other "near-successes", can be counted an innovative system for sorting mail – that was scrapped due to a lack of government support in the mid-1950s[7] – and a related system for the New York Federal Reserve Bank for sorting cheques. The company also succeeded in creating a system for keeping track of airline reservations (Vardalas, 1994). Its greatest success was the creation of a general, multi-purpose business computer (that contained the advanced feature of "multiprogramming," pioneered time-sharing, and used transistor technology). Ferranti Canada had difficulty selling their innovative products at home – partly, it is believed because of a lack of support from Ferranti U.K., and partly because of a lack of support for indigenous technology amongst Canadian government and industry buyers (Vardalas, 1994; Van der Wijst, 1972).[8] Eager to drop an unprofitable computer business, Ferranti UK sought a buyer in 1963 for its computer division, and the innovative Ferranti Canada figured prominently in the deal. ICT was apparently only interested in purchasing the computer company if the full rights to the Canadian innovations were included. When the company was sold, ICT took the innovations and effectively closed down Ferranti Canada's computing division. The computer development team left to form distinct consulting companies, in the hardware and software development fields (Van der Wijst, 1972).[9]

Thus, while there was a time when an indigenous computing industry seemed possible, by the late 1950s and early 1960s, the Canadian computer industry was dominated by American subsidiaries and smaller consulting firms. In accordance with this trend, employment in computing was less centred around hardware and software development, than in business applications of computing. While the explosion of employment in the latter area was reflected world-wide, and accompanied the expanded use of computers within larger organizations, it was perhaps more intense in Canada than in the United States (and likely the U.K. as well), because the latter countries had a stronger presence in the computer engineering and software development fields. The next section explores these changes in computing development and employment more closely.

Summary

There are a few elements in early computer history that are worthy of additional emphasis. First, is the initial grounding of the industry and IT occupations in the sciences: the foundation of the field primarily occurred with the intersection of math, physics and engineering. These foundations influenced later developments in the training of IT workers, the development of computer science as a discipline, and information processing as a profession. Second, is the extent to which the field was shaped by the somewhat diverse but overlapping interests of governments, universities and their faculty, and later business. These areas became major areas of employment within IT occupations, and also fundamentally shaped the development of the field, and especially the activities of IT professional organizations.

Occupational Change

In the late 1950s and 1960s, the computing field grew in at least two very distinct directions. First, the field expanded in the scientific realm: gradually in the 1960s computing developed as an independent field of scientific investigation and research. While research in computing was still generally carried out by those who had come to it from other disciplines, they endeavoured to define "computer science" and to establish it as a distinct discipline. They created professional organizations, and established computer science as a university subject. Computing centres affiliated with departments of mathematics and physics were created in the 1950s in many Canadian and U.S. universities.[10] In Canada, courses in computing were offered in the late 1950s and early 1960s in a variety of university departments, but especially in mathematics. The first computer science departments were established in the mid-1960s at a number of universities including the University of Western Ontario, the University of Toronto and the University of Alberta. Programs in 'computer engineering' arose slightly later, as electrical engineering departments, such as the one at the University of Windsor in the late 1960s, began to expand into this area (Thomas, 1970). Computer science and computer engineering departments became a locus of training for computer professionals, and a centre for research on computers and computing. Research into computing was also conducted within industry, by large computer companies and independent consulting firms alike, especially in the United States. The use of computers at research facilities and at universities spread, and a wider array of scientists would come to use the computer in their work. Advances in programming in the 1950s meant that increasingly, this task was not solely an activity to be performed by a professional programmer with exclusive knowledge of a particular machine, but one that scientists could conduct themselves, after receiving some training.[11]

A second (and larger) direction of growth in the computing field was in the business realm. Companies like IBM, Honeywell and Remington-Rand began 'mass-producing' computers to an expanding business market. In the 1950s and 1960s, IBM sold equipment that came bundled with software, and they provided customer service at no charge – employing people to set up and, at times, initially program the computers that they sold. As computers and computer services became more readily available, more private firms and government departments invested in the technology. Employment in computing expanded apace. In particular, there was a "huge demand for people with even a couple years of programming experience" (Johnson, 1998, p. 37). People were needed in organizations like IBM to make, program, and provide service for computers, and in a growing number of businesses, people were needed to use, maintain, and manage computer systems. IBM's decision to "unbundle" software from its hardware in 1969 fed the expansion of a nascent software industry, and expanded employment and industry development in the software field in the 1970s (Johnson, 1998). Thus, while the expansion of employment in the scientific and educational aspects of computing was important, numerically, it paled in comparison to the growth in the business sector.[12]

The extent of this employment growth is reflected in Canadian Census figures. While census data cannot capture the internal diversity of computer employment at this time, they do provide a picture of a rapidly expanding employment sector. In 1961, the census records a total of 784 computer programmers in Canada. This number is relatively small, but nonetheless notable, as the occupation did not officially exist a decade earlier. These workers were, on the whole, educated, and based in Ontario (which employed 63% of programmers) and Quebec (20%) (Gagnon et al., 2003). By 1971, the category had changed to "systems analysts, computer programmers and related occupations" and the number of Canadian workers in the field had exploded to 22, 480. These workers continued to be educated, and mostly employed in Ontario and Quebec, although the predominance of employment in the former had dipped slightly. Only 52% of workers in the field were based in Ontario, while 29% were based in Quebec (Gagnon et al., 2003). Rapid growth continued through the 1970s, and by 1981 Canadian workers in this category numbered 60,680. While almost half of these workers continued to be employed in Ontario (47.7%), employment in Alberta (8.8%) and British Columbia (7.6%) had noticeably increased (Gagnon et al., 2003).

More detailed information on employment in computing in Canada can be found in a series of salary surveys conducted by the Canadian Information Processing Society (CIPS) beginning in 1969. Here it is clear that most computing employees worked as programmers, 'computer operators,' keypunch operators, and systems analysts. Employment in fields such as 'engineering or design' and 'operations research' was relatively rare (IPSC, 1969). Sectorally, computing employment was concentrated in the manufacturing, financial and other service industries (including education) and government (CIPS, 1973b; see also Gagnon et al., 2003). Like the census, CIPS figures indicate that computer-related employment was highly concentrated in Ontario and Quebec (CIPS, 1973b). Nevertheless, the spread of employment in this sector is indicated by the fact that every province employed some IT-related workers at this time.

It is not surprising given the rapid spread of employment in the field that the contemporary literature reported worker shortages and difficulty filling at least some positions in the area. There were not enough people with computing expertise available. Computer science programs were created in the mid to late 1960s across the U.S. and Canada, but these did not generate enough graduates for the field, it appears, nor did they necessarily impart the skills that businesses wanted workers to have. University computer programs were generally not geared towards the needs of industry (CIPS, 1973a, and others). To meet these shortages, companies tended to provide training themselves, have workers learn on the job, or send current employees out for additional computer training. A shortage of computer personnel led to the establishment of a number of private computer 'colleges' in the 1960s that purported to provide training (Ensmenger, 2001). These became a bane to computer professionals as they provided sub-standard education, rarely taught reasonable skills, and misled students as to the programs benefits and usefulness (Stirling in Oettinger, 1967). Professional organizations then sought to establish guidelines for education programs and constructed accreditation mechanisms.[13] Businesses seeking to hire computer workers quite often hired workers with education in other fields, and provided opportunities for training in data processing. Thus, many workers who entered computing in the 1960s and 1970s did not have formal training in computer science or a related field.

The shortage in skilled computer personnel was particularly acute in two areas. The first, which characterized the 1960s, 1970s, and 1980s, was a shortage of people who possessed both business and computing skills. These included people in data processing, but also people involved in systems maintenance and management. People who not only had knowledge of computers and programming, but also a sense of organizational needs, were rare.[14] Companies often had very specific needs that were not met by the more abstract education provided by universities. Over time, the educational programs responded, at least marginally, to business demands, and made an effort to ensure that their graduates were more prepared. For instance, in the United States in the 1980s, organizations like the ACM established curricula for programs in areas such as systems management; the programs sought to meet the needs of industry by providing courses in computing along with courses in business and organizational psychology. Companies also responded by training their own employees in the skills they wanted them to have. In Canada in the 1980s, the need for people with skills in both areas was increasingly met by business schools which provided both short courses and degree programs aimed at teaching business people how to use and manage computers.[15]

The second North American-wide shortage in computer personnel appeared to reach ‘crisis’ proportions in the late 1970s and 1980s. This was a shortage of computer specialists with advanced training, especially PhD’s in computer science, who were in demand in both academia and industry (Denning et al., 1981; CCSDC, 1983). The first computer science PhD’s graduated in the mid-1960s, but even in the 1970s, the production of PhD’s in this field was not high. Yet the number and size of computer science programs were growing, increasing the demand for computer science faculty. University programs could not adequately staff themselves to teach the students enrolled in their programs, let alone carry out the cutting edge research that computer scientists believed was central to the advancement of their discipline. The demand for computer science PhD’s in industry ensured that salaries for workers in the private sector were high, and universities could not compete. Thus, while the profession was concerned that it turned out an insufficient number of PhD’s a year across Canada and the United States (for example, a total of 250 in both nations in 1979), it was even more frustrated by the fact that no more than half of these students actually sought positions in universities (Denning et al., 1981; Yau et al., 1983; Gries, 1987). Through the 1980s, professional leaders and educators sought to expand programs, increase the numbers of PhD’s produced, and improve the attractiveness of university employment to computer science PhD’s.

Both of these shortages had implications for work in computing. For instance, the shortages ensured that wages were fairly high, especially in certain sectors of the industry. One of the principal responses to the shortage of PhD’s in universities was to increase wages for computer science faculty to make them at least modestly more comparable to industry. Workers in other occupations similarly benefited from the shortage situation. Nevertheless, wages were not uniformly high across the computing field, and lower-wage employment, for instance in lower-skilled employment areas like keypunch operator, was common as well. Internationally, wages appear to have been highest in the United States, but wages in Canada were higher than in the United Kingdom, and climbed through the 1970s (CIPS, 1975, p.14, p. 17).

Moreover, the shortages had implications for job turnover and mobility. The availability of jobs ensured an open job market, in which workers tended to move around. Much of this mobility was horizontal – especially in the programming field – but vertical mobility was also possible. Given a shortage of educated personnel, many computer workers had opportunities to advance based on their experience alone. Moreover, some information technology experts took advantage of the market to leave established firms and create their own consulting businesses. While the recessions of the early 1980s and early 1990s, slowed mobility for a time (CIPS, 1982; Paradis, 1992), in general across the period, computing-related workers had a number of employment options.

However, the shortage situation also had negative implications for the field. Notably, it hampered the efforts of those interested in establishing computer science as a legitimate scientific discipline and profession. As noted, demand for workers was so high that people with limited skills and formal training could find work. Workers' training was extremely variable in nature and scope. In this context, establishing educational credentials and professional standards for IT workers was very difficult. Indeed, the shortage raised many concerns over standards in training, education, and quality of work. Interest in establishing credentials, degrees and accrediting education facilities increased, as is common in aspiring professions where the highly-trained mix with the lesser-trained. Concerns over standards and regulation expanded during the 1970s and 1980s along with public concerns over privacy, hacking, and what many in the industry termed a "software crisis." The latter reflected concern over software quality and reliability; some felt that computer organizations should do more to improve the quality of their products and their workers (Shore, 1988). In response to these conditions, there was a flurry of activity amongst American, British and Canadian computer specialist organizations towards establishing credentials, more stringent membership criteria, and accrediting education programs.[16] While these efforts were no doubt valuable in the computer field, they could not completely counteract the consequences of a continuing shortage of personnel. In fact, the same arguments advanced in the 1980s about a crisis of quality and the under-production of highly skilled IT workers continue to be made today, and are seen to have highly negative consequences for industrial and social development (see Duerden Comeau, 2003; and Downie, 2003).

Summary

In the 1960s, 1970s and 1980s, the computing field experienced rapid growth which led to employment shortages. The dual nature of this growth – in science/education and business – fundamentally shaped the information technology field. The extent of employment variability is a key characteristic. Computing organizations and computer science education have attempted to serve both constituencies, but employment in the two areas appears to differ, generating organizational division, and sometimes conflict.[17] In this era, it sometimes appeared that workers engaged in scientific developments in computing had little in common with workers who were concerned with computing for business purposes – other than their reliance on and use of computer technology. This shared reliance has not always been a sufficient basis for the establishment of training, education, and policy for the field, despite the fact that governments and computing organizations have strived to do precisely that. However, the implications of the ongoing shortages of workers in key areas of the field ensured that organizations and other bodies would continue to pursue educational and policy change.

Gender, Age and Ethnicity in Computing

Questions of the significance of gender, age, and ethnicity within computing loom large. IT occupations are overwhelmingly male-dominated: currently only 22% of workers in this field are women (Wolfson, 2003).[18] IT work is also seen as a domain for youth. Rapid technological change appears to ensure that only the young have up-to-date skills and workers over 30 flirt with obsolescence. With immigration being an identified strategy for reducing shortages in the IT labour force, questions concerning the significance of ethnicity gain renewed importance. In this section, I sketch the historical significance of gender, age, and ethnicity to the computing field, and also briefly consider the role of disability. The ongoing shortages in the IT field have sometimes led both industry and government insiders to seek out new workers – including women and immigrant workers – to fill vacant positions. The fact that so few women and older workers seem to have done so raises key questions about barriers and opportunities to employment in this field.

Women in Computing

Histories of women in the sciences generally tell similar stories. These tales generally have as their setting a highly-male dominated university and employment environment where few women dare tread. They identify a few women pioneers who attempt to enter this well-established male-dominated terrain, and document their efforts to deal with often subtle barriers to educational advance.[19] Often though, women students meet more substantial barriers upon graduation, when they attempt to gain employment in the field and find employers reluctant to employ women in any but the most subordinate positions. While some women succeed, despite these barriers, many others end up drifting from job to job and location to location, while others move out of the field all together.[20]

While there has not been a great deal of research into women in computing (especially in the Canadian context), that which does exist suggests that the story is a very different one. Women were involved in computing right from its very beginnings, and the stories that they have told about their experiences, rarely mention barriers and discrimination, but rather document welcome and accommodation. During the Second World War, women were employed in a number of capacities to use early computing technology, partly because of the shortage of male labour. While research into computer engineering and programming in the late 1940s was typically conducted by men, women were not entirely absent. Indeed, a number of women were quite active in the nascent field of computer programming. Amongst the most famous American women pioneers in computing was Grace Hopper, a PhD in mathematics who worked in the Navy as a programmer during the War. After the War, she participated in cutting edge research in computer programming, even taking on prominent and supervisory positions. Mina Rees, another computing pioneer, was the first head of the Mathematics Branch of the Office of Naval Research (Rees, 1987). These two were not the only women active in the field at the time. Many others came to computing in the late 1940s and early 1950s, generally with advanced degrees in mathematics (Gurer, 1995). In the early decades of computing, women were generally employed as "application programmers, programming scientific problems in math and physics and working on applying numerical methods to computers" (Goyal, 1996). In Canada, the principal female computing pioneer was Beatrice "Trixie" Worsley, a mathematician who received her training at the University of Toronto and Cambridge University, and wrote what is probably the first thesis on a computer-related subject (the computation of atomic wave function) in the late 1940s and early 1950s (Griffith, 1994; Gotleib, 1972). Worsley, like other early women in the field, worked with the (Canadian) navy during the war: she helped to design torpedoes equipped with elementary computers (Gotleib, 1972). After the war she was an active participant in early computing activities at the U of T. Her contributions were likely invaluable as she was at Cambridge with the Wilkes team when their computer first became operational. At the University of Toronto she worked on programming the FERUT computer – and is even credited with naming it (Williams, 1994; Griffith, 1994; Hume 1994). In her career, she was an associate professor in computer science at the University of Toronto and later taught at Queen's University.[21] Other female pioneers like Ursula Maydell who was the first employee of the Computer Centre (and later Associate Professor of Computer Science) at the University of Alberta, followed her into the field in the late 1950s (Smillie, 1996).

Thus, while women in other sciences tended to come to the field after it was well-established, women were involved in computing right from the beginning, and they held important and prominent roles in the field. In describing their experiences, early women in computing have not documented experiences of discrimination: rather, they describe an "egalitarian" (Koss, 2003) environment in which there were few "sexual barriers" (Goyal, 1996). For instance, Adele Mildred Koss (2003), who began her career as a computer programmer in 1950 working with Mauchly, Eckert and Hopper on the development of the UNIVAC, held that computer programming was wonderful work for a woman in those days. Employers in other areas were reluctant to hire her because she was an engaged woman, yet the UNIVAC team had no such hesitation. They provided opportunities for training and creativity in the field and allowed her to continue working through her pregnancy as long as she wanted, and part-time after that. Indeed, Koss had a long career in computer programming with a number of different firms, doing somewhat innovative research, much of which she conducted at home while looking after her children, and at work on a part-time basis. In a similar vein, American women like Grace Hopper, Mina Rees, and Jean Sammet (who was one of the women on the team that developed COBOL and the first woman president of the ACM) had careers characterized by opportunity, innovation and leadership. Trixie Worsley (1971, p. 11) argued that men in the computing field treated her well, and urged other women to join her. She assured them that they would receive “splendid treatment by [their] male colleagues,” arguing that “you will nearly always be treated like a lady and very rarely reminded you are a woman” (Worsley, 1971, p.11). While these women’s stories are personal and may not reflect the field more generally, there is every indication that there were opportunities for women in computing from its very beginnings, and that skilled women did not feel that they faced a great number of barriers and discrimination.

The stories told by computing pioneers like Hopper, Koss, and Worsley raise more questions than they can answer about women’s limited involvement in computing. Key amongst these is, ‘if there were opportunities for women in computing, why didn’t more enter the field?’ The answer to this question may partly lie with the fact that very few women had the mathematical training to be employed in computing in this era. So, while women were present at this time, they were a minority in the field. However to understand women’s lack of participation more completely, we need to consider pivotal changes to the computing field in the 1960s, 1970s and 1980s. These changes, when combined with the professionalization efforts of computer workers’ organizations, seem to have delimited women’s employment in the field.

In the 1940s and 1950s, women found work in computing primarily in universities, government organizations, and small firms. Many found themselves with valuable skills in an era of expansion and rose to more prominent positions, but most women appear to have had their first employment opportunities in these settings. However, as previously discussed, computing employment changed in the 1960s and 1970s. As larger firms moved into the computing field and other large firms bought computers, employment was increasingly based in large-scale organizations. Histories of women in science and business suggest that, at this time, such organizations were not always willing to hire women, and when they did, they were quite reluctant to promote them. A similar situation seems to have existed within computing. Thus, while firms responded to the shortage of computer workers in the 1970s by hiring women – in both the United States and Canada there was a substantial increase in their participation during this decade – they tended to pay them less than men, and to restrict their promotions (Goyal, 1996, p. 40-41).[22] Work in these larger organizations was decidedly less friendly to women (Gurer, 1995, p. 48).[23] Thus, it seems likely that while the expansion of computing employment in large scale organizations opened up employment opportunities for women, in this era, it also formalized gender inequality in the field. The fact that many firms sought to meet some of their computer employment needs by retraining their existing (largely male-dominated) workforce, also placed limits on opportunities for women in the field. Perhaps in response to these limitations, and the fact that employment growth in computing was occurring in areas other than programming, the growth of women’s employment in IT and computing jobs slowed during the 1980s, and the percentage of women involved in the field actually decreased in the 1990s (see footnote 22).

The nature of women’s opportunities in the 1960s and 1970s is outlined in a Canadian study reported in 1970. Morrison (1970) conducted a small (N=20) survey of Canadian women in IT to explore their experiences. He argued that computing differed from many other fields, as women were not limited to clerical or secretarial roles. In fact, women were quite involved in computing "at the professional level – [as] programmers, analysts, software experts, supervisors," and their competence was generally recognized (Morrison, 1970, p. 18). The women Morrison interviewed, on the whole, painted a positive picture of their employment in the field, but did point out that there were certain employment opportunities that were closed to them; most notably marketing and senior management. They felt that "when a company wants a programmer or analyst, a woman normally has a reasonable chance of getting the job," but that if the company sought a potential manager, the women were "out of luck" (Morrison, 1970, p. 18). The women reported that their salaries were lower than their male counterparts. They also claimed that while their immediate colleagues were quite accepting of them, some in other departments and some clients were less so. Moreover, they highlighted the difficulty of combining their work with family, emphasizing that it was difficult for women to take time off for child-bearing (Morrison 1970; also Goyal, 1996). The field changed so fast, it was held, that even just taking a one or two-year leave might put a woman hopelessly behind. The consensus, Morrison (1970, p. 19) reported, was that "if a woman plans to leave the EDP [Electronic Data Processing] profession temporarily she had better be prepared to leave permanently." Morrison's survey is supported by other contemporary studies, and suggests that women in IT occupations during this period liked their jobs, but faced barriers in terms of employment opportunities, promotions, pay, and combining work and family.

Another barrier to women in the field is hinted at in a letter by a female programmer to the *Communications of the ACM* in 1987: she held that while there may be work available in computing there was little in her area that was specifically in her field of interest (Verba, 1987). Some of her male colleagues lambasted her for her complacency, arguing that one needed to be able to take advantage of opportunities as they arose. One particularly virulent critique was from a computer professional who had moved his family to New Zealand to find meaningful employment (Amos, 1988). Lacking in this exchange was an understanding that women may not always be as mobile as many men. However, this lack of mobility, likely hindered career advancement, especially in fields such as programming where there were more opportunities for horizontal mobility than vertical (Ensmenger, 2001).

The sense amongst a number of commentators, then, was that opportunities were open to women who pursued them aggressively enough. For instance, one woman contended that if few women were in IT management positions it was because "too few of us have committed to becoming business women" – women did not follow the business news, or attend enough business functions, nor did they "let it be known" that they were desirous of a management career (Thompson, 1982, p. 9). Moreover, women who had good organizational abilities were said to be able to combine work and family successfully. Thus, some men and women blamed women's lack of progress in the field to 'lack of effort.' The obvious success of some women in the field – for instance, those women active in management, and the three women presidents of Canadian Information Processing Society in the late 1980s[24] – seemed to support this conclusion; turning attention away from barriers in the field, towards individual explanations for success or failure.

Overall, then, the expansion of computing employment at this time opened opportunities for women, with or without education in computer science, but the nature of organizational employment at the time, ensured that these opportunities were not unlimited. In particular, the literature raises questions about women's abilities to combine a computing career with family responsibilities.

Educational and professional changes in computing likely also had an impact on women's involvement. While the full nature of professional changes and their impact will be discussed in a separate paper, there a few important trends to be noted here. Most notably, professional activity in computing has largely centred around raising and altering standards of entrance, establishing credentials, and formalizing procedures pertaining to computing work. These activities have likely had the effect of further discouraging women's participation.
For instance, as we have seen, the earliest female computing pioneers came to computing with a background in mathematics. Women's opportunities may have been restricted as computer science became more of a basis for employment in the field. The ACM actively worked to define computer science as a separate discipline that was located between mathematics and engineering.[25] Given that women have historically come to computing from a math background rather than an engineering one, this redefinition of the field may have discouraged their entrance, at least for a time.[26] However, the real drop in women's participation in computer science education came in the late 1980s (Meyer, 1990). The timing of this drop, perhaps coincidentally, corresponds with a professional project aimed at altering and accrediting computer science programs and a renewed emphasis on credentials within the field. Prior to the 1980s, as we have seen, many people entered the computing field without having obtained a computer science degree. In fact, one Canadian woman, advised others interested in the field to avoid mathematics if it wasn't their best subject, and instead take courses like English or Sociology where they could excel (in Morrison, 1970, p. 19). Computing skills could be learned on the job. However, through the 1980s, a university degree in computer science became a more common standard of entry. The decline of alternative avenues to IT employment, combined with the dropping enrolments of women (and to a lesser extent men) in computer science programs, led to the declining presence of women in the field. [27]

Historically, given the demand for workers in the field and its technological base, the possession of informally-acquired computer skills has been valuable in employment and educational training. Yet, here again, women appear to lag behind men. According to Klawe and Leveson (1995), a New Zealand study found that women beginning university classes know far less about computers than their male counterparts. Lacking prior skills women may have more difficulty in computing courses and seem to be less likely to continue their computing studies (Klawe and Leveson, 1995, p. 31). Thus, because they did not generally acquire computing skills early, women may have found it more difficult to acquire these skills in university, and afterward.

Moreover, it seems that many women joined other more marginal workers including those from a lower socioeconomic background and people from minority backgrounds in seeking to obtain computing skills through private training facilities (Ensmenger, 2001). This seems to have been the case in the United States and in Britain, where the ACM and BCS (respectively) waged campaigns against these organizations which took advantage of their students, and rarely imparted useful skills.

Although more research is required in this area, it seems that a number of aspects of employment in computing during the 1970s and 1980s combined to simultaneously encourage and delimit women's involvement. Thus, while women were involved in the computing field from the very beginning, numerically they have remained a minority, especially in high-status roles, despite a continuing shortage of workers.[28] Why women's participation decreased in the late 1980s and 1990s is a central question that requires more investigation.

Minorities, Age and Disability

Concern within the IT profession over women's low representation has generated studies on the significance of gender to computing employment; however, less attention has been paid to ethnic diversity, age and disability in the field. Nevertheless, occasionally the historical record touches on these areas and this literature will be highlighted here. The history of minority workers in the field appears to be similar to the history of women to the extent that there is evidence of minority workers being involved in computing even in the field's early years. For example, two young Asian male students participated in computing at the University of Toronto in the early 1950s. Pictures and other records indicate some visible minority workers, like women, were employed as early programmers and in other capacities. For instance, B.A. Griffiths (1994, p. 64), commenting on his work at KCS in Toronto in the late 1950s and 1960s, held that his colleagues were an ethnically diverse group: one was from Austria, "four from Germany, three from Hungary, two from Belgium, two from Holland, and one each from China, France, Norway, Syria, and Indonesia or Thailand." Others were from Britain and the United States. In total, he continued "the foreign-born members of our staff outnumbered those born in Canada." While KCS may have been an exception, it certainly seems that early employment in computing in Toronto was characterized by a great deal of ethnic diversity. Whether this diversity persisted through the expansion of the 1960s and 1970s is another question – certainly census records suggest that the majority of early computer programmers (in 1961 and 1971) were Canadian born (Gagnon, 2003).

Additional support for the idea that computing was characterized by at least some diversity in its early years comes from a tabulation of computer science 'firsts' put together by ACM member John Hamblen in 1981. Hamblen (1981) claims that the first (white) man to graduate from an American doctoral program in computer science did so in 1965, while the first "black" PhD graduated in 1969, and the first "Chinese" student graduated in 1968. Thus, minority men graduated with degrees in computer science in the discipline's early years. Nevertheless, the extent of their involvement in the 1960s and early 1970s was likely not extensive.[29]

There is, further, a sense in the literature that access to computer skills was limited amongst many minorities, especially those from a lower socio-economic background. Barriers to women's employment that occurred with the expansion of employment in large-scale organizations, likely affected visible minorities of both sexes as well. As Jacqueline Jones (1998) has demonstrated for an earlier decade, American blacks were rarely hired in jobs that involved the use of advanced technology – such attractive jobs were generally reserved for whites. Nonetheless, one might expect that in an era of labour shortages in computing, opportunities for minority employment would exist. Access to training and education likely remained a problem, however.

On a few occasions, the historical record makes mention of the involvement of blind workers in computer programming. During the era of labour shortages some effort was made to teach the blind to program (CIPS, 1971; Oettinger, 1967). Training schools were established at a number of locales in Canada and the U.S. The extent to which they succeeded in actually placing their graduates is questionable (Stirling in Oettinger, 1967, p. 140). There is also a reference in the Canadian literature to an organization, the Pearson Computer Society, which trained "physically handicapped people for jobs that require computer-related skills" (Handley, 1987, p. 29). There is no record of the employment success of these workers.

The question of age in the field of computing is a complex one, and one that will receive more attention in a WANE working paper on professionalism and professionalization. Computing in the past, as today, has been viewed as a "young man's occupation" (d'Agapeyeff, 1970, p. 373). In the 1960s and 1970s this was partly seen to be the result of the "newness" of the discipline. However, the main cause seems to be the fact that technological change has the potential to render older workers' skills obsolete. Moreover, many workers with successful careers in computing, like those in engineering, are promoted into management as they age and hence do little actual computing work. It has also been argued that the nature of the industry – especially in area of software development and engineering – encourages this line of thinking, as the industry is constantly forward looking and does not venerate older workers who may have made important, if outdated, contributions. As Zwerman (1999) argues "the *old* [software] practitioners are normally cast aside as relics or as individuals who just could not keep current .... There is no interest in the old-timers and their work" (p. 68, emphasis in original).

The professional projects pursued by computing organizations may be seen, in part, as a reaction against this characteristic of the industry. For instance, university curricula developed by computer science leaders in the 1960s, 1970s and 1980s, emphasized core theoretical skills in mathematics and programming, with the hopes that graduates would continue to have adaptable skills after current programming languages, software and hardware became obsolete. Inevitably, this led to complaints that the programs were too theoretical and did not provide enough currently useful skills. This delicate balance between the 'practical' and the 'theoretical' is a common difficulty within professional education, but may be more acute within the computing field given that the 'practical' skills are seen to be only temporary in their value, while the theory, at times, has borrowed heavily from other disciplines.

Efforts at establishing credentials for computer workers, based on education and expertise, may similarly be seen as a drive to demonstrate the expertise and competence of workers who have been in the field for some time – generally there is an "experience" requirement. The link between experience and age is most explicitly made in the regulations of the British Computing Society, where workers have to be 24 years of age to become IT "professionals" and at least 30 to be esteemed professional "fellows."[30] While experience requirements in part reflect the belief that computer skills are enhanced by work experience, they also serve to define workers who have been in the field for some time as "more professional." In this context, keeping up-to-date with developments in the field becomes a matter of professional ethics.

Age is clearly important to employment in the IT sector, and is a topic that requires more in-depth investigation.

Summary

The historical literature does make some mention of women in computing, but otherwise pays little attention to issues of gender, race and ethnicity, age and disability. Nevertheless, it is clear that, historically, employment in the IT field has been male-dominated and perhaps youth-centred. Women have been an important minority within the profession. The barriers of class, age, and ethnicity need to be explored further.

Conclusion

This paper has explored the history of computing occupations in Canada and elsewhere. Although necessarily brief, the paper demonstrates that current concerns within the IT field – concerns such as a shortage of skilled personnel, the nature of training in the field, occupational variability, and the participation of women and minorities – have long historical roots. Moreover, historical characteristics of the field, including employment diversity, and debates over the scope and definition of computing work, its body of knowledge and education, continue to shape the field today.

Many of these characteristics have been particularly influential in the professional projects that have been ongoing in computing-related occupations since the late 1940s and 1950s. The history of these professional projects will be explored in a follow-up WANE working paper.

References

Amos, Hugh D. (1988). Letters: Employment opportunities. *Communications of the ACM 3, 1* (1), 6 - 7.

CCSDC (Executive Committee of Canadian Computer Science Departments Chairmen). (1983). Solving the crisis in academic computer science. *CIPS Review, 7* (2, March/April), 24-26.

Chiu, Charlotte and Leicht, Kevin. (1999). When does feminization increase equality? The case of lawyers. *Law and Society Review, 33* (3), 557-594.

CIPS (Canadian Information Processing Society). (1971). Blind programmer makes fewer mistakes. *CIPS Magazine, 2* (10), 6.

CIPS. (1973a). Students, smen and academics question the content of computer science education. *CIPS Computer Magazine 4* (1). 4-6.

CIPS. (1973b). *The 1973 Canadian Salary Survey. CIPS Computer Magazine 4* (4), 9 - 47.

CIPS. (1975). The 1975 salary survey. *CIPS Computer Magazine, 6* (4), 14-60.

CIPS (various authors). (1982) Cross-Canada check-up: The state of DP employment, CIPS Review 6 (4, Sept/Oct.), 40-42.

Croarken, Mary G. (1992). The Emergence of computing science research and teaching at Cambridge, 1936-1949. *IEEE Annals of the History of Computing, 14* (4), 10 - 15.

d'Agapeyeff, Alex. (1970). Tribute to Lord Halsbury. *The Computer Bulletin, 14* (11), 373.

Denning, Peter J., (Ed.) et al. (1981). The Snowbird Report: A discipline in crisis. *Communications of the ACM, 24* (6), 370-4.

Downie, Rob. (2003). *What we know about the Canadian ICT Sector.* Unpublished manuscript. London, Ontario, Canada: University of Western Ontario, Workforce Aging in the New Economy Project.

Duerden Comeau, Tammy. (2003). *Information technology (IT) employment: What is IT?* (Working Paper, No. 1). London, Ontario, Canada: University of Western Ontario, Workforce Aging in the New Economy Project.

Ensmenger, Nathan. (2001). The 'question of professionalism' in the computer fields. *IEEE Annals of the History of Computing, 23* (4), 56-74.

Gagnon, Richard, Jacobs, Lee, Vaillancourt, Francois and Vaillancourt, Luc. (2003). *Canada's IT labour force, 1961-2001: Four decades of growth and change.* Ottawa: Software Human Resource Council.

Gotleib, C.C. (1972). Trixie Worsley – a memory. *CIPS Magazine, 3* (6), 4.

Goyal, Amita. (1996). Women in computing: Historical roles, the perpetual glass ceiling, and current opportunities. *IEEE Annals of the History of Computing, 18* (3), 36-42.

Griffith, B.A. (1994). Biographies: My early days in Toronto. *IEEE Annals of the History of Computing, 16* (2), 55-64.

Gurer, Denise W. (1995). Pioneering women in computer science. *Communications of the ACM, 38* (1), 45-54.

Gries, David. (1987). The 1985-1986 Taulbee survey. *Communications of the ACM, 30* (8), 688-694.

The Earl of Halsbury. (1959). Ten years of computer development. *The Computer Bulletin (of the BCS), 1* (4), 153-159.

The Earl of Halsbury. (1991). Innovation for failure – some reflections on the work of the NRDC relevant to the early history of the computer industry in the UK. *Computer Journal (BCS), 34* (3), 272-274.

Hamblen, John W. (1981). Computer science 'firsts'. *Communications of the ACM, 24* (5), 329.

Hume, J.N. Patterson. (1994). Development of systems software for the FERUT computer at the University of Toronto, 1952-1955. *IEEE Annals of the History of Computing, 16* (2), 13-19.

IEEE (Institute for Electrical and Electronics Engineers). (1996). *Events in the history of computing*, Retrieved January 26, 2004 from www.computer.org/history/development

IPSC (Information Processing Society of Canada [CIPS]). (1969). Major occupation salary survey. *Bulletin - IPSC, 9* (4), 18-41.

Johnson, Luanne (James). (1998). A view from the 1960s: How the software industry began. *IEEE Annals of the History of Computing, 20* (1), 36-42.

Jones, Jacqueline. (1998). *The modernization of prejudice American work: Four centuries of Black and White labor*. New York: W.W. Norton.

Kinnear, Mary. (1995). *In subordination: Professional women, 1970-1970.* Montreal and Kingston: McGill-Queen's University Press.

Koss, Adele Mildred. (2003). Programming on the Univac 1: A woman's account. *IEEE Annals in the History of Computing, 25* (1), 48-59.

Klawe, Maria and Leveson, Nancy. (1995). Women in computing: Where are we now? *Communications of the ACM, 38* (1), 39-35.

Meyer, Ron. (1990). Skill shortages: A cloud on the MIS [Management of Information Systems] horizon. *Canadian Information Processing, 1* (2, June/July), 22-25.

Morrison, J.R. (1970). Beauty and the beast. *CIPS Magazine, 1* (7), 18-19.

Oettinger, Anthony G. (1967). President's letter to the ACM membership. *Communications of the ACM, 10* (3), 139-140.

Paradis, Normand. (1992). President's report. *CIPS Annual Report*, June 1992, 8.

Prentice, Alison. (1999). Three women in physics. In E. Smyth, S. Acker, P. Bourne and A. Prentice, (Eds.), *Challenging professions: Historical and contemporary perspectives on women's professional work*. Toronto: University of Toronto Press.

Rees, Mina. (1987). The computing program of the Office of Naval Research, 1946-1953. *Communications of the ACM, 30* (10), 831- 848.

Shore, John. (1988). Why I never met a programmer I could trust. *Communications of the ACM, 31* (4), 372-5.

Smillie, Keit. (1996). Biographies: The history of computing science at the University of Alberta. *IEEE Annals of the History of Computing, 18* (1), 70-76.

Thomas, P.A.V. (1970). The computer engineering program at the University of Windsor. *Bulletin - Information Processing Society of Canada, 19* (1), 46-7.

Thompson, Jennifer. (1982). DP management doors open for committed women. *CIPS Review, 6* (3, July/Aug), 8-9.

Van der Wijst, Bob. (1972). Saga of the FP 6000: How Canadians built the first time-sharing computer but could not sell it. *CIPS Computer Magazine, 3* (9), 4-7.

Vardalas, John N. (1994). From DATAR to the FP-6000: Technological Change in a Canadian Industrial Context. *IEEE Annals of the History of Computing, 16* (2), 20-30.

Vardalas, John N. (2001). *The computer revolution in Canada: Building national technological competence*. Cambridge, Massachusettes: MIT Press.

Vehvilainen, Marja. (1999). Gender and computing in retrospect: The case of Finland. *IEEE Annals of the History of Computing, 21* (2), 44-51.

Verba, Joan Marie. (1987). Letters: Employment in the computer field. *Communications of the ACM, 30* (7), 585.

Williams, M.R. (1985a). Eckert and Mauchley team up to produce their famous brainchild, the ENIAC. *CIPS Review, 9* (2), 30 - 31.

Williams, M.R. (1985b). Britain's Alan Turing leads the pack in cracking German's wartime codes. *CIPS Review, 9* (5), 30-32.

Williams, M.R. (1985c). Meetings in retrospect: History of computers in Canada. *Annals of the History of Computing, 7* (1), 63-65.

Williams, M.R. (1986). The stored program concept stirs up a hornet's nest. *CIPS Review, 10* (2), 29-32.

Williams, M.R. (1994). UTEC and FERUT: The University of Toronto's computation centre. *IEEE Annals of the History of Computing, 16* (2), 4 - 12.

Wolfson, William G. (2003). Analysis of Labour Force Survey data for the Information Technology Occupations, updated report (June). Prepared for the Software Human Resource Council.

Worsley, B.H. ("Trixie"). (1971). CIPS, Women, Margaret Mead. *CIPS Magazine, 2* (6), 11.

Yau, Stephen (Ed.), et al. (1983). Snowbird report: Meeting the crisis in computer science. *Communications of the ACM, 26* (12), 1046-1050.

Zwerman, William L. (1999). Profession/Occupation without a history. *IEEE Annals of the History of Computing, 21* (1), 66-70.

---

[1] Mauchly and Eckert's work was largely funded by the U.S. Army in their search for assistance calculating ballistic firing tables (Williams, 1985a); ENIAC stood for Electronic Numerical Integrator and Computer.

[2] Von Neumann, a mathematician, has been credited with creating the "architectural design for several generations of computers" (IEEE, 2003), and in collaboration with Mauchly and Eckert's team's developed the stored program concept (Williams, 1986).

[3] Later, the military also provided funding to the University of British Columbia, and spurred the expansion of software expertise in the region (Vardalas, 2001, p. 278). In this respect the Canadian military, similar to its U.S. counterpart, spurred national growth in computing. The British government also influenced, although seemingly not the same extent, computer development in the U.K (Earl of Halsbury, 1959, p. 155). In contrast, the growth of computers in Australia was encouraged, not by the military, but by the nation's concern for agricultural production (Vardalas, 2001, p. 280).

[4] The contract with the DRB and NRC involved establishing a computation centre at the University of Toronto, which would house a number of mechanical computing machines and be the location for research into the creation of an electronic computer (Vardalas, 2001, p. 23; Griffith, 1994).

[5] The Ferranti Corporation of England had made a copy of the Manchester Mark I on contract for the British Atomic Energy Authority, but the contract was cancelled after a change in government. Ferranti was left with a functional computer for sale. The Canadian atomic energy group heard about the computer from their UK counterparts and were the principal force in pushing the U of T to purchase this computer instead.

[6] KCS Data Control Ltd distinguished itself in the early 1960s when it created the first "computerized urban traffic control system" for the city of Toronto (Vardalas, 2001, p. 41).

[7] Political opposition complained that the government's funding of such a project was a waste of the tax payers' money, and, hence, the development of (what would have been) the world's first computerized mail-sorting system, was never fully produced. The Ferranti innovations did influence the creation of a similar system in the U.S.

[8] Canadian computer products seem to have been more expensive than their American counterparts because of the duty charged on computer parts (but not full-fledged computers). A lack of faith in the Canadian innovations was likely another discouraging factor (Vardalas, 1994; Van der Wijst, 1972).

[9] The hardware group formed ESE, an electronics firm, while the software team formed I.P. Sharp Associates, for a time one of Canada's largest software houses (Van der Wijst, 1972; Vardalas, 1984, p. 28).

[10] For instance, the University of Alberta acquired a computer in the late 1950s, and established computing courses in department of mathematics in the late 1950s and early 1960s (Smillie, 1996).

[11] For instance, J.N.P Hume (1994) documents how he had almost exclusive programming responsibilities on the FERUT, but that changes in programming (brought about by himself and Trixie Worsley) enabled science researchers to program themselves rather than waiting for him to do it for them (16-18).

[12] Expansion in both areas combined to fuel the rapid expansion of computer-related associations and local meeting groups, and activity in the area of education, training, certification, and accreditation (see also Ensmenger, 2001).

---

[13] Organizations that were particularly active in these respects were the Association for Computing Machinery (ACM), the IEEE (Institute of Electrical and Electronic Engineers) Computer Group, and the DPMA (Data Processing Management Association) in the United States and the British Computer Society in the U.K.

[14] In fact, Ensmenger (2001) argues that the shortage in the 1960s was not a lack of people with training in computers, per se, but a shortage of "experienced, professional practitioners" who could fit into the corporate structure (58).

[15] The University of Western Ontario was quite active in this respect offering, CIPS-sponsored courses on 'managing information systems effectively,' and incorporating computers into its degree programs.

[16] It was during the 1960s and 1970s that the American (and Canadian) Data Processing Management Association (DPMA) established credentials and examinations for data processing workers, and that the Institute of Electrical and Electronic Engineers (IEEE) and the Association for Computing Machinery (ACM) worked both jointly and separately to establish qualifying examinations and credentials, to develop curricula, and to begin to accredit university computer programs (the latter in the 1980s). The British Computing Society (BCS) during this period established educational and examination criteria for membership. Canadian organizations were quite divided over the value of certification, and thus less active, until the 1980s. Nevertheless, the Canadian Information Processing Society (CIPS) did co-operate with American organizations to establish credentials in the 1970s (through the ICCP, an Institute for the Certification of Computing Professionals), and encouraged Canadians to take these exams when they were offered in Canadian locales.

[17] Divisions within computing organizations such as the ACM, CIPS and the BCS have hampered their organizational activity at times and have been a source of internal conflict.

[18] 2001 census figures indicate that women make up 27% of information systems workers, but do not include those fields, like computer engineering, where women's presence is much lower. Wolfson (2003) concludes that when all IT-related occupations are considered, women compose only 22% of workers.

[19] For instance, the difficulty of working in laboratories alone and after dark, being discouraged from pursuing certain avenues of research, not having equal access to mentors, and other problems have been identified (Prentice, 1999; Heap, 2003; Kinnear, 1995).

[20] Failed women scientists and engineers often found work as school teachers and in other work roles only marginally related to their training (Heap, 2003).

[21] The importance of her career is likely further indicated by the fact that there is a collection of her papers at the Smithsonian.

[22] Canadian census data indicate that women went from composing 14 to 15 % of computer programmers in 1961 and 1971 to 28.5% in 1981. Clearly the rapid expansion of computing employment in the 1970s led to increasing numbers of women in this field. Although census categories change, women composed 34% of computer and information systems workers in 1991, suggesting that women continued to move into the field, with expansion in the 1980s. During the 1990s, however, the involvement of women in these fields proportionately decreased (led by a drop in their participation in computer science programs in the late 1980s on), and women made up only 27% of workers in the category in the 2001 census.

---

[23] Writing of the situation in Finland, Vehvilainen (1999) argues that many women moved into the computing field in the 1960s and 1970s, but that they were locked out by an ‘old boys network’ and concentrated in positions at the low end of business hierarchies.

[24] CIPS’ first female president was Marilyn Harris (president, 1986/7). Following her were Patricia Glenn (1988/9) and Patricia Bewers (1989/90).

[25] The extent to which computer science programs, especially in Canada, followed the ACM curriculum guidelines is also an empirical question, which I have not finished investigating yet.

[26] Engineering was (and is) a highly male-dominated field. For instance, women composed only 1% of electrical engineers (the field closest to computer engineering) in Canada in 1971.

[27] A link between professionalization and masculinization has been made for other fields; see in particular, Wright (2000).

[28] Chiu and Leicht (1999) argue that feminization in an occupation is ‘successful’ when it occurs in a field requiring skilled labour, in an era of rising wages and a high demand for labour. Women’s entrance in the 1970s seems to have occurred in such a context. Thus, conditions were likely ripe for some women in the field to advance and integrate successfully; however, there were clearly limits to this integration.

[29] At the very least, pictures of people active in professional organizations at this time do not reveal the participation of visible minority men and women.

[30] The explicit age requirements here are taken as indicators of experience, and likely reflect board of trade regulations. In September of 2003, the BCS decided to re-organize the categories of membership, and the age requirements will no longer be in place.