WOMEN AND COMPUTER SCIENCE:

ALTERNATIVE ROUTES

TO COMPUTING CAREERS

By

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ABSTRACT

Women's proportional representation in university Computer Science (CS) programs in Canada has been declining. This study set out to 1) provide a clear picture of the recent research into women and computing education and work; 2) develop a model based on past research and the theoretical perspectives of dual-systems theory, social closure, and social control; 3) assess the impact of social controls on women's education and work choices through interviews with computer workers; and 4) compare the trends in computer education and work over time.

This study finds support for theories of social closure and control: interviews show that, over time, factors vary in their influences on women's computing career choices. The increasing status of computing work, the broadening applications of computing, the growing shortage of workers, and the narrow entry into CS affect beliefs about computing. Respondents' belief in myths that computing careers involve very little human interaction, and that women lack the kind of curiosity required of a computer scientist, stopped many from entering CS.

The encouragement of mathematics teachers, and gaining computer-related experiences positively influence women to study computing. The alternative route to computing through a non-technical job shows that gaining computer experience even in the workplace can influence women making career choices.

Women's proportions are increasing in non-university computer education as women's proportions in CS have been declining. Women taking alternative routes to computing careers tend to work in the less technical occupations, and are segregated by sex within high technology industries. They are more likely to work part-time, are clustered in lower paying specialties, and earn less income than men. The income gap is small and narrowing for women with high computer skills. Despite the benefits of high skill computer work, women are increasingly preparing themselves for medium and lower skill computing work through non-university education.

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Chapter One: Introduction

1.1. Computing education and the shortage of computer workers

The proportion of computer science (CS) graduates who are women has been declining (Statistics Canada, 1994; Gadalla, 1998). Recent research shows that undergraduate full-time enrollments in CS have declined for women, as a proportion of total full-time CS enrollment, from 27 percent in 1982 to 19 percent in 1995 (Gadalla, 1998). Absolute numbers of undergraduate females enrolled full time in CS have fallen from 2,845 in 1982 to 2,178 in 1995. Undergraduate CS degrees granted to women also declined from 26 percent in 1982 to 20 percent in 1991. The absolute numbers of women getting their degrees in CS have risen slightly from 424 in 1982 to 442 in 1991, but the large increase in numbers of men getting their CS degrees (from 1,181 in 1982 to 1,789 in 1991) means that women's small gain in absolute numbers represents a loss in proportionate representation of those getting CS degrees (Statistics Canada, 1994).

At the same time, the demand for computer programmers and systems analysts has been increasing. In the United States the demand has exceeded the supply in recent years, resulting in a shortage of more than 190,000 programmers and systems analysts (Office of Technology Policy, 1997). The use of computers and computer technology is extensive in both industry and the service sector; both sectors require computer programmers and systems analysts. In Canada, according to results of the Survey on Preparedness of Canadian Business for the Year 2000, there was a need for 7,000 programmers to cope

with the Year 2000 concerns in business alone, not including governments and other public institutions. This underestimated the real need for programmers, since it did not include the need for programmers to do other work than that associated with the Year 2000 problem (Gower, 1998).

Government projections indicate that future job prospects for those with CS degrees are good, so much so that the Ontario government wants to double the CS pipeline. The government has budgeted "$150 million over 3 years to double entry-level enrollments in CS and high-demand fields of engineering" ("Enrolment target", 1998). The growth in jobs in the computer service industry is reflected in the increase in total wages paid to Canadian employees in that industry, from $660 million in 1982 to just over $4 billion in 1995 (Statistics Canada, 1998).

Given the importance of computer technology for almost all sectors of society, those who create and work on computer programs and systems are in powerful positions, both for possessing highly valued and specialized skills, and for their ability to impact on society with computing technology. The broad question that I will address in this research is:

> Why are women becoming a smaller proportion of those enrolling in CS programs, and graduating with degrees in CS, and what are the consequences for women in the computing workforce?

I examine the causes and consequences of women taking alternative routes to careers in computing. To begin answering this question I take a look at the recent empirical research on women in computing education and work. From this review of the past research, and building on three theories applied to women in technology, I propose a model of the social

closure process. To test parts of the model, I conduct: 1) a case study of the Canadian subsidiary of a large software company, and 2) a quantitative analysis of existing data from the 1991 and 1996 Canadian Censuses, the Survey of Consumer Finance, and other Statistics Canada education, demographic and industry data. The mixed research methodology allows for in depth exploration of women's education and work histories, and then sets the exploratory findings in the context of the trends in education and occupations at the national level.

The qualitative interviews explore the education, experience and work histories of women and men working in computing occupations. To understand what lies behind people's choices to pursue one path to computing work over another, I investigate the motivations, aspirations, historical circumstances, and beliefs of computer workers of various ages, skill levels, and holding a wide range of computer-related occupations.

In the qualitative analysis, I consider the following questions:

> To what extent have societal values and ideologies concerning women working in technology, and specifically computing, changed over the last few years, during which time women's proportional enrollments and degrees granted in CS have risen, then declined?
>
> What do education, experience, and work histories of people working in computing tell us about the process of controlling and closing access to technological occupations?

The interviews are semi-structured and exploratory; therefore, the following general question is also relevant to these data:

> What other factors contribute to women's occupational choices, or affect educational sex-typing and occupational sex-segregation?

The quantitative data provide a picture of Canadian education, occupation, and

industry over the last two decades. I outline the recent patterns and trends in women's and men's participation in computing education at university and non-university levels. These educational trends are compared with changes occurring in the sex distributions of various occupations and in various industries over a similar time period. I show in what occupations the wage gap between men and women is widest, and how the gap is changing over time. The statistical analysis considers:

> What are the trends over time in the gender distributions of educational enrollments at non-university and university institutions?
>
> Is sex-segregation and segmentation of women and men in CS education and computer-related occupations changing in the 1990s?
>
> Are there gender differences in industry location by occupation?
>
> How well are women and men computer workers compensated for their work, and are rewards for computer work changing over time?

1.2 Computing education and work – Present situation and historical context

The pattern of women's representation in CS education, and computing work has shifted over time. In the early history of computing, women made important contributions to the development of computers, and generated ideas and methods that moved technical development forward in significant ways. For example, two well-known pioneers in computing, Augusta Ada Byron Lovelace, and Grace Murray Hopper (Gurer, 1995), represent the many women who worked on computers in the days of their early development. Lovelace, born in 1815, developed the "loop" and "subroutine" concepts long before electronic computing machines appeared, and collaborated with Charles

Babbage who developed the theoretical basis for modern computers (p.46). Hopper, a mathematician and physicist made important contributions to the development of programming languages, and is known as the "grandmother of COBOL" (p.47).

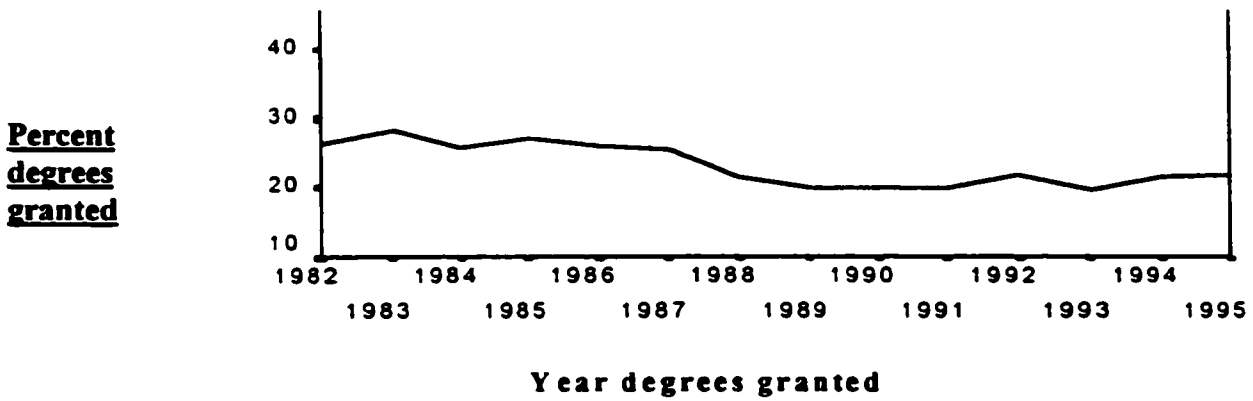
Computer programming was a female-dominated occupation in the 1940s and early 1950s when it was seen as a routine, mechanical process (Kraft, 1979; Tijdens, 1997). The perception of programming changed and it was recognized as demanding intellectual work at the same time as men returned from World War Two and women were forced to withdraw from the labour market. Men took over programming, holding a dominant position in the field ever since (Tijdens, 1997; Kraft, 1979).

In the early 1970s, women's proportions began to increase again, and steadily increased until the early-to-mid 1980s when the current decline began. Figure 1.1 indicates the percentage of degrees granted to male and female undergraduate students in Canadian universities from 1982 to 1995. The figure shows the declining proportion of women in CS education.

Policy documents of the Ontario Ministry of Education show changing ideologies about computer technology and gender since the early 1970s. Early computer curriculum does not take gender into account, assuming that both student and teacher are male (for example, see Ontario Department of Education, 1970a; 1970b; 1972). By 1985, however, gender equity was a clear mandate in computer studies as is evident from the following policy statement:

> Sex Equity: Equal access for male and female students to all courses in the schools is a high priority of both the Ministry of Education and society in general. Promotion of this policy in technological studies programs

Figure 1.1 Percent CS degrees granted to female undergraduate students, 1982 to 1995



> requires a special effort, since there is still a psychological barrier to the acceptance of sexual equality in vocational areas that have traditionally been considered the domain of either men or women. Cooperative effort on the part of parents, students, administrators, and technological studies teachers can help overcome such stereotyping. Course calendars, newsletters and informative presentations are useful vehicles for encouraging students to enroll in non-traditional fields. Enrolment can also be encouraged by inviting speakers who have experienced success in non-traditional educational fields and industrial occupations. Courses that appeal to both sexes, such as auto maintenance, should be offered. When planning courses of study, it is important that teachers be sensitive to the needs of both sexes.
> Ontario Ministry of Education, 1985, p.18.

Around the same time as these computer technology education policy documents were written, the decline in women's proportional enrolments in university CS programs began.

Another historical change was occurring at the same point in the early-to-mid 1980s. Centralized information systems employing mainframe computers with terminals were slowly replaced by micro-computers. Data entry, a female-dominated computing occupation, was decentralized so that entry could be done by clients, at sales counters, and so on. The number of microcomputers grew significantly through this period, providing more employment for high skill information technology workers. Hence, the female-dominated computing jobs were declining at the same time as the male-dominated high skill jobs were increasing (Tijdens, 1997). Increasingly, women studying for a career in computing were facing a male-dominated work environment.

Research on gender inequality in education finds that men are consistently more likely to enter the more lucrative fields of study. Davies & Guppy (1997) found that

> Females are less likely to get into lucrative fields of study and to be in such fields in selective schools, both of which translate into real limitations in subsequent earnings. Gender segregation by fields of study stubbornly

> persists in a context where other barriers are crumbling. This is one of the final frontiers of gender inequality specific to education . . (p.1434)

As the supply and demand for computer workers change over time, the role of education as the credential gatekeeper also changes. Whereas high school qualifications were the requirement for programming jobs in the 1970s, in the 1980s the supply of workers increased and university degrees were increasingly required (Tijdens, 1997). The current labour shortage means that there is some relaxing of educational requirements again. When there is a labour shortage, the professional body (in Canada, this is the Canadian Information Processing Society (CIPS)) loses power to control who enters computer-related work. Nevertheless, it is likely that the situation will change again, the supply of workers will increase, educational expectations will be more stringent, and the professional body of computer scientists may be able to achieve their goal of professional accreditation, further closing work opportunities to those without CS qualifications. Understanding women's declining proportions in university CS education is important in light of these historical shifts.

1.3. Dissertation overview

Chapter 2 reviews the recent research into gender and computing education and work. A summary of the findings is developed in the form of a classification of findings, which positions research by stage: elementary, secondary, post-secondary or work stage. The classification depicts the findings of past research, assessing those findings on the comprehensiveness of the methodology used and the number of studies with similar

findings. From the classification, general conclusions can be drawn about the state of research into women and computing, and about the factors affecting women's computing experiences at various stages in education and work.

Chapter 3 sets out three theoretical approaches that have been used to explain women's underrepresentation in male-dominated education and work. I show how dual-systems theory, social closure theory, and social control theory contribute to our understanding of the problem. I see these theories as complementary. Dual-systems theory explains the broad social constraints of patriarchy and capitalism; social closure theory then looks more specifically at the exclusionary practices that close off occupations to some, while raising the value of the occupations to those with appropriate credentials; social control theory argues that ongoing formal and informal processes are at work in controlling entry to occupations. Based on these theories, and the literature review in Chapter 2, I develop a social closure/control model that proposes a process that occurs over the life course, controlling women's entry into and status in computing occupations.

Chapter 4 presents the analysis of qualitative interviews conducted at the Canadian subsidiary of a large software company. I explore questions of capitalist and patriarchal beliefs, stereotypes, motivations and ideology surrounding women in computing through interviews with men and women working in a variety of computer-related occupations. Respondents possess a range of educational backgrounds, experience, and skill levels. As Jacobs (1989) admonishes, research examining women's careers in "a dynamic framework" (p.189) is needed to understand the extent of the impact of social controls such as ideologies on sex-segregation over time. By asking respondents to provide their

education, experience and work histories, I explore at what point in women's lives, if ever, ideology is an effective control over their ambitions to work in computing. More specifically, which ideologies are important at which points in womens' educational and occupational histories?

In the social closure/control model introduced in Chapter 3, I suggest that ideology may play an important role in at least two periods in the life course. First, ideology may help sustain through the educational stages, the controls of sex-appropriate behaviours and values learned in early socialisation. Second, ideology about women working in computing may control women's representation in CS in spite of labour force needs. I assess whether there is support for ideology as a control at these stages, and explore other critical points of ideological control.

In Chapter 5, I analyse national educational, occupational and industrial data to identify the trends in computer-related work, income and high- and low-technology industry locations for women and men with various educational backgrounds. Industrial and occupational changes in Canada are examined here, focusing on sex-segmentation in industry, and occupational sex-segregation.

According to the report *America's new deficit*, (1997, p.32), "information is lacking on the supply of IT workers from employer provided training and from academic programs other than computer and information sciences, both believed to be important training grounds for the US IT work force". Therefore, I also examine whether, and to what extent, women are taking educational routes to computing careers other than getting university CS degrees. If women are taking alternative routes to careers in computing, the

professionalisation of CS may significantly change their work opportunities. Although I do not directly measure the impact of professionalisation attempts, I examine trends in women's proportions in computing occupations, in industries and in the average incomes of women and men in high, medium, and low skill levels of computer work[1], keeping in mind the current drive for professional accreditation, the growth in university CS departments in the 1980s, and the recent burgeoning of alternative, private educational credit programs in technology.

1.4. Contribution of the dissertation

My dissertation will make a contribution to sociology by advancing our understanding of the processes governing women's entry and continuation in computer occupations. This study will contribute to our understanding of dual-systems, social closure, and social control theories as theoretical approaches to sex-segregation and will explore the ways ideology about women and technology affect the education and occupation structures, and hence the entry and status of women in technological occupations in computing.

[1] As identified in the National Occupational Categories and the 1991 Standard Occupational Categories.

Chapter Two: Research from the 1990s

Past research into women's underrepresentation in CS education generally targets one level of women's educational experiences: either the elementary, secondary, or post-secondary level. Individual attitudes and behavior, structural conditions, and societal norms and values have been explored for their relevance to this question. Based on empirical research, changes at each level have been recommended and sometimes attempted and assessed. For example, to address what are considered "individual deficits" that prevent women from entering CS careers, some have recommended encouraging and monitoring students to ensure equal access to computers for girls from Kindergarten to grade 12 (Grossman, 1998:38).

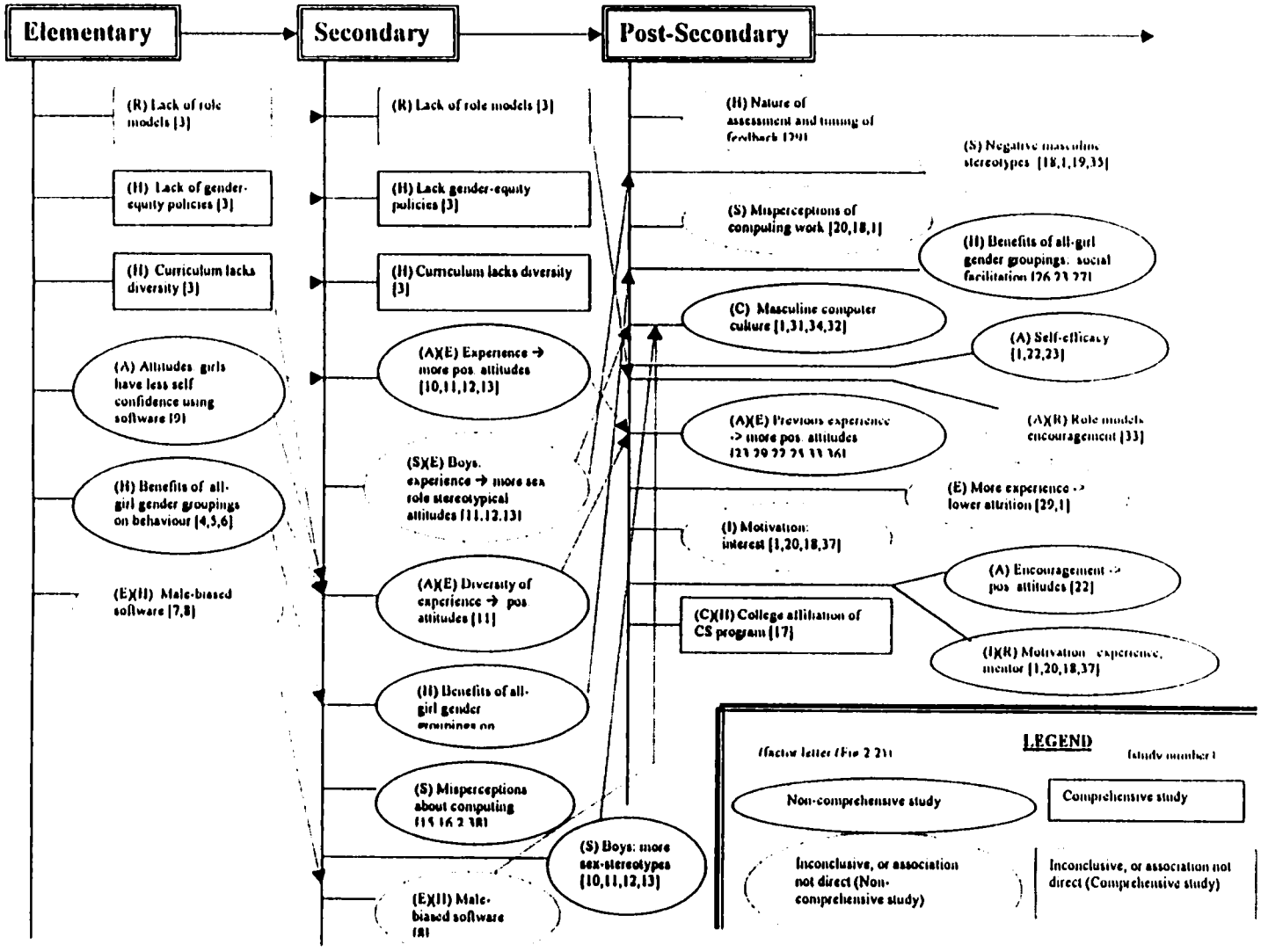
At the structural level, changes in the CS curriculum have been recommended so that computers are taught in a "purposeful context." With this approach, assignments are not focused predominantly on the machine, but also on social applications of computing, since women have indicated a stronger interest in the latter (Fisher, Margolis, & Miller, 1997). In relation to social norms and values, making female role models more visible, and working to dispel inaccurate stereotypes of computer science and scientists, have been two recommendations for increasing women's interest in computing (Grossman, 1998; Craig et al., 1998).

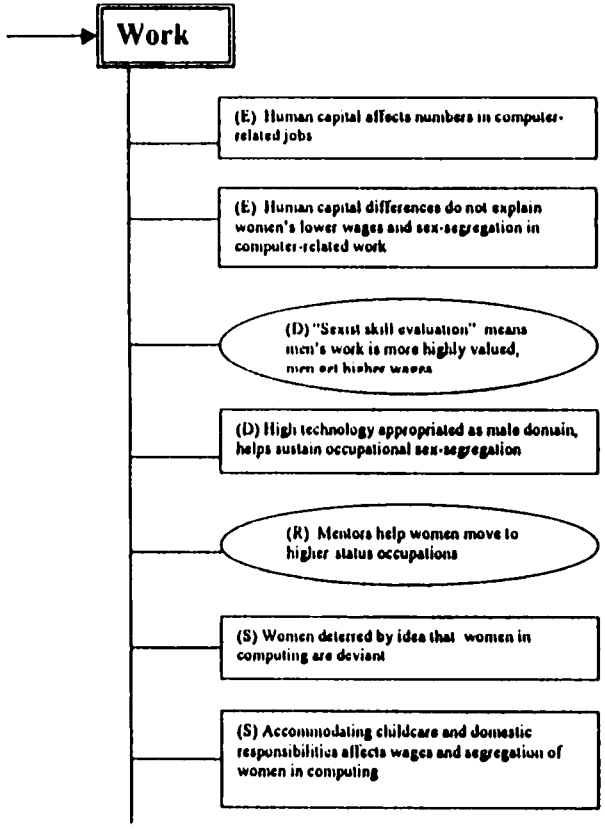
Each empirical study contributes some information toward understanding the complex issues surrounding women and computing education and work, but reviews of this research can lead to conclusions that are misleading in two ways. First, findings are

sometimes generalized to females of all ages, education and work levels when empirical studies on gender and computing tend to test hypotheses on one age group, or on students at a specific level of education (Seymour & Hewitt, 1997). Second, the methodology and measures used vary widely from a few comprehensive studies using random samples, to small, pilot studies and exploratory research. A comprehensive overview of the research into women and computing must take these factors into account. This review attempts to do that; it brings together the results of these studies to see what general conclusions can be drawn from past research on gender and computing, and defines the parameters for future research into this area.

The literature reviewed in this chapter is summarized in Figure 2.1: A classification of research on women and computing. The first page of the classification shows the relevant factors identified in the research on education and computing. The second page continues the classification into the work stage, and covers the research concerned with women's experiences in computing work. As will be discussed in more detail below, the education and work literatures differ in important ways, and address slightly different questions. Based on these differences, the research is reviewed in detail at the education stages, whereas a sampling of the work research is reviewed. The classification will be useful for academic researchers, education policy makers, and teachers, because it shows gaps in past research, evaluates how well-supported the findings are, and establishes what is known about the problem and what is still to be discovered.

Figure 2.1: Life Stage Classification of Factors Affecting Women in Computing




Work
(E) Human capital affects numbers in computer-related jobs
(E) Human capital differences do not explain women's lower wages and sex-segregation in computer-related work
(D) "Sexist skill evaluation" means men's work is more highly valued, men get higher wages
(D) High technology appropriated as male domain, helps sustain occupational sex-segregation
(R) Mentors help women move to higher status occupations
(S) Women deterred by idea that women in computing are deviant
(S) Accommodating childcare and domestic responsibilities affects wages and segregation of women in computing

2.1 Criteria for inclusion

2.1.a. Empirical research

Research on women and computing is reported in the education, sociology, science and computing literatures. Publications can be grouped by four distinct aims: 1) to publish findings from empirical research into this topic; 2) to suggest interventions (I call these "review and suggestion" articles because they give a brief review of the literature and then suggest interventions); 3) to tell about some of the initiatives that have been undertaken to attract and retain more women in CS (I call these "report on projects" papers); and 4) theoretical approaches to the problem.

"Review and suggestion" articles give a brief review of the literature and exhort computer scientists, academics, or men and women in general, to make changes in education or work that will result in more women entering CS (see, for example: Bell, 1994). The aim of the "report on projects" articles is to tell about some of the initiatives that have been undertaken to attract more women into CS, or keep them in the program once there. Sometimes an evaluation is conducted at the end of an intervention, and the evaluation is then reported in these kinds of articles. For example, Craig *et al.* (1998) report on some initiatives in Australian universities that aim to reduce the sense of isolation felt by women in CS. To reduce attrition caused by isolation, some universities have initiated mentoring programs for first year female students, offered bridging courses for distance education CS students, offered workshops for staff, or hired a part-time Women in Computing coordinator to facilitate events for women in computing (Craig *et al.*, 1998).

Theoretical approaches to women's underrepresentation in computer education and work are covered in the theory chapter. "Review and suggestion" articles, and "Reports on projects" will not be covered in detail here. This chapter has the specific aim of describing and assessing *empirical* research, so the focus is on those publications with the first aim – reports of empirical research.

2.1.b. Computing technology

There is a large literature on women in science generally, but the argument has been made that computing is unique: it is a relatively new field; the specific gender roles and relations in this field are being negotiated in relation to the existing social system; and there are unique challenges specific to the need for CS students to develop a human/machine relationship (Frenkel, 1990; Howell, 1993). Gadalla's (1998) study of enrollments in mathematics, computer science, and engineering disciplines indicates significant differences in the enrollment patterns in these fields of study. In light of these particularities, this chapter will review research specifically focusing on computing.

2.1.c. Recent research

Computer education has been in a state of continual change over the last decade, both at the level of policy, and in resource allocation, teacher recruitment and teacher training. Some early research may not be relevant any longer; so, although the early research is summarized, the detailed discussion focuses on empirical studies published in the last ten years. Thirty-eight studies fit the criteria for inclusion in the education section of this review: reports of empirical research published in the last decade, on gender and computing in education. This chapter brings together the results of these

studies, and a sampling of work studies, to see what general conclusions can be drawn from past research on gender and computing, and defines the parameters for future research into this area.

2.2. Educational classification and evaluation

There are two parts to the review. First, I will construct a stage classification of factors explaining women's underrepresentation in CS, based on empirical research. By a stage classification, I mean a classification that outlines the factors that are significant to women's computing experiences at various stages in their education and work histories. This is not a developmental model that traces developmental changes from one stage to the next; it does not focus on individual growth over time. This classification identifies important factors at various stages of education and looks for patterns and changes across the stages.

I identify four stages: 1) Elementary School years (Kindergarten to grade 8); 2) Secondary School years (grade 9 to High School graduation); 3) Post-Secondary School years; and 4) Work years. Although there may be a slight overlap with studies of "middle school" level students, the three education periods reflect transitions and/or prime decision-making periods of a person's education. Also, most empirical research on women and computing focuses on one of these periods of time, or distinguishes between individuals in these different stages.

Second, I will evaluate the empirical research that has been done to date by categorizing studies into one of two groups: 1) non-comprehensive (preliminary,

exploratory, or pilot studies), or 2) comprehensive studies. The non-comprehensive group includes primarily studies with small or nonrandom samples, qualitative studies, and evaluative reports of pilot intervention projects. These represent the vast majority of empirical studies on this issue. While these studies in themselves are not generalizable to the population, they are summarized here to indicate the direction of past research, and to show potentially fruitful kinds of research for the future.

Comprehensive studies are defined as those studies using a random sample, and/or a comparison group design for analyzing policy or other data. These studies are more widely generalizable because of the random sampling design. The number of studies in the education stages, eligible for this categorization, is quite small. The work research tends to be more comprehensive, drawing on national statistics or extensive case studies.

The relevance of a stage perspective for this kind of research is that one can gain a sense of what factors are significant for women over time. At what stage are decisions about interests, education and careers made? What factors are most important at what stage? From this classification of salient factors at each educational stage, relevant and targeted action can be taken for social change.

Figure 2.2 shows eight groups of factors that have been identified in the literature as important for women's computer experience at various stages of their lives. The empirical research into the effect of these factors on women's participation in computer science will be discussed as they are covered in the literature.

Figure 2.2: Major groups of factors affecting women's computer experiences

I Interest/motivation	**C** Culture (class, lab, and general computer culture)
A Attitudes	**S** Stereotypes / sex role beliefs (knowledge of the computing field)
E Experience	**H** Historical/structural factors
R Role models/mentors	**D** Sex discrimination

2.3. The literature: Early literature on women and computing

This chapter focuses on research in the past decade (since 1990); but before discussing the current literature I will briefly present the main findings of research conducted prior to 1990.

Research on women and computing before 1990 forms the basis for the more recent research into this topic. Frenkel (1990) summarizes the early research, pointing to important factors such as the disproportionately negative effect on women of the chaotic state of CS education at pre-college levels (Klein, 1985). She describes the difficulty of getting appropriate technology and teaching expertise to establish CS in schools. Their inclination to follow rules and procedures means young women in schools suffer more than men during transition periods, in this case, when there is no curriculum and teachers are often not trained to teach CS (Frenkel, 1990, p.39).

In the 1980s women's sense of isolation in CS led to the creation of SYSTERS, an email list for women in computing (Frenkel, 1990, p.38). The isolation problem is

described in the literature on the chilly climate in university CS departments. Women were dropping out of graduate programs, or entering industry, rather than endure the patronizing behaviour, invisibility and doubting of their qualifications that many encountered in academia (p.37). Early research also found that, in some cases, women had problems with foreign professors from countries where women's roles are strictly defined (Etzkowitz in Frenkel, 1990; Baum, 1990).

Problems of access to computers were addressed in early research. Girls in general were found to have less access to computers than boys, both in school and at home (Kiesler, Sproull & Eccles, 1985). This problem was exacerbated for girls from minority groups, particularly for girls and women of colour. Computer labs in schools were found to be dominated by male students; female students had to be aggressive about getting their turn at the computers, something they were reluctant to do (Kiesler *et al.*, 1985). Even when technology was available in schools, early research found sex bias in educational computer software (Breene, 1992, p.40), and sex stereotypes associated with the hacker culture (Turkle, 1988; Breene, 1992, p.40).

Partly because of their lack of access and experience compared to boys, girls generally were found to have low self-confidence with computers (Frenkel, 1991, p.39). Some research documented discrimination against women by teachers and guidance counselors who advised young women to follow careers in more traditional fields (Breene, 1992). Girls were also found to attribute successes with computers to luck and failures to lack of competence, rather than to the successful or unsuccessful use of strategies (Clarke, 1990; Ware, Steckler & Leserman, 1985). A study of the college

experiences of a group of valedictorians found that these bright females consistently lost self-esteem through college whereas the males increased in self-esteem (ACM Committee of the Status of women in CS, 1990).

Howell (1993) criticizes some of the early research that relied on questionnaires for data collection. She argues that complex social constructs are difficult to access with questionnaires, and warns of potential gender effects when male/female differences are examined using questionnaires. For example, women's lower confidence may affect their interpretations of, and responses to, questions, with the resultant loss of validity of the measures. Nevertheless, the research from the late 1970s and 1980s explores important issues, and provides a foundation for the more recent research into women and computing. While some issues have lost some of their salience (for example, curriculum is now available, and teachers are better qualified to teach computer classes), others have been more fully explored in recent years (for example, social-psychological factors). What are the important recent findings for the different educational stages?

2.4. The literature: Current literature since 1990

The overall classification (Figure 2.1) presents the factors identified in this paper as significant for education and work stages. Factors in rectangles are found in comprehensive research. Those in ovals are findings of non-comprehensive research. Dotted rectangles or ovals indicate that the finding is inconclusive (i.e., that studies do not agree on this finding) and arrows indicate those factors that continue to later stages.

In parentheses the letter of the factor group is indicated (Figure 2.2), and in square brackets are numbers referring to Appendix 1, which lists the studies in the classification.

2.4.a. Elementary Stage Factors: Comprehensive studies

Reinen & Plomp (1993) report on the Computers in Education study of the International Association for the Evaluation of Educational Achievement (IEA). Based on a stratified random sample of schools in 20 countries, the study sought answers to three questions: "i) to what degree are female role models offered to girls in the schools; ii) in what way do school policies take gender equity issues into account, and iii) to what extent are gender equity issues dealt with in the curriculum" (p.353)?

2.4.a.i. Role models

The authors acknowledge that past research into the effect of role models on behaviour is not conclusive. It appears that mentoring may have a much more positive effect on women in science generally than simply having role models (Byrne, 1993). However, with the exception of Portugal, the Reinen & Plomp (1993) study found that while there is a majority of female teachers at the elementary stage, the proportions of female computer coordinators and female principals are much lower than the proportion of female teachers. Fewer women in these leadership positions means fewer role models for girls, they conclude.

On the other hand, looking specifically at the percentage of teachers who identify themselves as computer *users* in the classroom, they find that at the elementary stage there are equal numbers of men and women, or more women, in the United States, Canada (BC only) and New Zealand. Bringing together the findings for computer

coordinators, principals and teachers, the researchers still conclude that there is an underrepresentation of female role models in computing; computer use in elementary schools is dominated by men.

A second, related question investigated in this study examines the extent to which these women actually *act* as positive role models. The authors wanted to ascertain what knowledge and skills these role models possess that may inspire students; what problems they experience in using computers; and what attitudes they have to computing. Male elementary teachers rate their knowledge and skills higher than, or equal to, female teachers at this level. Women experience more serious problems than men with getting adequate time for, and help with, computer class supervision. Male elementary teachers report having more problems with inadequate computer resources (p.360). This study finds no significant differences between the attitudes of male and female elementary teachers; attitudes were measured as ratings (positive to negative) of "educational [and] social implications" of computer use, the "need for training" and "self-confidence" (p.360).

2.4.a.ii. School organisations and policy

Reinen & Plomp find, upon examining school organizations and policies for gender equity at the elementary stage, that few schools (approximately 13 or 14%) have a special policy on gender equity (p.361). Where policies do exist, these most often promote: 1) the training of female teachers in computing, and 2) the selection of women as computer activity supervisors. The authors argue that these most common applications

of policy indicate an effort to increase role models, rather than more direct goals such as ensuring equal access for girls, or instruction geared to girls' interests.

2.4.a.iii. Curriculum diversity

Reinen & Plomp's research on curricula is based on the assumptions that a diversity of computer applications leads to more positive attitudes to computing for girls, and that some programming languages seem to be more appropriate for girls than other languages (applications are the different kinds of software taught, e.g., drill and practice, tutorial, word processing, spreadsheets, etc. (p.361). At the elementary stage they find that the average number of computer applications taught is small, ranging from an average of less than two applications in Japan to about five applications in New Zealand. In Canada (BC only), the average number of applications taught is slightly less than four.

Programming is taught in elementary education by about 35% of the teachers surveyed, without any real evidence that gender is a consideration in the choice of programming language. However, looking specifically at Canada (BC), the Logo language, which has been identified as preferred by girls, is used more often than BASIC, the language more preferred by boys (p.363).

2.4.b. Elementary Stage Factors: Non-comprehensive studies

Non-comprehensive studies of gender and computing at the elementary stage have focused on differences in students' use of and reactions to software, and on peer interaction when children are learning in groups at computers. The latter focus considers

the effect of same-sex and mixed groupings on computer-related attitudes and achievements of young girls.

2.4.b.i. Gender groupings

Three studies examine the effect on learning of different gender groupings around computers (Lee, 1993; Barbieri & Light, 1992; Inkpen *et al.*, 1995). Working in same-gender groups appears to benefit girls working on computer tasks. Compared to mixed groups, in all-female groups girls tend to be more verbally active about the task at hand, are more likely to get adequate help when they ask for it, are more positive in their affective comments about the task, and are more likely to have an equal share of control of the computer and mouse. In addition, one study finds that girls are more successful at computer tasks and are motivated to stay longer at the computer when working in all-girl groupings (Inkpen *et al.*, 1995). Measuring motivation by the length of time spent at the computer, this study shows that playing with a partner, and success in the game affect children's motivation to continue playing at the computer (p.4).

Lee (1993) randomly selected a group of 64 fifth and sixth grade students from two elementary schools in a midwestern US, suburban, middle-class school district to observe students' interactions as they work cooperatively on a computer-based project. She divided students into groups of four members, based on gender: 1) same-gender groups (all male, or all female), 2) majority-female groups, 3) equal-ratio groups, and 4) majority-male groups. Girls in the all-female groups tend to be more verbally active about the cooperative task than those in the mixed or all-male groups, and they are more likely to ask for help and receive adequate help from the other group members. In the

majority-female and equal-ratio groups, girls still tend to ask for help more often than boys, but are less successful than boys in getting the help they require from other group members (p.570).

Lee also finds male/female differences in "socio-emotional interactions" within the groups. Girls are more likely than boys to make positive or neutral comments during their group experience; boys are more likely than girls to make negative comments during their group experience. When the groups are mixed, girls' negative comments increase, and boys' positive comments increase (p.571).

Also concerned with interactions at the computer, Barbieri & Light (1992) studied a group of 66 children, ages 11 and 12, to see whether different gender pairings of the children working on a problem solving task on a computer affected their performance of the task. From a school in southern England, children in two classes were randomly assigned to boy-boy pairs, girl-girl pairs or boy-girl pairs. The authors find that boys are much more likely than girls to sit by the computer where they would be able to use the mouse with the right hand; girl-girl pairs tend to take turns with the mouse more frequently than boy-boy pairs; and boys, more than girls, express a preference for working alone. In mixed-gender pairs, boys control the mouse most of the time, and, not surprisingly, girls in mixed-gender pairs express least satisfaction with their partners (p.211).

Inkpen *et al.* (1995) build on these findings, exploring the conditions under which group work has the most positive impact on girls. In a pilot study at an elementary school (N=104), and then later at a research lab at a science museum (N=331), they

compare achievements of girls working in three distinct conditions: working together on a computer; working side-by-side on two computers; or working alone at a single computer. They find that both boys and girls working in single-sex groups on a single computer solve the most puzzles, but boys are equally successful working side-by-side on two computers. Girls are significantly more successful working together on a single computer than working side-by-side, in this study (p. 4). Measuring motivation by the length of time spent at the computer, this study shows that playing with a partner, and success in the game, affect children's motivation to continue playing at the computer (p.4).

None of these studies on gender groupings is categorised here as comprehensive, but the findings are consistent that when girls work in same-sex groups they are more motivated to do computing, they are more assertive about getting help, and they gain more control of the computer. What is not known is whether these benefits lead to a greater likelihood of girls continuing in computer studies through secondary and post-secondary stages of their education.

2.4.b.ii. Software choice

Several studies of elementary stage computer experience have focused on software or courseware (Huff, 1996; Chappell, 1996: Ring, 1991). To address the hypothesis that choice of software or courseware in the classroom may be a factor in girls' lesser interest in computing, these studies look at representations of gender in software, educational software design, and the assessment of and reactions to computer courseware by students at the elementary stage. They find that educational software is gender biased in favour of

boys, and that this bias increases with software designed for upper grades. Ring (1991) finds that girls have lower self-confidence than boys using educational software.

Huff (1996) examines educational software designed by teachers either for boys, girls, or children generally. Using independent raters of the software, he finds differences in the kinds of software designed for these groups: for boys, programs are like games, whereas for girls the programs are more like educational tools. Interestingly, he finds that programs designed for "children," where gender is not specified, are very similar to those designed for boys. He concludes that, despite there being 80% female teachers designing the software, there is a gender bias in the development of software that favours boys and their interests (p.7).

Chappell (1996) finds a similar bias in software programs designed for educational use, but also finds that the male bias increases as grade level increases. She measures gender representation, violence and competition in 17 mathematics educational software programs. The average gender representation in these top-selling programs, from programs designed for pre-kindergarten to grade 12 students, is 25% female. At the Kindergarten level, the average female representation is 33.3%, a proportion that declines throughout the elementary and secondary levels to 12.5% female representation by grade 12 (p.32). The percentage of violent acts compared to non-violent acts in these programs increases from 11.4% at the Kindergarten level, to 50% in programs for grade 12 students. Similarly, the percentage of competitive acts both against the program and against a peer, increases throughout elementary and secondary stages (p.32).

Although the findings are not generalizable to other educational software, the trend in these top-selling programs suggests that throughout the elementary years the programs designed for educational use become more and more competitive and violent, and are increasingly likely to feature male characters than female characters (p.34). These findings suggest the need for further research into the association between the increasing masculine bias of programs and the loss of interest in computing that occurs during the elementary and secondary years.

One attempt to look at that association (Ring, 1991) focuses on a single courseware package used by 192 students (96 male, 96 female) over a two month period. Students, ages 5 to 13 years, used a courseware package and then responded to a questionnaire designed to measure their reactions and attitudes to the courseware. Generally, the reaction to the software is positive, but significant differences are found for six of the measures. Females rank three measures that indicate unease or difficulty with the program significantly higher than males. Males rank three measures that indicate the program is overly easy or slow significantly higher than females (p.213). Ring concludes that females have lower self confidence about computer use than males.

2.4.c. Overview of Elementary Stage Factors

Research on gender and computing education at the elementary stage has primarily focused on structural factors. Lack of gender-equity policies and lack of diversity in curriculum have been found in comprehensive research; the connection between these structural conditions and girls' interest and achievements in computing draws on early studies and is not assessed in this research. All-girl groupings at the

elementary stage consistently are found to have a positive effect on girls' computer-related behaviour.

Gender discrimination is found in the development and use of male-biased software. It is not clear what effect biased software has on girls' computer behaviour at this stage, but one non-comprehensive study finds that girls have less self-confidence using software than boys.

There is comprehensive evidence of a lack of female role models in computing. The debate on whether simply having more role models would have an impact on girls, or whether being mentored really makes the difference in girls' behaviour, and the consistent finding that all-girl groupings benefit girls, suggest the need for further research into role models, mentors and peer influences at this stage.

Two potentially important factors are lacking in the elementary stage research. The first concerns stereotypes, sex role beliefs and knowledge of the field. At this early educational stage, what do students know about computing work, whom do they see working in this field and being successful, and how is that influencing their interest and motivation to learn and use computers? The second factor pertains to experience. To what extent does experience affect attitudes to computing at this stage? What structural changes can be made to ensure that girls at the elementary stage gain the same computer experience as boys?

2.4.d. Secondary Stage Factors: Comprehensive studies

The comprehensive findings at the secondary stage are similar to those at the elementary stage: schools lack female role models in computing and leadership; they do not provide a diverse, interesting curriculum; and gender-equity policies are rare.

2.4.d.i. Role models

Reinen & Plomp (1993) find that, as at elementary education, the percentage of female computer coordinators in secondary schools is much lower than the percentage of secondary stage female teachers overall (e.g., in BC Canada, female teachers are 37% of the total, while female computer coordinators are 14% of the total (p.358)). Also, similar to elementary education, female teachers at the secondary stage consistently rate their skills and knowledge lower than males do.

Male and female secondary school teachers identify different kinds of problems with computing. Women stress having problems with their own lack of knowledge, difficulty getting expertise and assistance, trouble maintaining equipment, and insufficient access to the computers. Men stress the problems of limited and inadequate resources (p.360).

2.4.d.ii. School organization and policy

Regarding gender-equity policies in secondary schools, as with elementary schools, there are few schools with policies in place, and those schools that do have policies apply them in limited ways (p.361).

2.4.d.iii. Curriculum diversity

Reinen & Plomp find a fairly low diversity of applications of computers in secondary schools. Slightly better than the elementary stage where average numbers of

computer applications by country ranged from 1.5 (Japan) to 5 (New Zealand), at the secondary stage the range is from 2.5 (China) to 7.5 (New Zealand). With the exceptions of New Zealand and Poland (5.5 applications), however, most countries provide little diversity in the applications of computers in secondary schools (p.362).

2.4.e. Secondary Stage: Non-comprehensive studies

Non-comprehensive studies of gender and computing at the secondary stage focus primarily on gender differences in attitudes to computing, software, group composition, and knowledge of the field of CS. As with elementary stage students, studies show that girls at the secondary stage benefit from all-girl groupings for computer work.

2.4.e.i. Attitudes

The assumption underlying the attitude research is that factors such as self-efficacy, computer experience, encouragement and social support, among others, affect attitudes to computing. Negative attitudes to computing would in turn be associated with a lower likelihood of enrolling in computing courses, or pursuing a computer-related career. Attitude change toward both computing, and women in computing, is considered an important long-term solution to the problem of women's underrepresentation in computer education and work (Platt, 1991). Based on this logic, several studies (Shashaani, 1994; Jones & Clarke, 1995; Levin & Gordon, 1989; Durndell, Glissov & Siann, 1995) find that male students have more positive attitudes to computing than female students do. Experience with computers and diversity of experience are found to be associated with positive attitudes to computing.

Two cautionary notes with respect to these studies: the first concerns the general difficulty in demonstrating causality, and the second concerns the very different ways that "attitudes to computing" are conceptualized and measured. The studies find correlations between variables such as computer experience and interest in computing, but most do not show whether more computer experience leads to greater interest in computing, or vice versa. Also, the conceptualization and measurement of attitudes to computing vary significantly across studies. In this review, reports on attitude research will specify what attitudes are measured and how they are measured. Despite these problems, the attitude research identifies gender differences that could be tested in a more controlled comparison group or experimental design to establish whether the requirements for causality are met (most importantly, temporal order).

Four studies examine the effect of computer experience on attitudes toward computers (Shashaani, 1994; Levin & Gordon, 1989; Durndell, Glissov & Siann, 1995; Jones & Clarke, 1995). Three of the studies (Shashaani, 1994; Levin & Gordon, 1989; Durndell, Glissov & Siann, 1995) find that boys at the secondary stage have more computer experience that girls, and that more experience is associated with more positive attitudes to computing. The fourth study (Jones & Clarke, 1995) does not include males, but finds, like the others, that more computer experience is associated with more positive attitudes to computing. When prior experience is measured only by "owning a computer," Shashaani (1994) does not find an association with students' attitudes, although other studies do find this factor to be significant.

The studies do not agree on sex-stereotypes about computing. All studies find that boys are more likely to hold sex-stereotypical attitudes about computing (Levin & Gordon, 1989; Durndell, Glissov & Siann, 1995; Shashaani, 1994), but Levin & Gordon (1989) and Durndel *et al.* (1995) also find that for boys, sex-stereotypical attitudes increase with computer experience. Shashaani, on the other hand, finds that as both boys' and girls' experience with computers increases, belief in equality of both men's and women's skill and ability to use computers also increases. The disparity in findings may be related to a cohort effect. All of these studies use cross-sectional survey designs, so it is not possible to rule out differences amongst more and less experienced cohorts as an explanation for different levels of sex-stereotyping by the more experienced boys.

Levin & Gordon (1989) administered a questionnaire to 222 students, grades eight through ten, to ascertain whether prior exposure to computers has an effect on students' attitudes to computing before they are introduced to computing in school. Prior exposure was ascertained by asking if students own a computer at home, have taken an extracurricular programming course, or know how to use computers. General, affective and cognitive attitudes were measured. To measure affective attitudes, students ranked various negative and positive reactions to computing on a scale of one to seven (for example; boring/interesting, hard/easy). To measure cognitive attitudes students were asked whether or not they felt certain activities could be performed by computers (for example, "Can solve math problems," or "Can check tests"). A series of 22 questions were asked to ascertain general attitudes concerning: 1) students' "desire to become familiar with the computer" (p.74); 2) students' perceptions of who should or can use

computers; 3) students' assessment of the need for computers; and 4) students' perceptions of computers used for instruction.

Using these measures, Levin & Gordon argue that both male and female students who have a computer at home have much more positive affective and cognitive attitudes to computing than those who do not have a computer. They find that the influence of prior exposure on attitudes is stronger than the effect of gender on these attitudes: girls and boys who own computers rate them more "enjoyable, important, inexpensive, and easier" than students without computers (p.84).

Regarding general attitudes to computing, however, the authors find sex differences in perceptions of who can or should use computers. Males with more computer experience tend to have more stereotypical attitudes about who is capable of working with computers; they identify boys, geniuses and adults as most capable. Females with similar computer experience indicate a wider range of users who are capable with computers, suggesting that sex differences in stereotyped attitudes about computing may develop earlier in males than females (p.85).

Shashaani (1994) conducted similar research on the relationship between experience and attitudes to computing. She surveyed 1730 students from five high schools, using a Computer Attitude Scale (CAS) to measure students attitudes to computers. The CAS measures attitudes towards: 1) computer interest, 2) computer confidence, 3) computer stereotypes, and 4) perceived computer utility (p.351). Shashaani used a more extensive method than Levin & Gordon (1989) to ascertain students' prior experience with computers, asking seven questions about courses taken,

ownership, whether students intend to take computer classes, the extent of their computer use each week, and how students would prefer to use computers (p.351). Boys have more experience than girls, based on the measures used in this study.

Shashaani's findings contrast with those of Levin & Gordon in two areas. Concerning experience effects, Shashaani finds that owning a computer is not associated with students' attitudes to computers, except with higher scores on their perception of the utility of computers (p.361). Like Levin & Gordon, however, she does find higher scores on a general computer usage measure are associated with more positive attitudes to computers, and women score significantly lower on usage. Male students use computers more than female students despite taking the same number of computer courses, owning computers, and having access to school computers.

As discussed above, Shashaani finds that boys see computing as a masculine domain (Shashaani, 1994, p.356), but unlike Levin & Gordon (1989) and Durndell *et al.*(1995) who find that more experienced boys hold more stereotypical attitudes, Shashaani (1994) finds that both boys and girls with more experience are *less* likely to hold stereotypical views about who is capable of working with computers than those with less experience. This different finding could be related to differences in the samples used (nonrandom in both cases), or may reflect the fact that the studies were done in three different countries[1]. The two studies where more experienced boys are found to hold more stereotypical attitudes were conducted in Israel (Levin & Gordon, 1989) and in

[1] Shashaani asks about "intentions to take computing classes" and "whether respondents would like to use computers" as measures of experience. I believe these are not good measures of present behaviour and may be biasing the findings.

Scotland (Durndell *et al.*, 1995). Shashaani's study (1994) was conducted in Pittsburg, Pennsylvania, USA. More importantly though, the cross-sectional survey design used in all three studies does not account for a cohort effect.

Durndell *et al.* (1995) selected for their study 429 students from five secondary schools in Scotland. Using a questionnaire, they examined experience, attitudes and age factors as they relate to gender differences in computing. Experience was measured using indices for school use and out-of-school use of computers. The aggregated items represent a more detailed measure of experience than the measures of Shashaani and Levin & Gordon.

Similarly, the attitude scale used by Durndell *et al.* is more detailed than measures used in the two previously discussed studies. Attitudes were measured using 55 statements which students rated from 'strongly agree' to 'strongly disagree' (i.e.: five-point Likert-type scale). Attitudes were measured in relation to "interest in computers, career choice, gender stereotyping of computing, personal feelings when respondents worked with computers, and the kind of personal characteristics respondents considered necessary for individuals to succeed at computing" (p.222). In a separate section, gender stereotyping was tested using a sentence-completion method (e.g., "The person to make best use of computers is a ___" (p.222)), where respondents fill the blank with either 'woman,' 'man,' 'man or woman,' or 'not sure.'

As with the other two studies, Durndell *et al.* find that use of computers by boys is significantly higher than by girls, both at school and outside school; the gender difference in usage is greatest for the youngest (first year) and oldest (sixth year) age

groups (p.225). There are two exceptions to this finding. First, use of computers for word processing outside the school is not significantly different for males and females. Second, the authors find that school use of computers for playing games is equivalent for males and females, despite the studies that identify a male-bias in commercial games (p.225).

A similar pattern in attitudes to computing is found, where boys are significantly more positive about computers than girls are, and this gender difference is greatest for youngest and oldest students. Like Levin & Gordon (1989), this study finds that girls have less sex-stereotyped attitudes about computer use than boys do, and the gender difference increases with age (p.225).

2.4.e.ii. Gender groupings

Two studies extend the work on gender and attitudes to computing at the secondary stage, to see whether single-sex settings or groupings have an effect on women's attitudes to computing (Jones & Clarke, 1995; Cooper & Stone, 1996). As with the elementary stage, these studies find that all-female groupings benefit women: women are more confident about their abilities with computers, have more sources of help, and gain more diverse experience with computers when in all-woman groups or settings.

Jones & Clarke (1995) investigate the effect of single-sex settings on secondary school students' experiences and attitudes toward computers. This study tests whether the finding at the elementary stage that single-sex groupings are better for girls than mixed groupings at the computer is true for girls at the secondary stage too. Jones and

Clarke (1995) drew their sample of 231 girls from grade ten students in five high schools. Three of the schools were all-girl, and two were co-educational schools.

Using a questionnaire, the authors measured computer experience with 16 questions to which students responded on a five-point scale from 'none' to 'a great deal' (p.54). These questions measured opportunity to use computers, amount of computer use, diversity of experience, and sources of information. This goes beyond the earlier studies noted above, indicating students' exposure to a variety of software packages, and accounting for diversity of sources available to provide students with computer information, such as the "media, peers, parents, and teachers" (p.54) Attitudes were measured using a 40-item scale which assessed affective, cognitive and behavioural factors. This measure closely resembles that of Levin & Gordon (1989), but Jones & Clarke combine responses to provide a "global attitudes" score (p.54).

The study shows that girls in single-sex settings have more computer experience and more positive attitudes to computers than girls in co-educational settings. The experience indicators with the strongest associations with positive attitudes are exposure to a greater diversity of computer tasks, and exposure to more sources of computer information. In other words, in single-sex settings female students get a greater diversity of experiences, and have more sources for computer-related information; in turn, these "experience" factors are associated with more positive attitudes to computing (p.58-9).

Cooper & Stone (1996) examine how gender composition of learning groups affects students' anxiety levels about using computers. Thirty-nine boys and 41 girls of junior high and secondary stage were recruited from advertisements in a local paper. These

students were put into groups of six to 20 students, composed of either boys only, girls only, or boys and girls together. As in studies on gender grouping at the elementary stage, these authors find that when students are in same-sex groups, there is no difference in self rankings of overall knowledge of computers by boys and girls. However, when boys and girls are mixed, the girls rank themselves lower in their overall knowledge of computers than girls in same-sex groups, and the boys rank themselves higher than boys in same-sex groups on experience and knowledge of computers. Cooper & Stone (1996) conclude that "gender differences in computer experience and knowledge may be a function of the context in which these measures are taken" (p.87).

2.4.e.iii. Perceptions of computing

To increase enrolments in computer education, some have addressed the possibility that students have misperceptions about computing work. Many secondary school students are under the impression that computer careers involve programming all day, every day. They are not aware that a wide variety of technical and management positions are available to people with computing education, that computer workers move up the job ladder rapidly, and that they command higher starting salaries than graduates from many other fields (Lynam & Kamal, 1992; Craig *et al.*, 1998).

One market research study found that if students have negative misperceptions of the computing industry, they are unlikely to choose to study computing. Perceptions of the career that awaits a student after graduation is found to be a strong motivator for studying in any discipline (Craig *et al.*, 1998).

Teague & Clarke (1991) compared 68 undergraduate CS students' perceptions of computing with the perspectives of seven professional women working in computing. They find that women more than men choose computer science for its good career prospects, and men more than women choose it because they like it (p.365). Students described negative stereotypical perceptions of computing work (solely programming, no people contact, and so on), whereas women working in computing presented a very different picture of their work. These women described work that involves much interaction with others in problem solving, training, and assessing needs of clients. The authors argue that more effort must be made to expose young women to a more realistic view of computing work.

Much of the literature on perceptions of computing presents descriptions of interventions aimed at correcting misperceptions (Lynam & Kamal, 1992; Teague & Clarke, 1993; Craig *et al.*, 1998). Evaluations of the interventions vary; most have not been systematically evaluated. Based on observations and comments, in each case the authors feel they have been effective in promoting computing careers and clarifying what that kind of work can be. For example, one intervention distributed pre- and post-test attitude questionnaires and found that prior to participating in a Girls in Computing Day, computing was viewed by girls as solitary work, nor did they feel it offered much opportunity for creativity. After the day, the girls' attitudes were markedly more positive and their perceptions were more realistic (Craig *et al.*, 1998).

Other interventions include speaking to high school students about computing careers (Lynam & Kamal, 1992); developing a computing careers video aimed at

secondary stage girls; running computer camps for girls (Teague & Clarke, 1993; Craig *et al.*, 1998); distributing a "Careers in Computing Information Pack" to high school students and mature women; offering a distance computer course with "gender inclusive material" on basic computing skills; and running workshops for secondary school students on the World Wide Web (Craig *et al.*, 1998).

2.4.e.iv. Software

Chappell's (1996) study of math software compares software used at various stages of education. As noted above, at the preschool and elementary stages there is significantly less violence and significantly more female representation in math software than at the secondary stage, on average. The effect of biased software at the secondary stage on women's representation in computing education is not established.

2.4.f. Overview of Secondary Stage Factors

Similar to the elementary stage, structural factors are found to be important at the secondary stage: curriculum diversity and gender-equity policies are lacking at this stage. Studies of all-girl groupings at this stage focus more on their effect on girls' attitudes than behaviour. Research on experience is also linked to girls' attitudes: experience is associated with more positive attitudes for girls, and the more diverse that experience, the better. For boys, however, greater experience is tentatively associated with more sex-role stereotypical attitudes. This finding, coupled with students' misperceptions about computing, suggests the need for more interventions to clear up stereotypes and provide accurate information about computing work.

Lack of role models remains problematic at the secondary stage, although the same concerns about mentoring as discussed for the elementary stage suggest the need for further investigation of this factor. Gender discrimination in the use of male-biased educational software is more pronounced at this stage, although a direct link to women's underrepresentation in computing has not been made.

Missing at the secondary stage are studies of computing culture, specifically the culture associated with computer classes and labs. At the *post*-secondary stage, women who do take computing identify their secondary school class experiences as influential in their choice. More research is needed to discover what specifically increases women's interest in computing, whether the computer culture encourages or discourages them, and to what extent mentor and peer encouragement affect women's motivation to study computing at the post-secondary stage.

2.4.g Post-Secondary Stage Factors: Comprehensive studies

At the post-secondary stage there is a larger volume of research conducted on women and computing than at the other stages. The volume of research is a rich source for hypotheses concerning women's underrepresentation in CS, but only one study fits into the "comprehensive" category. In cases where several studies arrive at similar conclusions, this suggests more conclusive and potentially generalizable findings. Studies at the university level tend to draw samples from first year student volunteers at a single university.

2.4.g.i. College affiliation of CS program

Camp (1997) compares women's enrolments in CS programs housed in US engineering colleges with those in arts and sciences colleges. She finds that there are significantly fewer women graduating from CS when the department is in an engineering college (p.108). She argues that engineering culture is even more masculine than CS culture, so when the CS program is associated with engineering it is less attractive to women than when it is associated with less macho cultures.

2.4.h. Post-secondary stage: Non-comprehensive studies

Non-comprehensive studies at the post-secondary stage focus on stereotyping, attitudes to computing, gender grouping and social facilitation, experience, culture, and motivation.

Studies generally agree that computer scientists are stereotyped as male, very smart, antisocial, and content to sit in front of a computer for long hours (Fisher *et al.*, 1997; Durndell & Lightbody, 1993; Durndell, 1991). Durndell & Lightbody (1993) find that students' lack of interest in pursuing CS degrees is related to these stereotypical perceptions of computer scientists. On the other hand, Colley *et al.* (1995) find no evidence that *women* using computer technology are negatively stereotyped.

There is disagreement in the research about stereotypical perceptions of computing work. In interviews with non-CS students, Fisher *et al.* (1997) find CS is believed to be synonymous with programming. Students express negative perceptions of programming work and these beliefs form the basis for a general aversion to the field of

CS. On the other hand, Colley *et al.* (1995) do not find that students have stereotypical perceptions of computer-related careers. One exception to the latter finding is that students underestimate the salary levels of computer professionals (Geenens & Rao, 1992, p.27). As will be discussed below, women, more than men, cite the promise of the field as an important motivator in choosing computing careers (Fisher *et al.*, 1997), and therefore the underestimation of salary may impact women more than men.

Prior computer experience is associated with greater success in computer education at the post-secondary stage. Given the line of logic that experience affects attitudes and attitudes affect behaviour, Brown *et al.* (1997) were concerned that attrition from CS programs is the product of lack of experience. Studies identify previous experience as an important factor in understanding attrition rates (Fisher *et al.*, 1997; Taylor & Mounfield, 1994); however, Brown *et al.*'s attempt to compensate for lack of previous experience by providing students with extra introductory college computer experience finds no reduction in attrition or improvement in grades afterwards. One exception to Brown *et al.'s* findings occurred when early feedback on students' performance in the course was given via extra testing of students early in the term. The early feedback was provided only one year on a trial basis, and despite its positive impact (grades improved and attrition was lower that year), the costs associated with the extra testing discouraged faculty from its ongoing use (p.115). The impact of early feedback is consistent with the notion that women tend to underestimate their abilities (Fisher *et al.*, 1997) and may benefit more than men from extra feedback.

As was the case at the secondary stage, studies on post-secondary students' attitudes to computing do not use the same attitude measure (Teague, 1992; Busch, 1995; Busch, 1996; Pope-Davis & Twing; 1991; Pope-Davis & Vispoel, 1993). Different measures and nonrandom samples may help explain why there are contradictory findings among studies of attitudes to computing at the post-secondary stage. One study finds no significant effects of computer experience on students' attitudes at the post-secondary stage (Pope-Davis & Twing, 1991), when computer experience is measured broadly as years of experience. In another study, significant, positive improvements in computer attitudes (computer confidence, liking, usefulness or anxiety) are found for both male and female students given computer training, compared with a no-training control group. No significant gender differences are found in attitudes: the course positively affected both men's and women's attitudes (Pope-Davis & Vispoel, 1993, p.90).

On the other hand, less self-efficacy among females may have the positive effect of motivating more group activity and cooperation in group work around the computer: there is significantly more activity among groups comprising a majority of females (Busch, 1996). The social facilitation associated with working in all-female groups also appears to have a positive effect on women's performance at the computer (Corston & Colman, 1996). One study finds, however, that women-only educational settings are perceived by black women and white women differently. White women tend to be more individualistic in their preferred style of learning, black women tend to work more collaboratively and cooperatively (Stepulevage *et al.*, 1994).

Despite the benefits associated with all-female groups, the norm for CS is a majority of male students. CS culture has been explored as another factor potentially deterring women from entering the field. Although a distinctly masculine culture is found in CS, its effect on women is less clear (Fisher *et al.*, 1997; Rasmussen & Hapnes, 1991; Henwood, 1996). In general, it appears that women in CS accept the masculine culture and adjust their expectations and aspirations accordingly, whereas women outside CS are deterred from entering by anticipation of male hostility toward women who do non-traditional work (Henwood, 1996). One study found the prospect of being in all-male work settings to be a greater deterrent for males than females, however (Durndell & Lightbody, 1993).

Research shows that both male and female students are most strongly motivated to enter CS by their interest in the field (Fisher *et al.*, 1997; Geenens & Rao, 1992; Durndell & Lightbody, 1993). Other motivations to enter CS differ for males and females. Class experiences and a sense of the promise of the field also motivate women to enter CS, whereas games, class experience and the influence of peers somewhat motivate men (Fisher *et al.*, 1997).

A more detailed examination of these studies will provide insight into the methods and findings of this research.

2.4.h.i. Stereotypes

Durndell & Lightbody (1993) and Durndell (1991) asked three cohorts of first year university students enrolled in business or natural sciences in 1986, 1989, or 1992, to report their reasons for not choosing to study computing. The results show little change

over time in students' perceptions of "computer specialists hunched over their terminal all day having little contact with human beings and restricted in their future career patterns" (Durndell & Lightbody 1993, p.335-36). Students say that their lack of interest in pursuing CS degrees is related to these stereotypical perceptions of computer scientists.

Fisher *et al.* (1997) used ethnographic methods to gather in-depth data from 29 male and 20 female CS students, and nine non-CS students who were achieving A grades in a programming class for non-CS students. Using this method, the findings are very similar to those of Durndell & Lightbody (1993): computer scientists are perceived as very single-minded, focused, and smart. While acknowledging that some fit the stereotype, most CS students do not feel they match it (p.109). This study also examines perceptions of CS as a discipline and finds a common belief that CS is synonymous with programming. CS students are seen to have a very heavy work load. Non-CS students express negative perceptions of programming work. These beliefs form the basis for a general aversion to the field of CS.

To explore how stereotypes are assigned, Colley *et al.* (1995) presented 42 male and 108 female undergraduate students from one university with "target figures" to which a description was attached, and asked them to rate the figures on various descriptors (e.g., self-reliant, well-adjusted, assertive, etc.). The descriptions of the target figures included sex, and type of computer use (programming, word processing, games)[2]. Using this

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[2] The following is a general example of a description: "*Susan/Stephen* has just started *her/his* first year at University. It is *her/his* first time away from home and *s/he* is living in a house with four other students. *S/he* is enjoying the first few weeks of lectures and has lots of interests outside of *her/his* course including reading and travel. *S/he* has her own computer and has *learnt how to write computer programmes/learnt how to use a word processor/played lots of games on it* before coming to University" (Colley *et al.*, 1995, p. 22).

methodology there is little negative stereotyping of female or male target figures. Generally women attribute more positive traits to programmers, both male and female, and men attribute more positive traits to game players, both male and female (p.25). The authors did not test the relationship between students' beliefs and their own participation in computer studies.

The findings of the Colley *et al.*(1995) study appear to contradict those of Durndell & Lightbody (1993) and Fisher *et al.* (1997). If the descriptions of target figures do not evoke the picture of a CS student, however, Colley *et al.* may actually be providing evidence to support the other studies. Although the descriptions vary by gender and computer use, the rest of the descriptions portray well-rounded individuals with a variety of interests. Since that is the opposite of the single-minded, focused, isolated stereotype described by students in open-ended questions and interviews, it follows that students will rate the target figures positively. In fact, the target figures could represent students in a large variety of disciplines other than CS and, hence, CS stereotypes may not be evoked by the descriptions.

The link between students' perceptions of computing, and their career choice decisions was explored by Geenens & Rao (1992) through a questionnaire to 214 beginning computer course students. The 15 item questionnaire grouped items to ask: "How should a student select a major?, what are the perceptions about a computer-related major?, and, what are the expectations of the financial rewards of a college career?" (p.26). No attempt was made to find gender differences in students' perceptions, but the findings may have implications for women, since the most significant finding is that

students underestimate the salary levels of computer professionals (p.27). As will be discussed below, women, more than men, cite the promise of the field as an important motivator in choosing computing careers (Fisher *et al.*, 1997), and therefore the underestimation of salary may impact women more than men.

It appears that there is a negative perception of CS as a demanding and isolated work experience. The heavy demands of computing, especially programming, is a greater disincentive to women than men, but, at the same time, programming is more highly esteemed by women than men.

2.4.h.ii. Attitudes

Four studies use the Loyd & Gressard (1984) Computer Attitude Scale (CAS) to measure attitudes to computing amongst post-secondary students (Busch, 1995; Pope-Davis & Twing, 1991; Pope-Davis & Vispoel, 1993; Massoud, 1991). The CAS is an index of statements of attitudes, each rated on a Likert-type scale. Massoud (1991) and Busch (1995) use a 30 question version of the CAS which measures computer anxiety, computer confidence, and computer liking. The other two studies use a 40 question version of the same scale and gain an additional measure of computer usefulness.

Massoud's (1991) analysis simply looks for gender differences in attitudes to computing, using the CAS. In a survey of 252 adult students examining anxiety, confidence, and liking, Massoud finds males have significantly more positive attitudes to computing.

In addition to the CAS, Busch (1995) also measures self-efficacy by asking students if they believe they could do certain computer tasks, and then asking them to

rate how well they believe they could do them. Eight female and 67 male business administration undergraduate students took a mandatory introductory computer course and then completed the questionnaire on attitudes to computing. The study finds that self-efficacy is significantly higher for males than females when complex tasks are examined, but no differences in self-efficacy are found for simple tasks. The power of this test is low given the small number of women in this study.

Gender differences in attitudes to computing are related to previous computer experience and encouragement from friends and family. Computer experience in this study is measured by asking students to indicate the extent to which they had used "word processing, spreadsheet programs, programming or computer games before attending college" (Busch, 1995, p.151). Since men report having more experience and more encouragement, attitudes of men are more positive than those of women (p.154).

Pope-Davis & Twing (1991) also examine the effect of experience on attitudes to computing, but measure experience as number of years (versus weeks) of experience. Using this measure in a survey of 207 College of Education students in an introductory computer skills course, no effect of experience on attitudes to computing is found (p.334). The lack of variance using this broader experience measure may explain the lack of a significant finding, contrary to the Busch study (1995).

Pope-Davis & Twing (1991) also find no significant gender differences in computer confidence, liking, usefulness or anxiety. It seems likely that lack of significant gender differences in computer experience may explain lack of gender differences in

attitudes, given Busch's findings. Where women have similar computer experience to men, computer attitudes are also similar.

Morgan *et al.* (1991) in a study of 199 post-secondary students found gender differences in the early experiences of their subjects with machines. Women were significantly less likely than men to have been "allowed to use dangerous equipment" when a child, were "less likely to have been encouraged to explore how machines worked", and were "more likely to report having been frightened by some kinds of equipment" (p.168). Finding that the women in their sample also have more negative attitudes to computing than men, they argue that these early experiences may have been important influences on students' later attitudes.

Using the CAS scale again, Pope-Davis & Vispoel (1993) examine the effect of a computer training course on the attitudes of 17 male and 90 female undergraduate and graduate university students. A non-randomly assigned comparison group of 55 males and 32 females in an introductory psychology course did not receive the training. Both groups completed the CAS before and after the course was given to the test group. Significant, improvements in computer attitudes (computer confidence, liking, usefulness or anxiety) are found for those students given computer training, compared with the no-training control group. No significant gender differences are found in attitudes: the course positively affected both men and women's attitudes (p.90).

Sanders & Galpin (1994) administered a questionnaire to 302 first year university students prior to beginning their courses. They compared male and female students registered for a first year CS course with those not registered for CS. Attitudes to

computers were measured with 28 statements to which respondents may answer agree, neutral, disagree, or don't know/not applicable. The findings are not aggregated into a single "attitude" measure. There is no attempt to look for causal associations, but the study finds that men who are registered for CS have more informal prior exposure to computers, and are more confident and positive about computers than women are. Registered women have more formal exposure to computing and are more likely than men to have a male computer user in their families. Compared with women not registered for CS, those registered for the course have more positive attitudes to computers, have more formal exposure to computing, and have more programming experience. Interestingly, non-registered female students have the highest percentage of female computer users in the family (considered a "role model" in this study) compared with registered students and non-registered males. The authors speculate that having a female computer user in the family working in a negatively perceived job may be a negative role model for women (p.221).

Experience is an important predictor of attitudes. Some efforts to compensate for women's lack of experience have not been found to be as effective as others; however, just providing the experience of an introductory CS course positively impacts attitudes (Brown *et al.*, 1997). Self-efficacy may be related to the complexity of the computer task, suggesting that a progression from simple to complex tasks would be particularly helpful for women learning computing.

2.4.h.iii. <u>Gender grouping and social facilitation</u>

An experimental design was used by Corston and Colman (1996) to identify the effect of different gender grouping conditions on people's performance on a computer task. After random assignment of 36 male and 36 female undergraduate students to one of six conditions (male alone, female alone, female with female audience, female with male audience, male with female audience or male with female audience) students complete a pre-experimental questionnaire, then work on a computer task within their assigned gender grouping in a lab.

Males perform significantly better than females on the computer task overall. A significant social facilitation effect is found, with those working with an audience getting significantly better scores than those working alone. More salient for gender analysis is the significant interaction effect for gender by audience: the effect of a female audience on women is much stronger than on men (p.177). There is very little effect of a male audience on either male or female subjects.

The pre-test questionnaire included three questions that elicit self-rating of the student's level of computer usage, computer competence and computer anxiety. While these are rough measures, they indicate that women have more computer anxiety than men. Significant negative correlations between computer-related anxiety and 1) scores on the task, 2) computer competence and 3) computer usage supports earlier findings that experience with computers is associated with attitudes (anxiety) and performance. The cross-sectional design of the study means causation cannot be established. Nevertheless, the significantly higher scores of women with a female audience supports the findings

from the elementary and secondary stages that there are strong benefits for women experiencing computer training in same-sex groupings (p.181).

Whereas Corston & Colman (1996) study computer task performance for women with all-female audiences, Busch (1996) studies the effect of same-sex groupings on women's cooperation and self-efficacy in computing. Busch measures the self-efficacy in computing of 87 male and 63 female first year business administration students after they had taken a compulsory computing course. Previous computing experience was measured by the extent to which students had used various software packages. Previous encouragement to work with computers was a combined variable adding levels (1-5) of encouragement from parents, teachers and friends.

College administrators assigned students to six-member groups, either majority female, majority male, or equally male and female. In response to a questionnaire, female students assess themselves as having lower self-efficacy than males, a factor Busch finds to be related to previous computer experience, encouragement and access to one's own computer (p.132). Women report significantly less previous experience and encouragement than men (p.133). Low self-efficacy is found to be associated with more group cooperation: majority-female groups, therefore, cooperate more than majority-male or equally mixed groups (p.133).

At the post-secondary stage, these studies indicate that same-sex grouping may be beneficial for women in improving computer abilities, particularly in light of women's greater anxiety and lower self-efficacy with respect to computing. However, Stepulevage *et al.* (1994) find that black and white women perceive computing differently, interact

differently and hold different assumptions about power and access to computers. White women tend to explain women's underrepresentation in CS in terms of individual deficits, whereas black women explain it as a power issue. This exploratory study is based on a small sample of 11 women[3] participating in a women-only computer unit. This small study raises the question of racial differences that may moderate the benefits of same-gender grouping.

2.4.h.iv. Experience

Research shows that prior computer experience is associated with attitudes to computing. Given the line of logic that experience affects attitudes and attitudes affect behaviour, Brown *et al.* (1997) were concerned that attrition from CS programs is the product of lack of experience. Using "action research[4]" methodology they made changes to a first year CS course to try to address some of the problems that may be discouraging women. Since less prior experience is associated with lower grades, and students with lower grades are more likely to be women and to drop out, the authors introduced several changes to help inexperienced students. Introductory lab sessions in the first two weeks were introduced, difficult topics were postponed until later in the year, and self-selected streamed lab groups were introduced to keep inexperienced students from being discouraged by those who found the work easy because they had more experience (p.112-13). Female lab tutors were actively recruited and the lab environment was improved. In

[3] "Two students identified themselves as Afro-Caribbean, one as Black Caribbean, two as African, and six as white. For this paper, we identify the Afro-Caribbean and African women as black since our analysis showed a commonality between their views vis a vis those of the white women" (p.280)

addition, optional tutorial sessions and more tutored "in-lab" help was provided in various ways (p.113). Programming assignments and the text and curriculum were changed to more of an applications and procedures focus, which is considered more interesting for women, and early feedback on students' progress was provided.

With one exception, these attempts at making first year CS more "gender neutral," and minimizing experience differences, made no significant difference in attrition rates or students' grades over the years in which they were used. Women continued to drop out more than men, and to achieve lower grades than men, but gender differences in attrition and grades were lessened in one year when early feedback was given on students' performance in the course. The costs associated with extra testing prohibited its ongoing use (p.115), but the initial finding is consistent with the notion that women tend to underestimate their abilities (Fisher *et al.*, 1997) and may benefit more than men from extra feedback.

Fisher *et al.* (1997) also study factors associated with women's attrition from CS. As described above, their methodology is ethnographic. Confirming the findings of Brown *et al.* (1997), this study finds that not only do women have less previous computer experience, but they also *feel* less prepared than other students in CS (Fisher *et al.*, 1997, p.106). The study reveals a gender gap in confidence among first year students: males are more confident about their ability to master the course material, see themselves as highly prepared for their classes, and claim an expert level of knowledge of a

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[4] This refers to research that has a goal of changing a social condition. It is characterized by a close reliance on input from the stakeholders (teachers, students in this case) to help establish the research goals and assess and adapt the methods used.

programming language (p.107). For those women who do make it through the first year, however, their confidence levels increase much more than those of their male counterparts. This supports the conclusion above that women lacking confidence can catch up. As the course work gets more difficult in the upper years, respondents say the benefits of previous experience lessen and women's hard work in the first year or two pays off (p.107). Extra feedback along the way and staying in the program may mitigate the negative effects for women of having lower self-efficacy and less computer experience.

From a survey of 656 first year students enrolled in an introductory, non-major college CS course, Taylor & Mounfield (1994) also find that women have less computer experience than men. This study finds that taking secondary school computer courses is more significantly associated with success in the course for women than for men. Bernstein (1991) finds similar associations in her study of 51 management science students' success with a spreadsheet program. For women, having prior spreadsheet experience, or being comfortable with computers, is associated with better results on a spreadsheet test. For men, better test results are associated with strong mathematical ability, or seeing the task's relevance for their future career (p.57).

2.4.h.v. Computer culture

Moving from micro-level factors discussed above, such as attitudes, experience, self-confidence, and so on, some studies have examined computer culture, climate, and the kinds of gender politics associated with computer studies (Fisher *et al.*, 1997; Rasmussen & Hapnes, 1991; Bernstein, 1997; Henwood, 1996). These studies agree that

CS is a male domain with a masculine culture. Exactly what comprises that culture and how it affects women's experiences are explored using ethnographic qualitative methods.

Rasmussen & Hapnes (1991) interviewed students and teachers at one university where female students comprise only 8 – 10% of the total enrolment in CS. They find that the CS culture is a complex network of several distinct cultures: the female students; the hackers; the dedicated students; the professors and teachers; and the 'normal' male students (p.1109). The general finding of the researchers is that two all-male groups – the dedicated students and the hackers – have the strongest connections with professors and teachers (also all-male). These students are characterized by women CS students as "key-pressers," computer nerds who sit for long, long hours at the computer, and have a fascination with the machine that amounts to an intimacy the women feel should be reserved for other humans (p.1109). Three dominant CS values are shared and promoted by the two male groups and the all-male faculty: "machine fascination and interest in the possibilities of computers; work addiction and total absorption in computers; [and a] playful attitude towards the computers" (p.1117). The women in this study hold values and interests at odds with the dominant CS culture, and accept marginalization as the inevitable result of not sharing the three dominant CS values.

Henwood (1996) argues that women's acceptance of marginalization may be related to well-intentioned but ill-founded interventions and ideologies of WISE (Women into Science and Engineering). Although Henwood does not focus solely on women in computing, her findings are relevant. She defines the dominant discourse of WISE as comprising the following elements: the responsibility for women's underrepresentation

lies with women themselves (lack of qualifications); women should be in science and engineering because of a desperate shortage of workers (last resort); women do not enter these fields because of lack of information; and the masculine *image* of science and engineering needs changing, not the reality of a masculine *culture*.

Henwood interviews 16 women and six men from both a traditionally female-dominated and a male-dominated course[5]. She finds that, while women may not know specifics about jobs, the heavy work does not discourage them; rather, they recognize and are deterred by the potential male hostility toward women who do non-traditional work. They believe they will constantly have to prove themselves to male coworkers and employers. Interviews with women working in science and engineering confirm that this is women's experience. On the other hand, women believe that work identified as masculine has higher status in society. Hence, they are attracted to it and do not actively work to feminize it. The WISE ideology that women are needed to fill shortages, and that only lack of qualifications hinders their participation in this work, may have the unintended consequences of limiting women's freedom to confront the power inequalities and sexism of science and technology work (Henwood, 1996, p.212).

The findings are similar for Fisher *et al.* (1997), although this study is still in the early stages. Women agree that the CS culture is a male one, but some find the male culture to be problematic and others feel comfortable with it. Those who report discomfort cite causes such as unwanted romantic attention in the labs, being treated with disrespect because they are women, and a general sense of alienation (p.109).

Building on the notion of a masculine computing culture, Camp (1997) statistically analyzed women's enrolments in CS programs housed in engineering colleges or in arts and science colleges. She finds that there are significantly fewer women graduating from CS when the department is in an engineering college (p.108). She argues that engineering culture is even more masculine than CS culture; therefore when the CS program is associated with engineering it is less attractive to women than it would otherwise be.

Taking the position that women's high attrition rates from CS may be related to discomfort with computing culture, Bernstein (1997) reports on one university's innovations to make students more comfortable and knowledgeable about computing culture by adding "computing culture" content to first year CS classes. Including a discussion of computing artifacts such as books, movies, salary data, Web sites and electronic lists, electronic resources for women, and so on (p.102), this innovative part of the curriculum set out to expose students to both popular and professional computing culture outside the university. Informal response assessment finds students "overwhelmingly positive" about the process (p.103). No data are provided on attrition rates.

These studies show that masculine values prevail in CS culture. For some women who accept and are comfortable with those values, no negative effect is reported. Women who reject the masculine values and feel uncomfortable with the CS culture accept their own status as marginal: an alternative culture is rarely envisioned or

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[5] The female dominated course is a "Diploma for Personal Assistants," and the male-dominated course is a

advocated. The implementation of initiatives to introduce computing culture into the first year CS curriculum indicates a possible shift from the dominant value of "machine fascination" to a broader focus that includes exploring the social and cultural impact of computers. Whether that shift becomes widespread, and whether it has an impact on enrolments and attrition rates is unknown at this point.

2.4.h.vi. Motivations

What motivates students to enter CS and to remain in the field once there? Researchers find various answers to this question, but all agree that, most importantly, students enter and remain in fields that interest them (Fisher *et al.*, 1997; Geenens & Rao, 1992; Durndell & Lightbody, 1993; Lips & Temple, 1990). The studies reported here: 1) compare motivations of men and women; 2) compare motivations of students at various levels of university; and 3) explore why students are *not* motivated to enter CS.

Fisher *et al.* (1997) find that interest is the only very strong motivator for men, whereas women also cite class experiences and a "sense of the promise of the field and its future" as strong motivators to enter CS (p.108). Men cite class experiences, influence of peers, and game-playing as important reasons for staying in CS, but not as strong motivations to enter. Games and peers are not important motivators for women, although being encouraged is important for retention in CS (p.108-9). Separating international women from U.S. women, the authors find international women are motivated to enter and stay in CS for pragmatic reasons, and because of the connection of CS to mathematics, science and engineering. Interest is not as critical for the enrolment

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"Higher National Diploma in Software Engineering" (p.204).

of this group of women, but does play a part in motivating them to continue in the field (p.109).

In a study of 311 undergraduate students, Lips & Temple (1990) find that both women and men are directly and strongly motivated to enter CS by comfort and confidence with computers. Like the other studies described here, the authors find interest and enjoyment of computing to be strong motivations to enter CS for both men and women, but they find gender differences in other motivations. Men are motivated by self-confidence in their math abilities, whereas women are motivated indirectly by formal experience with CS, resulting in greater enjoyment of computers and increased motivation to enter CS.

Geenens & Rao (1992) compare motivations of sophomores with seniors in a beginning computer course. Sophomores do not agree as strongly as seniors that interest is the most important motivator for selecting a major at university. They also are more likely than seniors to feel that high school experience is sufficient to choose a major (p.26). Seniors disagree that high school experience is sufficient to help students select a university major. These differences in perceptions suggest that the motivation of high school experience diminishes, and interest becomes a stronger motivation as students progress in university.

Geenens & Rao (1992) also find that students underestimate the average starting salary of CS graduates (p.27). Given women's motivation by the promise of the field, and international women's pragmatic motivations for entering CS (Fisher *et al.*, 1997), this underestimation may have a greater impact on women than men.

There may be some problems associated with asking students why they choose *not* to study CS, since there may not have been a conscious process involved in the elimination of CS as the choice of study. Nevertheless, Durndell & Lightbody (1993) ask this question and find the strongest disincentives for both males and females are: "I do not want to be sitting in front of a terminal all day;" "the subject matter would not be interesting;" and "I am more interested in people than objects" (p.335). The strength of these factors does not change significantly over time (1989 – 1992). A significant gender effect is found on one item: males, more than females, report the prospect of working in an all-male environment as offputting. It is difficult to interpret the latter finding. The authors suggest that this means that fear of male domination is not an important issue for women (p.336). It could also mean that the men who *do* enter CS are those who like or prefer all-male environments.

2.4.i. Overview of Post-Secondary Factors

At the post-secondary stage, structural factors are found to be important. Both affiliation of CS with departments other than engineering and all-female groupings appear to facilitate women's enrolment in computing education. Whereas at the elementary stage behaviour was studied in relation to all-female groupings, and at the secondary stage the effect of all-female groupings on attitudes were studied, at the post-secondary stage research on all-female groupings focuses on social facilitation. Social facilitation is found to impact positively on task scores, attitudes, and cooperation of women in all-female groups. Non-comprehensive results indicate that the nature of assessment and timing of feedback may be important for reducing women's attrition from

CS education. The research on motivation is not conclusive. Students may be motivated by interest, but some students cite other motivations, such as experience and having a mentor.

Stereotypes about CS and sex roles continue to be problematic at the post-secondary stage; however, at this stage the findings are not conclusive. Some studies find that these factors are not applicable to their samples. More conclusive are findings on the masculine computer culture. Non-comprehensive studies report women's perceptions of computing as a male domain. That perception may account for women's significantly lower enrolments in CS departments in engineering colleges.

As at the elementary stage, previous experience is associated with more positive attitudes to computing and may lead to lower attrition. Other attitude research at this stage indicates that women have lower self-efficacy with respect to computing, but are encouraged by having fathers as role models. Role models may not necessarily be encouraging to women.

Although there are many more studies at this stage than at earlier educational stages, the need for comprehensive research is clear. Many of the studies are carried out on first year students who are convenient rather than representative.

2.4.j. Work Factors

This section provides a sampling of the literature on women working in computing. The methodological problems identified in the education literature are not found to the same extent in the work literature. The research on gender and computing work tends to

be more comprehensive, often using large, random samples, or strong comparison group designs. For this reason, and because of space limitations, the review of the work literature is organised as a more general review compared with the detailed discussion of the education literature. The research we will examine asks what factors affect women's work experiences in computing.

The literature tends to focus on two important issues in women's computer-related work experiences. First, men earn higher wages than women doing similar work (Heywood & Nezlek, 1993); and second, computer-related work is sex-segregated (Ranson & Reeves, 1996; Donato, 1990). Potential explanations for these two issues include: human capital differences (i.e., do women have less education and experience than men, and does that explain wage differences and segregation?); sex discrimination; lack of mentors and role models; gender socialization; and social control (i.e., the use of attitudes, culture, guilt and ridicule, among other things, to control the number of women who enter male-dominated occupations). This section gives a summary of the research into each of these explanations.

2.4.j.i. Human Capital

Studies of computer professionals in the United States in the 1980s find women in the lower paid, lower prestige computer-related occupations (Ranson & Reeves, 1996), despite having made significant early contributions to computing (Gurer, 1995, 1996). The human capital explanation for women's lower wages and segregation in less prestigious occupations places the responsibility for women's lower status on their lack of investment in education and training. When women are less likely to pursue a

university degree in CS, they will not qualify for the higher status and higher paying occupations in computing. Where women are equally educated and possess similar levels of experience, this view suggests, women will hold equally prestigious positions to men, and claim equally high wages. The recent studies that compare women and men with similar human capital find that women's lower average wages and their segregation in lower status computer work cannot be explained completely by human capital differences. Women with similar human capital to men earn less and tend to be segregated in lower paying, lower status jobs. Although educational credentials and experience are requirements for entry into certain occupations, getting these credentials and experience is not sufficient for entry, nor for predicting where women will work, or their incomes.

In an early study of three computer occupations, Donato & Roos (1987) find that human capital is the most significant predictor of wage differences for men and women. Testing this theory, Ranson & Reeves (1996) find that human capital differences among computer professionals in 14 Canadian work organisations can be traced to selective recruitment: men are hired for skills required to move up the occupational ladder, whereas women hired for similar positions require only the skills for the immediate job. This phenomenon is especially true of those companies in their study that have greater than 35% female computing professionals. Companies with less than 35% female computing professionals are more likely to restrict women's entry at the point of recruitment, but are less likely than those with greater proportions of women to close off women's opportunities for mobility once hired, or to hire women with distinctly different

qualifications than men (Ranson & Reeves, 1996). Ranson & Reeves conclude, "if recruitment is so organised that the only people with the right qualifications will *always* be men, then the relationship between human capital and management positions is spurious; a human capital explanation simply masks discrimination – through gatekeeping – at another level" (p.182).

Human capital differences are explored by Wright (1994) for their effect on wages and segregation among computer workers. Looking at seven computer occupations that satisfy the definition of providing "support for others people's use of computer systems" (p.9), she finds that male and female computer workers are not significantly different in educational background, and, in fact, women workers are more likely than men to take ongoing studies relevant to their work. Human capital is not a satisfactory explanation for women's lower wages and segregation, when looking at computer professionals.

Burnell (1993) finds similarly that whereas women are, on average, better educated than men, occupational sex segregation disadvantaging women is significant. She argues that this finding supports the notion that women must have better qualifications than men to get similar jobs (p.150).

Once in the workforce, women with CS degrees are not being rewarded at the same level as men. Furthermore, where human capital differences do exist for men and women, these may reflect hiring practices that tend to take a longer-term view of men's career progress than women's. Women's place in the computer workforce may reflect their earlier educational choices, but the research clearly shows that educational

background is not a sufficient explanation for wage differences and occupational segregation based on sex. Whether women choose not to pursue a CS degree because they perceive that they will not be adequately rewarded is unclear.

2.4.j.ii. Sex discrimination

Inequities in wages that remain after human capital and segregation are controlled are generally attributed to discrimination (Ranson & Reeves, 1996; Donato & Roos, 1987). One way men maintain their privileged status in technological occupations is to differentiate themselves from women (Reskin, 1988). Emphasizing or creating differences between men and women is found to be a strategy in recruitment practices that favours hiring men (Cockburn, 1991).

Grundy (1994) describes the power and status differences of men and women in the computing department of a District Health Authority. She uses the phrase "sexist skill evaluation" to describe the higher value given to jobs men do over those done by women. In her study, she identifies "pure" types of work as those that are abstract and detached from the end-user. These higher status jobs tend to be appropriated by men in the department, and are seen as more prestigious than the "messy" work of dealing with the problems arising when the end-user becomes involved (p.361). The latter jobs tend to fall to women to sort out, and are seen as less prestigious, according to Grundy. She argues that segregation and wage differences may be explained by sexist skill evaluation which favours men and men's choice of work.

Burnell (1993) explores the notion that men have claimed technology as their domain. If that is the case, she argues, intensive use of technology should serve as a

barrier to women's employment in certain occupations and industries. She finds significantly higher *occupational* sex-segregation within high technology industries compared with low technology industries. Women are more likely to be segregated into lower paying jobs than men in high technology industries. Controlling for other factors, such as education, size of industry, age of workers, and self-employment ratios, she finds that technology is associated with greater occupational sex-segregation. Examining *industry* sex-segregation, Burnell finds that women are also significantly less likely to work in high technology industries compared with low technology industries.

Looking at the issue of technological change (versus the more static model above), Burnell finds that industries experiencing greater technological change have greater occupational segregation; however, she does not find that women are underrepresented in those industries. She concludes (1993, p. 164),

> The process of technological change appears to result in the restructuring of labor markets along gender lines, in the sense that industries that undergo relatively rapid technological change have a greater degree of occupational segregation, other things being equal.

2.4.j.iii. Mentors, role models, tokens

Women's promotion into higher status, male-dominated work may be contingent on their access to a mentor. In a case study of information technology departments in two large organizations, Shapiro (1994) finds that both men and women are aware of the informal criteria and procedures required for movement up into senior management, but they learn of these informal requirements differently. For men, these informal requirements are part of their tacit knowledge of management. Women learn of the requirements from sympathetic senior management. This finding conveys the

significance of timely and effective mentoring for women in computing careers, although attempts to orchestrate mentoring for women have not always met with success (Pfleeger & Mertz, 1995).

As was the case for education, role models are not necessarily found to be positive influences for women starting out in the workforce, and may play a discouraging role for young workers starting out in computing work. Grundy (1996), for example, argues against the real value to women of role models. She observes that women in high status computing occupations have often achieved success by accepting uncritically the masculine culture of computing. Further, those observing these role models will see that they have had to struggle harder than men to get where they are, they may not be adequately compensated for their hard work, and they will not necessarily be rewarded by further promotion up the status ladder.

In the case of token women in work settings, Wright (1994) finds that the wage gap for computer professionals decreases as the proportions of women in the particular specialty increases. This supports the broader discussion in the women and science literature of a need for a critical mass of women in an occupation before changes in expectations, attitudes, and rewards occur (Byrne, 1993). In other words, the benefits gained by having token women in male-dominated occupations are minimal for women in terms of increasing wages or decreasing occupational segregation.

2.4.j.iv. Gender socialization and social control

For women in male-dominated occupations, their socialization to take primary responsibility for childcare and domestic duties creates added stress beyond the demands

of the job. Wright (1994) finds that more women than men choose part-time over full time computer work to have more time for family and home (12% of the women, 2% of the men in her national sample). An Association of Computing Machinery (ACM) study found that 21% of women computer scientists in their survey placed the need to integrate career and family as central to their career decisions (Igbaria, Greenhaus, & Parasuraman, 1991). These choices have obvious effects on wage levels and promotion opportunities, and may limit the kinds of jobs available for women requiring this kind of flexibility.

Difficulties balancing career and family responsibilities may be related to outdated assumptions of social support (Pearl *et al.*, 1990). The pattern of work leading to tenure at university, and to promotions in industry, generally involves tremendous amounts of time and energy devoted to work in the first few years after graduation. Pearl *et al.* (1990) argue that this work pattern was developed based on the assumption of a "helpmate-in-the-background" (p.53). While men may still have this kind of support, few women do. Accommodations such as parental leave policies and deferred tenure are positive steps to improving this situation; however, the persistent cultural expectation that mothers take the responsibility for parenting, rather than sharing that responsibility equally with fathers, may mitigate the positive effects of policies such as these (p. 54). Women's perceptions about their ability to overcome these obstacles and be successful in male-dominated fields may be more important than their actual ability or opportunity to do so (Breene, 1992).

Jacobs (1989) argues that women's entry into male-dominated occupations is controlled by other people's attitudes and the consistent, accumulated message that to do

so is deviant in our society. He uses a "revolving door" metaphor to illustrate women's movement in and out of computing work as they wrestle with their own interests and ambitions, and the social controls faced in the attempt to realise those ambitions.

Wright (1994) finds support for Jacob's theory of social control. Women move out of, and transfer between, computing specialties, at higher rates than men when education, experience and structural location are controlled. Women are more likely to be employed in the lower paying information systems jobs, leaving the engineering specialties for men. Wright argues that the masculine culture of engineering explains women's lower representation in the computer occupations most closely associated with engineering. Nevertheless, she finds that women are transferring to the higher-paying specialties at a higher rate than the reverse direction. For this reason, she argues that there is "controlled progress" toward less segregation and more equitable wage levels for women computer professionals. She does not extend this research to look at women in computer work more generally, however, and therefore does not address the larger question of segregation by occupation.

Grundy (1996) argues that women attempting to work in technological occupations, particularly computing, face intense scrutiny, ridicule and guilt. Pressured not to question the work norms that are fashioned after the "helpmate-in-the-home" model, women work long hours and then are criticised for neglecting their duties as wives and mothers. These cultural demands discourage women from continuing in computer work, or push them toward less demanding, lower paying computing occupations.

2.4.k. Overview of work factors

Whereas experience has had benefits for girls and women through the education stages, at the work stage, women's experience and education are not rewarded as one might predict. The research on human capital shows that, while lack of education and experience may limit women's participation in computer-related work, where women do make investments in these forms of "human capital," they do not see the benefits in wages and status of occupation that men see.

Explanations of women's lower wages include various forms of discrimination by sex. "Sexist skill evaluation" and the appropriation of the highest technological occupations and industries by men are discussed in the literature as discriminatory against all but a few token women.

As in education, the role of mentors is significant in helping women move up to higher status computing occupations. On the other hand, role-models and token women are not found to benefit women in general.

Studies find that sex-role beliefs and ideologies about work and family responsibilities influence women's work patterns. Many women's career decisions are influenced by the social expectation that they will provide primary childcare and take responsibility for domestic organisation. Choosing to work fewer hours, or in less demanding jobs, to accommodate childcare and home responsibilities impacts women's wages and may contribute to the sex-segregation of computer-related work.

2.5. Discussion

Three general patterns can be seen in the classification of research. First, more studies use post-secondary students as subjects than students at other educational stages, and more factors are tested at the post-secondary stage. This reflects the use of convenience samples of undergraduate students. Access to subjects affects what is studied and how the studies are conducted. When undergraduate students are used as subjects, the methodology is often to distribute questionnaires and do quantitative analysis of the results. Consequently, most research at the post-secondary stage is non-comprehensive and quantitative.

Secondly, the vast majority of studies in the education stages are non-comprehensive. Where the findings are strongly significant, or where several non-comprehensive studies find similar results, these studies provide support for the importance of a factor, and are therefore enclosed in a solid line (Figure 2.1). Nevertheless, the findings are preliminary and require further, more comprehensive study. At the work stage, the research tends to be more comprehensive.

A third general pattern is the increasing focus of research into social psychological factors at higher education stages. There is only one study that identifies girls as having less self-confidence assessing software at the elementary stage. At the secondary stage several studies find a relationship between experience, or diversity of experience, and more positive attitudes to computing. At the post-secondary stage, research explores in more detail the specific attitudes that are affected by experience,

encouragement, role models, and structural factors. What motivates and interests women in computing is studied at this stage. In general then, the focus of education research appears to move from an emphasis on structural factors at the elementary stage to individual factors at the post-secondary stage. At the work stage, attitudes and motivations are no longer the focus of research. Other than socialized sex-role research, the studies at the work stage focus mostly on behavioral and relational issues.

2.5.a. Structural factors

The factor designations in parentheses (see Figure 2.2) indicate that structural factors (H) have been studied at all three educational stages. Structural factors include education policy, curriculum, and organization of CS departments (their affiliation and gender groupings). Education policy has been studied at the elementary and secondary stages, but there is no research on this structural factor at the post-secondary stage. Although gender-equity policies have the potential to create opportunities for girls, the Reinen & Plomp (1993) study finds that policies are directed more at increasing role models than at increasing access or opportunities for girls.

Across all educational stages, direct or indirect benefits of all-girl groupings for girls have consistently been found. At the elementary stage, all-girl groupings improve task performance and other behaviours, such as asking for help and staying on task longer. Studies at the secondary stage focus more on the effect of all-girl groupings on attitudes, and find that girls' attitudes are more positive in all-girl groupings than in mixed groupings of students. This effect may be indirect through girls' access to greater diversity of experience in all-girl schools. At the post-secondary stage, the

benefits of all-female groupings relate to social facilitation: women encourage one another in their computer work when grouped together.

Although there is no evidence that women will go on to post-secondary education in computing if they have experienced the benefits of all-girl groupings, the immediate benefits for women may encourage them to consider computing as a viable option. For women who are in post-secondary CS education, working with other women provides social support in the program. Women's lower enrollments in post-secondary CS programs affiliated with engineering suggests that women are discouraged from enrolling when the culture of the program is more masculine. Given the consistent finding of benefits for girls and women, efforts should be made to consider how to structure all-female groupings into computer education. Since CS is a male-dominated occupation, this option should perhaps be part of a larger, mixed curriculum plan for CS education.

Diversity of curriculum is comprehensively studied at the elementary and secondary stages. This research indicates that most countries have little diversity in the computer applications taught to students. Since other studies find that software is male-biased and that bias may be discouraging to women, curriculum should be reassessed and consideration be given to ensuring that software used is not gender-biased. Further, increasing the applications of computing to better reflect interests of all students should be a priority for CS programs. At the post-secondary stage, the importance of early feedback on performance for women should be studied more comprehensively to identify whether early feedback would have a positive effect on women's confidence and

computer attitudes. Would this structural change decrease attrition rates and increase women's grades, as early evidence suggests?

2.5.b. Role models/mentors

We know from the research that there are few female role models for girls and women in computing at the elementary and secondary stages. The effect of having few role models on enrollments in CS is unclear, however, especially since there is some confusion in terminology. Sometimes a role model (a person in computing with whom girls and women can identify) is confused with a mentor (someone who takes an interest in a student, provides opportunities for her, and encourages her to continue in computing). Whereas role models for girls would usually be women, mentors can be men or women who take an interest in the student. The research does show that women are encouraged to enter computing by a positive secondary school experience in computing, which may reflect having had a teacher who mentored them. We also know that women at the post-secondary stage are encouraged by their female peers. In contrast to these kind of mentoring relationships, role models are not found to be conclusively beneficial for women, since those at the secondary stage with mothers in computer-related work are discouraged from pursuing CS by those role models. At the work stage, mentoring is found to be important. Further research into the effect of role models and mentoring is required, especially at the elementary and secondary stages where early mentoring may have a significant impact on girls considering careers.

2.5.c. Culture and sex-stereotypes

There are no studies on computing culture at the elementary or secondary stages, but the early development of a masculine culture is reflected in the choice of male-biased software and sex-role stereotyping. While beliefs about the appropriateness of computing for males and females at the elementary stage are not clear, by the secondary stage boys are found to have much more sex-stereotypical attitudes to computing than girls. Several studies find that this difference becomes greater with more computer experience. This suggests that by the secondary stage, girls not only have to deal with being a minority in computing classes, but they also face a majority of students who believe men do computing better than women.

At the post-secondary stage, these sex-role beliefs translate into a masculine computing culture that causes women to feel uncomfortable in computer labs and classes. A study of college affiliation of CS programs (Camp, 1997) shows that women are conscious of the masculine culture and try to minimize its impact by choosing schools with CS in non-engineering colleges. Not only are women aware of the masculine culture, but they have negative masculine stereotypes about the men who study and work in computing. The typical stereotype of a computer scientist is not an attractive image for women.

On the other hand, the broader, cultural expectations placed on women to take responsibility for childcare and domestic duties leads some women to pursue jobs with flexible hours and part-time work, and hence have a negative impact on wages. The view that women in male-dominated work are deviant may underlie the sex-segregation of computer-related work.

Misperceptions about computing are found at the secondary and post-secondary stages. At these critical stages, when women are choosing their careers, more information and exposure to the reality of computing work is suggested by these findings. Although no studies are available on this issue at the elementary stage, exposing young students to computing work may also be important for attracting more women to computing by motivating them to acquire the experience and confidence in computing that is found to be significant at later stages.

2.5.d. Experience, attitudes and interest/motivation

As mentioned above, the research on these individual factors increases at each successive stage. In most studies, no causal relationship is found between attitudes and enrollment in CS. Some studies show that experience, such as an introductory computer course, affects attitudes positively. Another potentially important factor is that women's self-efficacy with respect to computing grows the longer they stay in the CS program.

Experience and an interest in computing are found to motivate women to study computing. Women who are encouraged by a mentor have more positive attitudes and are more motivated to study computing. At the work stage, mentoring helps women to learn the informal procedures necessary to move up the occupational status ladder. The gains to women from having more computing experience do not carry over into wage levels at the work stage, however. Where women have comparable human capital – education and experience – they still receive lower wages than men.

2.6. Conclusions

It is evident from the classification that more research is needed before we fully understand why women's proportional representation in CS is decreasing. More comprehensive studies in education are needed if we are to draw general conclusions from the research. Also, research on computing culture and sex role beliefs should begin at the elementary stages where sex-stereotypical beliefs are forming. Structural changes need to be made based on comprehensive research on policy and curriculum.

A closer examination of women's computer-related experiences over time will improve on past research that takes a more static look at this complex issue. This review categorizes studies by life stage to identify how closure may be occurring at different times in women's lives. To assess the pattern of women's enrollments and attrition from CS as a process over time requires examination of the education and work histories of individual women, and of general trends in women's education and work experiences over time. Based on the findings in the literature, and the theoretical perspectives set out in the following chapter, I will propose a testable model to explain the process by which women end up a minority in computer education and occupations (see Figure 3.1). My qualitative interviews and quantitative analysis will assess parts of that model.

Chapter 3: Theories of Closure and Control

As the use of computer technology constitutes an increasingly significant part of our everyday life and work, several questions arise. How does this technology impact on women and men? How are various computer-related technological occupations distributed in society? What statuses are these occupations given by society? What strategies are being used by various groups to gain or maintain powerful technological positions in the computing field? Since all technology affects our environment, our health and well-being, how men and women share the responsibilities and benefits associated with technology needs to be examined.

In the following section I will begin by defining technology generally, show how it has been historically associated with power, and show how the association of technology with power is gendered. Then I will outline three theories that have been used to explain male dominance of technological education and work in general: dual systems theory, social closure theory, and social control theory. I discuss the potential relevance of these theories to the question of why women's proportionate enrollment and degrees received in CS are declining. Finally, I propose a testable model that builds on and extends the theories discussed here (see Figure 3.1).

3.1 General background to gender, technology and power

3.1.a. Technology defined

In its broad form, technology has been defined as "practice," or "ways of doing

something" (Franklin, 1990; Boulding, 1969). Since this definition of technology is very general, Franklin argues that it is best when not speaking in general terms, to refer to a specific form of technology, such as high, computer, or management technology (Franklin, 1990). Following Franklin, when a specific kind of technology is being referred to in this study, it will be qualified.

Technology is not only machines and tools: it can also be understood as a social process encompassing the design, development and application of machines, or simply a method of doing something (knitting, for example (Franklin, 1990, p.16)). Hacker (1989) defines technology both materially and relationally as: "The organization of material and energy to accomplish work" (p.7; see also Hacker, 1990:213). Likewise focusing on a social definition of technology, Marx explains the social relations of technology as part of a macro theory of social conflict and change. Within the context of capitalism, technology includes the introduction of machines into industry, a process that displaces human labour and increases productivity (Marx, 1967). Technology is part of the particular means of production used in the domination of nature at any time in history, and gives rise to certain relations of production between those who own the technology and those who do not (Hunter, 1981:17). Given this basic definition, which places machines in the social context of human relations, what is the relationship between technology and power?

3.1.b. Technology and power

From a theoretical perspective, technology has long been associated with power; at the most basic level, those who have plows have an advantage over their neighbours

who only have their hands, or sticks, with which to prepare soil and plant seeds. Marx saw power in both the material instruments of labour and the social relations of production. He argued that technology in the form of machinery is a method of social control used by the capitalist to subdue the labourer:

> But machinery not only acts as a competitor who gets the better of the workman, and is constantly on the point of making him superfluous. It is also a power inimical to him, and as such capital proclaims it from the rooftops and as such makes use of it. . . for repressing strikes. Marx, 1967:410

Ownership of technology, or the instruments of labour, gives one power over non-owners and over nature (p.481). This power relationship is at the root of the conflict that drives the progress of history (Engels, 1972:14). Technology raises the degree of exploitation of workers, further dividing the capitalist and working classes (Marx, 1967:373). In this process, science and technology become "weapons of domination in the creation, perpetuation, and deepening of a gulf between classes in society" (Braverman, 1974:6). Technology is closely linked with power, and the role of engineers or those with technological expertise is crucial to that power relation (Bell, 1973:115).

3.1.c. Technology, power and gender

Technological occupations have historically been a male domain. In *The Origin of the Family, Private Property and the State* (1972) Engels draws on archaeological, anthropological and historical evidence to show the process through which women eventually were restricted to low technological work - preparing food, clothing, shelter - whereas the higher technology associated with metal work was reserved for men. Restrictions on women's work were associated with the institution of private property

and the shift to male dominance in other areas of life arising from men's desire to pass their property to their own children. The shift meant male charge over marriage and property, and control over political and religious life. Cockburn (1992) maintains that, given the male control over these other sources of power, it is not surprising that the more powerful forms of technology associated with the production of tools, weapons and the military were dominated by men (Cockburn, 1992:199).

Cockburn (1992) traces the history of technology from the early ages designated by archaeologists according to the "material of the dominant technology: stone age, bronze age, iron age" (p.196), noting as did Engels, the growing gendered division of labour associated with the change from early kinship-based communities to hierarchical, agricultural societies characterized by warfare and forced labour. To explore why power becomes associated with the technology used by men, she looks at how ownership of the means of production - tools, implements - defines class power, and how this power is often associated with the male domain of power, the military. Further, she notes that those whose skills enabled them to produce tools, implements and weapons were in a position of power over all those dependent on them for these objects. Those who are in control of the technology are more powerful than those who depend on others' skills to acquire the tools they need.

Moreso than other non-owners, women of all classes were dependent on men on whom they counted both for their basic family needs, and for the tools with which to transform nature into food, clothing and shelter (Cockburn, 1992:199). Whether in the home or workplace

> since the bronze age, women have worked *for* men, . . . It is clear that they also produced *by means of* man-made technologies. They were subject to that particular form of material control that comes of men as a sex having appropriated the role of toolmaker to the world. Cockburn, 1992:201

Where women have moved into the "toolmaker" role, their entry and participation is subject to other kinds of controls. For example, Witz (1992:30) considers the power situation of women in technological professions such as engineering and the military: "Which mode of control prevails [over female labour] depends upon a number of factors, such as the structure of local gender relations, rates of technological change, and the nature of industrial and occupational expansions." What the controls are, and when those controls are most critical to women's participation in technological education and work have not been fully explored.

The dominance of men in technology cannot be explained simply. We will consider three social theories that have been used to explain women's underrepresentation in science and technology, and in male-dominated occupations in general. First, dual-systems theory explains an overall pattern of male and profit-motivated control in society. Social closure theory attempts to explain how this control excludes and segregates women by restricting access to credentials. Social control theory argues for an expanded understanding, beyond credentials and discriminatory policies, to a series of social controls that reinforce sex-segregation over the life course.

I end the chapter by proposing an application and extension of these theories to the situation of women in computing. Here I present a model of social closure/control that describes a process whereby women are gradually, in various ways, closed out of participation in computer education and work over the life course.

3.2 Theoretical approaches

3.2.a. Dual-systems theory

Witz (1992) argues that the sexual division of labour can be explained by a dual systems model of capitalist and patriarchal relations. Dual-systems refers to capitalism and patriarchy as two different, but related systems of exploitation[1]. She argues that the two systems interact (p.25), and that they are based in material conditions, a point she draws from Hartmann's "*materialist* formulation of a theory of patriarchy" (Witz, 1992:16; Hartmann, 1979). She concludes (Witz, 1992:25):

> The complex interrelationship between patriarchy and capitalism . . demonstrate[s] how both employers and working men espoused an ideology of female domesticity and . . . turned this to their own material advantages; employers to justify paying women less than men, thus facilitating the use of women as cheap labour, and union leaders to resist the employment of women, . . . thus maintaining their patriarchal privileges in both the workplace and the home.

Relating this to the case of CS and other powerful technological occupations, the ideology is one that associates technology and technological competence with being male. The consequence is that these occupations are filled primarily by men (Cockburn, 1992).

There are times when historical situations, such as labour shortages or wars, set capitalist and patriarchal interests in conflict (Walby, 1986). Economic theory claims that market needs influence the extent to which women are allowed entry into male-dominated fields, overriding cultural factors (Witkowski & Leicht, 1995). This theory

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[1] Patriarchy is a system, not a description of individual male behaviour or attitudes; "a direct personal system of control was translated into an indirect, impersonal system of control, mediated by society-wide institutions" (Hartmann 1979, p.207).

has some merit; for example, during World War 2, when workers were scarce, women were encouraged to enter positions typically filled by men. Their entry into these typically male-dominated occupations was supported by new ideologies. For example, Milkman (1987, p.50) notes that:

> Wartime propaganda imagery of "woman's place" on the nation's production lines consistently portrayed women's war work as a temporary extension of domesticity. And jobs that had previously been viewed as quintessentially masculine were suddenly endowed with femininity and glamour for the duration.

Child care arrangements were also offered, freeing women to work outside the home. After the war the ideology of the "man as breadwinner" again prevailed. Those women who still needed to support themselves were compelled to take lower paying, typically female-dominated work deemed to be more "appropriate" for women (Milkman, 1987). That market needs are not the only influence on women's work opportunities is evident in the overall benefit to men from this series of events. Patriarchal ideology is also at work here. The dynamic relationship between capital and patriarchy demonstrated by the war and post-war gender division of labour is instructive for our understanding of the situation of women in computing. The constantly changing situation of computing and the current labour force shortage of information technology workers point to the potential importance of ideology for women's participation in computing education and work.

Other than a few exceptional cases, women have not been very successful in achieving positions of power in patriarchal societies; few women are in corporate management, in high-level politics, or in technology-related occupations (Gutek, 1993).

Beyond the cultural barriers that keep women out of positions of authority over men (Clement & Myles, 1994), science and technology-related occupations carry with them the ideology of technology as a male domain. Nevertheless, within the CS community some see the computer as empowering to women (Cherny & Weise, 1996), and there is some support for this notion. For example, women are increasingly joining online discussion groups and lists[2]. The use of computer technology has, for some, reduced the barriers of gender, race, and ethnicity at the level of individual interaction (Kendall, 1996:207).

Despite individual testimonies to empowerment through computers, however, there is ample evidence that technology is a male domain. For example, Borsook (1996) did a content analysis on the computer magazine *Wired*, and found that the percentage of women authoring stories, as subjects of feature articles, or listed on the mastheads were significantly lower than the percentage of women on the Internet. Coyle (1996) argues that the cultural bias that associates technology with masculinity is distorting the fact that women are actively using computer technology at home and work, so that "we will never see the women who are making a contribution" (p.45). As evidence of this bias, Spender (1995) asked teachers to rate boys' and girls' abilities on computers, based on descriptions of their behaviour. Spender then reversed children's gender identification so that the descriptions told of girls doing what the boys had been described doing previously. She found that no matter what the children purportedly did, the teachers

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[2] "The CommerceNet/Nielson Internet Demographics Study revealed that males represent 66% of Internet users and account for 77% of Internet usage," however. (Universal Access Office "Gender and the information highway")

agreed that the girls lacked confidence and were not good with computers, whereas the boys were confident and competent with computers (p. 179-180). Although some individual women are finding computing and computers empowering to them, the ideology of computer and other forms of technology as a male domain remains and is perpetuated through practices in the education system and in popular culture.

Clement and Myles (1994) use statistical analysis of work and domestic power relations to examine questions about the connection between neo-patriarchal power relations (a term that refers to males dominating in the highest positions and women only ruling other women) and class power relations. They contend that gender affects and permeates class interests. They note two major changes in contemporary capitalism: (1) the growth in the service industry, and (2) the increased numbers of women in the labour force (p.123). Drawing on the work of Wright (1985, 1989), Acker (1988), and Smith (1989), they find that (Clement & Myles 1994, p.140),

> what we have been calling class relations are not just class relations and what we have been calling a class structure is more than a class structure. Relations of power and authority in the modern workplace exist not only to regulate relations between capital and labour but also to reproduce a particular way of organizing relations between men and women.

Dual-systems theory helps explain the pressures of patriarchy and capitalism on the behaviour of women and men. To understand women's declining enrollments in CS, this perspective indicates two important considerations. First, the role of ideologies that help control the educational and occupational choices of women and men should be considered if we are to understand this phenomenon. Second, the impact of historical and structural factors on the opportunities open to women must also be examined in relation

to this issue.

Dual-systems theory describes an overall system that results in men holding the highest level, most powerful occupations. How exactly is this result accomplished? The next section turns to social closure theory to explain more specifically how closing access to certain occupations increases the value of those occupations in the labour force, and how gender is a critical criterion for entry into many occupations.

3.2.b. Social Closure Theory

Studies have documented the kinds of processes used to restrict access to the knowledge and skills of professions such as medicine, law and engineering (Witz, 1992). Witz (1992) refers to this monopolization of knowledge and skills as "social closure;" occupational closure signifies the process of closing, or restricting to a limited group, access to certain occupations.

3.2.b.i. Social closure defined

Parkin (1979) developed Max Weber's initial conceptualization of social closure, defining it as "the process by which social collectivities seek to maximize rewards by restricting access to resources and opportunities to a limited circle of eligibles" (Parkin 1979:44). Parkin expands this concept to describe three forms of social closure, each related to power and the struggle for dominance (p.45): exclusionary closure, usurpationary closure, and dual closure. In brief, exclusionary and usurpationary closure are oppositional; the former is an attempt to exclude groups by restricting access, usually to property or occupations, while the latter is "that type of social closure mounted by a

group in response to its outsider status and the collective experiences of exclusion" (p.74). Dual closure occurs when those who have been excluded use usurpationary closure against the dominant class, and also use exclusionary closure against less organized groups (e.g., workers who try to exclude women or certain ethnic groups from their workplace). Social closure is not necessarily a description of particular, individual practices; rather it is a conceptual tool for explaining certain processes that restrict some groups from positions of power and enable other groups to gain monopolies over certain skills and resources.

3.2.b.ii. Social closure, technology and gender

Witz (1992) applies social closure theory to occupational sex-segregation. She identifies social closure in occupations taking the form of either occupational segmentation (men and women working in different sectors, such as construction versus teaching) or sex-segregation (within the same organization, men and women work in distinct positions, such as men in management and women in clerical work.). Witz chooses a historical methodology to study the ways "men have organised and acted to limit and control the terms on which women participate in paid work" (p.36). Specifically, she traces the use of closure strategies, adapted to fit women's experiences[3], in various professions, over time, showing how sex-segregation of occupations has

[3] There are "three major modes of patriarchal control over female labour. First, an *inclusionary* mode, sustained by means of the family system of labour as a form of "internal contract" within sites of capitalist production, where the labour of women and children is under the control of the male head of household. Second, the *exclusionary* mode, where organized male workers collectively engage in attempts to preserve certain spheres of work together with privileged wage rates, justified by appeal to the ideology of the "family wage", for themselves and to prevent women from entering these male spheres of employment. Third, a *segregationary* mode where male and female occupations or jobs are demarcated by gender, thus creating a hierarchical gendered occupational order" (Witz, 1992, p.29).

maintained men's superiority over women at work and continues to provide cheap or free labour for the capitalist system.

Witz explains sex-segregation as: "the encirclement of women within a related but distinct sphere of competence in an occupational division of labour and, in addition, their possible . . . subordination to male-dominated occupations" (p.47). In her view, this kind of demarcationary segregation "directs attention to the possibility that the creation and control of occupational boundaries and inter-occupational relations may be crucially mediated by patriarchal power relations" (p.47).

If women are taking alternative routes to computing work, this may be an attempt at usurpationary closure – at gaining some of the income and status of computing work. In *Update: America's New Deficit* (1998, p.4), the United States Office of Technology Policy reports that only:

> one-third of people working in computer programmer employment hold degrees in CS, and about one-quarter of those in computer and information sciences employment hold computer and information science degrees. Other workers in these fields hold degrees in areas such as business, social sciences, mathematics, engineering, psychology, economics, and education.

It is not yet necessary to have a CS degree to do programming and other highly skilled computing work. In the case of CS, the rapid technological changes and the expansion of computer technology into the service sector may delay the kind of exclusionary closure that has characterized other professions such as law, medicine and engineering. There is, however, a strong movement in the Canadian association for computer scientists (Canadian Information Processing Society (CIPS)) to form a professional body: "The CIPS Certification Council is dedicated to establishing a registered and regulated

information systems profession in Canada as well as to establishing the groundwork for a fully licensed profession" (CIPS, 1998). While there is as yet no formal professional body that regulates and licenses computer scientists, it is still likely that higher income levels and advancement in computing careers are linked to having CS credentials.

Where dual-systems theory tells us that ideological, historical and structural factors work to benefit men, and to increase capital, social closure theory describes a more particular process that leads to monopolies over certain kinds of work. Social closure theory focuses primarily on the impact of historical events, policies and credentials on access to occupations. Social control theory, to which we now turn, argues that there are many formal and informal social controls over the life course that contribute to occupational segregation. In essence, social control theory looks more closely at the processes leading to social closure of occupations.

3.2.c. Social Control Theory

Jacobs (1989) introduces social control theory to explain educational and occupational sex segregation. He finds that while occupational sex-segregation remains fairly constant overall, there is significant mobility of individual women into and out of male-dominated occupations. In the United States, the number of women leaving tends to be slightly less than those entering male-dominated occupations overall; hence he finds very slow progress toward reducing occupational sex-segregation in the last twenty years. Jacobs argues that both formal and informal social controls work throughout the life course to maintain segregation, despite women's entry into male-dominated occupations. Like social closure theory, social control theory argues that other forces beyond

individual choice are at work in maintaining occupational sex-segregation. Rather than occurring at a decisive moment, women are segregated from male-dominated occupations by a gradual process involving mobility into and out of male domains as different social controls operate over the life course.

Two controls typically understood to contribute to sex-segregation are early socialisation and human capital deficits. Jacobs provides convincing evidence that other factors beyond socialisation and human capital are at work. Jacobs finds that the effects of early socialisation are not enduring; early socialisation is a social control only for a while (p.89). Examining sex-typing of aspirations and occupations, he documents the instability of students' aspirations and measures women's mobility into and out of male-dominated work. He shows that, although at some point in time women usually aspire to work at some female-dominated occupation, they also aspire to male-dominated work, and many do work in male-dominated occupations for a time. This belies the notion that only a few women enter male-dominated occupations and those few remain there over their working lifetimes. In fact, Jacobs demonstrates that many women enter male-dominated occupations, stay for a short time and leave, usually to female-dominated or sex-neutral occupations. Early socialisation theory assumes values and preferences that are fairly stable over time. Based on Jacobs's statistical analysis, and supported in a recent replication (Levine & Zimmerman, 1995), this is not the case: aspirations and work preferences are surprisingly changeable and do not adequately predict occupational achievements.

Human capital theory assumes that women are not adequately skilled to work in

male-dominated occupations. Since women do move in and out of male-dominated work, the human capital explanation for sex-segregation is also inadequate alone. Further, those women who do have credentials do not receive equal pay and job status in comparison to men with similar qualifications (Rees, 1992).

If socialisation and human capital do not adequately explain ongoing sex-segregation, Jacobs argues, other forms of social control over the lifetime may help to explain it satisfactorily. Early socialisation explains part of the process, but ongoing pressures in educational and occupational settings reinforce sex-appropriate attitudes and behaviour. Looking specifically at law and medicine, he documents the impact of discrimination on sex-segregation. In both cases, he shows that when key historical opportunities arose for women's movement into these male-dominated occupations, women entered in significant numbers. For example, he finds a significant influx of women into medicine shortly after the Title IX Amendments to the United States' Higher Education Act of 1972. The amendments included an explicit forbiddance of sex discrimination in medical school admissions. In the next five years, three times the number of women applied to medical school than in previous years (Jacobs 1989, p.158). Women are sensitive to weakening discriminatory barriers and move into male-dominated occupations when they recognise opportunities opening up for them. He concludes: "It is an enduring and imperfect set of influences that allow a notable degree of mobility in both directions while maintaining the overall system of segregation" (p.104).

Although Jacobs documents the extent of sex-segregation over time, and proposes

social control theory to explain the constancy of that segregation, he only superficially explores what methods of social control are at work, and at what point in the life course they are relevant. The task of mapping out the controls that reinforce occupational sex-segregation is a difficult one. Noting the need for future research into the causes of patterns of sex-segregation found in his research, Jacobs suggests that socialisation, discrimination and historical opportunity may be important factors at various times in the life course (p.63). Dual-systems theory argues that patriarchal and capitalist ideologies control access to power, influencing the historical and structural circumstances that also act as social controls. Social closure theory emphasizes the significance of credentials, policies and historical events in controlling access to occupations.

Other research documents controls affecting the distribution of women in these male-dominated occupations. For example, research shows that sex-segregation is reinforced by advantages in training and promotion that accrue to males more so than females (Milic, 1994); the use of part-time female labour and lay-offs as a way to adapt to new technologies (Hacker, 1989); union non-representation of women; gender-role expectations (Horowitz, 1997); masculine cultures (Byrne, 1993; Fisher, Margolis, & Miller, 1997); and credentialist or legalistic tactics associated with "professional projects[4]" (Witz, 1992, p.195). Specific to computing, the research discussed in Chapter 2, and identified in the classification of factors, provides a starting point for mapping out the social closure process as a series of social controls over the life course.

Based on the classification in Chapter 2 and the theories discussed above, the first

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[4] By "professional projects" Witz refers to attempts to make certain occupations into professions.

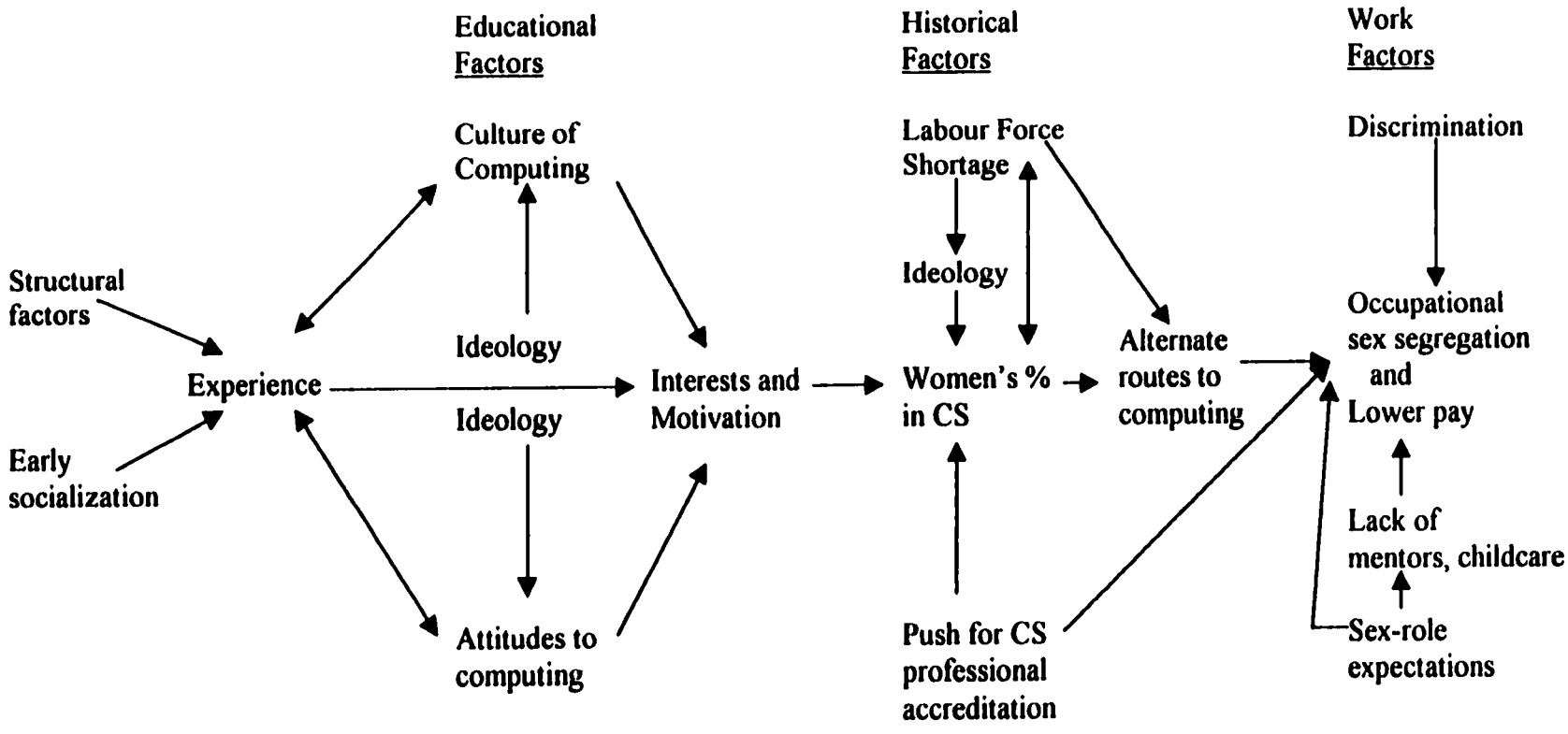
task of this dissertation research is to map out a hypothetical process of social controls over the life course that may be closing women out of university CS education, and that may impact their later work experiences.

3.2.d. Development of Social Closure/Control Model for women in computing

Although closure processes may be similar in other male-dominated occupations, the model I propose is specific to computing (Figure 3.1). It is based on the findings of research into this issue at various points in women's lives, and on the important considerations raised in the theoretical literature discussed in this chapter.

I test this application of the theories in this research. I identify social controls at work over the life course that may be affecting women's enrolments in CS and their segregation in lower paying computer-related work, and present these in a testable model of social closure/control. How do education, experience and work histories of women and men fit this model of social controls? What happens when women take alternative routes to computing work? Subsequent chapters will test and flesh out this model.

Figure 3.1 Model of the social closure/control process for women in computing



Chapter 4: Computer workers: Geeks to super-technologists

4.1. Introduction

The social closure model suggests that ideology is a potentially important factor influencing women's educational choices and their participation in the labour force. In the last chapter I speculated that ideology might play an important role in at least two periods in the life course. First, ideology may help sustain through the educational stages the controls of sex-appropriate behaviours and values learned in early socialisation. Second, ideology about CS and computer scientists may be controlling women's representation in CS in spite of labour force needs.

In this chapter I assess whether there is support for ideology as a control at these stages, and examine other critical points of ideological control. I use qualitative data to explore the significance of ideology and to ascertain at what points, if any, ideology affects women's decisions. More specifically, the questions I ask are:

> What do education, experience, and work histories of people working in computing tell us about the process of controlling and closing access to occupations in computing technology?
>
> What do these individuals' experiences tell us about changing societal values and ideologies?

This chapter presents the findings from interviews of men and women in a large, Canadian subsidiary of a software company. The interviews examined the education, experience and work histories of women and men working in computing occupations. To understand what lies behind people's choices to pursue one path to computing work over

another, I investigated the motivations, aspirations, personal histories, and beliefs of computer workers of various ages and skill levels, and holding a wide range of computer-related occupations.

Jacobs (1989) argues that research examining women's careers in "a dynamic framework" (p.189) - or at more than one point in time - is needed to understand the extent of the impact of social controls such as ideologies on sex-segregation. By asking respondents to provide their education, experience and work histories, I explored at what point in women's lives, if ever, ideology is an effective control over their ambitions to work in computing. Which ideologies are important at which points in women's experiences?

4.2. Methods

4.2.a. The setting

I was given research access to the Canadian subsidiary of a large software company. As a subsidiary, the Canadian company focuses more on marketing, sales and product support than on the actual research and development of the software. Although there are programmers who adapt the software for Canadian consumers, and who develop software for internal processes (e.g., Human Resources), the majority of the technical positions are in product support and in the fast growing technical consulting areas.

Approximately 350 employees work in the Canadian company: most in the head office, but some in various branch offices across Canada. The average length of time spent in a position within the company is 18 months to two years before progressing to a

new position. A fast paced culture, one Human Resources consultant described the situation for employees as "running at Mach 2 with our hair on fire." This fast pace helps explain the company's culture, which promotes an entrepreneurial spirit, ongoing learning, and maximizing the effectiveness of work. Product support and technical consulting are the more technical of the occupational groups, whereas sales and marketing require a combination of business and communication skills, in addition to some technical knowledge.

At the entry level, employees are typically hired either on contract for product support, or into telesales. Each of these entry-level jobs is held only for a short time. The contract product support positions typically last six months, after which time about 70 percent to 80 percent of contract workers are promoted to product support specialist and are hired permanently. College graduates in CS and university graduates with any degree, with good communication skills and the confidence and willingness to learn technology fit the criteria for hiring into these entry positions. External hiring for other, non-entry level, positions looks for experienced applicants with a combination of educational qualifications and relevant work experience.

Teamwork is a part of the product support work experience. The teams are loosely structured and flexible, but they comprise contract people, product support specialists and principal support specialists who represent the highest level of product knowledge and expertise in product support.

Technical consultants, the fastest growing area in this subsidiary, may be recruited from the high-end product support employees, but are increasingly recruited

from outside the company. Consulting positions almost always require a university degree, although not necessarily in CS. Additionally, external hirings require experience including business management skills and experience in training. There is no position in Canada that is strictly technical; all require some business or "people" skills. Those who stay strictly technical tend to go into development in the US, where, even there, they would require some people skills for the teamwork involved in product development.

Technical sales people – in both telesales (clients with 10 to 5,000 computers), and field sales levels (clients with over 5,000 computers) – are hired based on their sales experience and some level of technical knowledge, although the latter is not stressed at the point of hiring. Field sales people have technical consultants to help them with the technical end of the sale. At this subsidiary, the two most highly valued and compensated skills are technical skills and advanced sales skills.

4.2.b. The interviews

Respondents were recruited by invitation through the Human Resources (HR) Department. A liaison in HR sent out the researcher's letter of invitation by electronic mail to all employees in the Canadian company. After the initial invitation two reminders were sent out via electronic mail. Those who agreed to be interviewed were asked to contact an administrative assistant in HR, who set up all the appointments and booked interview rooms. Respondents were asked to sign consent forms as approved by the McMaster University Committee on Ethics. The interview sessions were conducted in private conference rooms and, with the respondent's consent, were recorded on tape.

Interviews lasted from 45 minutes to one hour. In addition, two interviews with the HR person looked at the company structure, status and general reward levels of employees.

Taped interviews were transcribed *verbatim* and entered into the QSR NUD*IST qualitative research software for analysis. QSR NUD*IST is produced by Qualitative Solutions & Research Ltd. The name stands for "Non-numerical Unstructured Data Indexing Searching and Theorizing." It is a tool for organizing and managing large text databases to help researchers build and test theories about the data[1].

The interviews were primarily exploratory, but there was a confirmatory component in the analysis that examines whether the social closure/control process as set out in the model is supported in this group of respondents.

4.3. The Respondents

Some studies have focused on women who have pursued a degree in CS and are working in the field; others have tried to find those who may be qualified but have not chosen computers as their field of study at university. There are problems with both of these strategies. In the first case - women who are in CS programs, or have completed degrees in CS – respondents can identify what factors have influenced them to pursue a CS degree, but they will be inadequate spokespersons for those who have not pursued a CS degree. In the second case – women who are qualified to enter CS but are in other science disciplines - respondents may never have considered taking a degree in

[1] "A QSR NUD*IST project is the product of the researcher's knowledge and organizational and analytical skills. QSR NUD*IST creates an environment to store and powerfully explore data and ideas, to minimize clerical routine and maximize flexibility, and to discover new ideas and build on them." (NUD*IST 4 Help file)

computing, so in many cases, the deciding factor will probably be lack of interest. Those who would be most helpful in answering the question posed in this dissertation are those with a demonstrated interest in computing work, who have the ability to do this work, but have not chosen to enter university CS programs.

The respondents in this study meet the conditions of interest and ability: respondents are working in computing, but most have not taken CS degrees as a way to gain entry into computing work. Two of the 23 respondents have CS degrees; the remainder are working in computing but do not have CS degrees. All but two women reported having taken all the secondary school mathematics and science courses required to pursue a CS degree. One of the women who was missing only one mathematics course had begun plans to take that course at night school. In fact, many of these respondents are doing work that is also done by those with CS degrees[2]. Although they are not all programming in their work, these people would be good candidates for a CS program because they like computer technology and have the ability to work with it. Their explanations, and their education, experience and work histories are the basis for answering my question.

The selection of respondents was non-random: all 350 employees were invited and participation in the study was voluntary. The selection method used may have

[2] As noted in chapter three, previous research has found that only about 33 percent of computer programmers hold a CS degree (see p. 93). Nevertheless, this does not suggest that people entering computing via alternative routes have the same theoretical knowledge as those with CS degrees. The limitations imposed by educational background will undoubtedly increase with the complexity of the work.

influenced who responded to the call for participants. An email request may have been deleted automatically by some employees when they saw it was from the Human Resources Department. However, since they have no inter-office paper mail services in this company, the administrative staff felt that email distribution was the best choice. Employees who responded could be more concerned about gender and computing work, compared with those who did not respond. These potential problems suggest caution in generalizing from the interviews to a larger group.

Twenty-three employees responded to the requests for interviews. Thirteen of the respondents were women, ten were men. Since we are observing differences in the education and work patterns of men and women, exploring experiences of both groups provides a basis for comparative analysis. In the analysis of the data, this study focuses on the women's experiences, but draws on the men's experiences when they help to illuminate or enhance our understanding of women's situation in computing work.

Table 4.1 provides descriptive information about the respondents. Of the individuals interviewed, eight have Bachelor of Arts degrees, eight have Science degrees and three have Business or Commerce degrees. The remaining four have not completed a university degree: one has a public college degree, one a private college degree and the other two partially completed university BAs. Of those with university degrees, only one man had pursued additional qualifications via private training or work-related courses beyond his Science degree. Four of the six women with Arts degrees went on to take additional private technical training. Two of the three women with Science degrees, and the woman with a degree in Commerce also took additional training. More of the women

Table 4.1 Respondent information

	College or partial degree		Arts Degree		Science Degree		Bus. or Commerce Degree	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Count	3	1	6	2	3	5	1	2
Have taken private training	3	0	4	1	2	0	1	0
CS degree					1	1		
Average age (overall average: 32.7 years)	31.5	23	28	36	38	36	36	31.5
Average yrs in computing	10	1	4.5	9.5	8	12.7	15	7

interviewed come from non-Science backgrounds, and more have taken private computer training whether they have a Science, Arts, or Business background compared with the men.

Respondents range in age from 23 years to 49 years, with most respondents falling between 27 and 38 years. The number of years respondents have worked in computing ranges from six months to 19 years.

Table 4.2 shows, at the time of the interviews (January to March, 1999), how the various divisions of the company were staffed. An asterisk indicates interviewed personnel. The spread of the asterisks indicates that respondents come from a wide range

Table 4.2: Employee Distribution at the Software Subsidiary Company

	Male	Female	% Female
Company Directors	6	1	14%
Upper level Managers	24	10*	29%
Marketing			
Middle level Managers	11*	17*	61%
Other (co-op, etc.)	4	16	80%
Large Account Sales			
Middle Level Managers	13*	5*	28%
Technical Specialists	17*	0	0%
Account Representative	3	4**	57%
Other (co-op, marketing asst)	0	2*	100%
Product Support			
Manager	3	2*	40%
Technology support	32	7*	18%
Service reps	6*	11	65%
Sales – Telesales, Solutions			
Middle Level Managers	15*	2	12%
Recruitment and Development, and Systems Engineers	10	1	9%
Acct Reps.	3	8	73%
Telesales Reps.	11	1	8%
Other	4	4*	50%
Consultants (incl. Regional Office Consultants)			
Principal Consultants	4*	0	0%
Senior Consultants	15*	2	12%
Consultants	46*	3#	6%
Human Resources			
Manager	0	1	100%
Consultants	1*	1*	50%
Administrative Assistants	0	2*	100%
Other			
Managers, Education and Development	1*	1*	
IT Specialist		1*	

*Individual in this position was interviewed.
Two of these women had recently left for other jobs. Only one of the five women was at head office.

of occupations within the company. Regional office personnel percentages are not included in the table, nor are percentages for the education and training division, for which no total count was provided. Nevertheless, the table shows the respondents who work outside the home office, in education and training, or other places under "Other," but no percentages are given.

4.4. Findings

The interviews tell a story of personal histories as they interact with larger historical changes in the field of computing. The perspective taken in this chapter is that of the respondents: their experiences; their perceptions of historical changes in the computing industry; the beliefs and ideologies they articulate; and the contradictions they express that may reveal computing myths that affect women's choices.

The first section of findings discusses the obstacles to computing that women recounted from their schooling experiences, and the impact of these obstacles on their educational choices. Among these obstacles, the women talked about sexism, lack of guidance, the masculine culture of computing, lack of family support, intimidating entry requirements for CS, and mathematics as a critical filter.

The next section describes the obstacles women experienced at work, and their impact on women's work experiences in computing. These obstacles include sexism and childcare issues. These first two sections cover many of the obstacles that have been reported in previous research, confirming that women in this study experience many of the same difficulties as women in other studies.

The third section moves into new findings based on this exploratory research. Here, and in the fourth section, I discuss obstacles associated with respondents' perceptions of the computing industry, and those working in it. The third section focuses on perceptions about historical changes in the computing industry, and the impact of those changes on women's work. The fourth section turns more to ideologies and beliefs that women hold about computing, and the influence of those beliefs on women's choices and experiences in computing.

The final section looks at the alternative routes to computing that women take as they negotiate the obstacles described in the first sections. Throughout the discussion of obstacles, it is clear that women are sometimes temporarily deterred, sometimes strengthened in their resolve, and sometimes prevented from taking one particular route to working in computing. Here we find some support for the social closure/control model as women describe their progress through education and work experiences, and the varying significance of different obstacles along the way. True to Jacobs's social control theory, these obstacles appear to have real, but limited, effects on women's pursuit of computing education and work over the life course.

All of the women interviewed were interested in the computing industry, but the reasons they gave for not entering through university CS varied. Some women, and some men, felt sure from the start that they did not want to be doing strictly technical work. They wanted computing experience to help them further their business careers and to enable them to work in the computing industry. These respondents saw the technology as a secondary consideration. Some women felt they would have had to struggle too hard

in CS to do well: they did not feel the effort would be worth the costs for them. The male-dominated education and work environments, and the insufficiently practical computer curriculum were discouraging to some women.

Women recounted the obstacles they faced at the secondary and post-secondary stages to entering male-dominated work, and further obstacles once working in computing. Although men had some of the same experiences, they did not describe them as obstacles, even when specifically asked if they faced any obstacles.

4.4.a. Obstacles at School

4.4.a.i. Obstacles: Lack of information

Of particular interest for this study, are those women who expressed regret at not taking CS. Why did they not get a CS degree? Many did not know about CS, about the career opportunities it offered, about the excellent wages and the challenging work. For some women age was a factor, because they went through school in the late 1960s and 1970s when computing was still relatively new. Prior to entering the labour force these women neither understood the wide-ranging impact computers would have on society, nor did they understand the variety of possible applications of the technology.

> . . . what you took in school versus what you can do with it in the work world. And in terms of computing, I may have been interested in it, but I just saw no application, I had no idea how connected that is to business.

They raised the point that their educational experiences directed them into kinds of work that were considered appropriate for women. One of these women described withdrawing her children from the public education system and putting them in an all-girls school with a strong science and technology offering. She wanted them to grow up

learning that they can do anything they want to do, and being informed about all the options before them.

The women who said they wished they had known about computing were not intimidated by working with men, and all of them had worked or studied in male-dominated situations prior to computing. For these women, being a minority was not stopping them from entering CS. They had the intellectual ability to gain entry into CS had they tried. Their career choices were made without full knowledge.

The section below on marketing computing careers is a specific example of the obstacle of information shortage. The failure of guidance counselors to provide adequate information about computing work to women with aptitude for working in computer technology is discussed in relation to the myths that women believe about computer workers and work. There is a subtle difference between the lack of information as an obstacle to women, and the situation described in the ideology section, in which not only are women poorly informed, but they also have their own beliefs, however inaccurate, about what it takes to study and work in computing.

4.4.a.ii. Obstacles: Sexism

Women who had been in the workforce for a fairly long time cited sexism as an obstacle they had faced when going through school. For example, when one woman asked to be placed with a realtor for a high school internship, it was assumed that she wanted to learn to become a receptionist, not a realtor[3]. When she confronted the realtor with the mistake she was still denied the opportunity to learn sales. She quit the

[3] This occurred about 20 years ago when real estate sales positions were dominated by men.

internship. The segregation of work into male and female appropriate occupations was discouraging to women hoping to enter non-traditional occupations at that time. This woman ended up starting a social work degree. Then she discovered the typically low incomes earned by social workers and dropped out. She took a job selling cars, wanted to move to computers, and so she took a receptionist job at a computer company. From there she shifted to sales and to training people to use computers in their businesses. She is now a manager associated with the marketing department of the software company, having picked up strong technical skills along the way.

Another issue that comes out of the comments on sexist behaviour is more relevant to the question of why women are not going into CS in the first place. Women respondents agreed that they are not encouraged to do so.

> So that's probably the biggest thing is women being encouraged in the system, it's never really been there and it still really isn't there you know.
>
> So you know when I look at when I was younger, there's no reinforcement that women should go into those traditional male engineering type roles. . . Women are not reinforced to get there.

One woman who experienced sexism in secondary school described her desire to avoid that obstacle.

> So it's just like . . . you don't want to be near to that.

4.4.a.iii. Obstacles: Culture of computing education

Another obstacle for women is the male-dominated culture of computing education and work. Women told about things like men belching, or acting in other crude ways when working in a predominantly male environment. Women felt uncomfortable in

these situations. They recognized that many women are intimidated in a male-dominated setting and prefer to work with other women.

> I guess also it is seen as a male oriented course. So I think that can sometimes be off-putting. You know, a lot of women go for the BA's because that's the area that has a higher percentage of women in it. And I think that some people may be off put by that, you know.

Some women described how they have learned to handle themselves in these situations, usually using humour.

> But she was very much a "butch broad", and I just couldn't be that. I know how to joke with the guys, because I had to get past "I'm a female", so you have to be able to play the game to a point.

> I had a lot of that too growing up, 'cause I worked for the steel company and I'd be the only girl with 5-600 guys and you learn very quickly how to tell them to take a hike. You just learn how to be in that guy's world.

Some manage it by being strong. Describing a friend, one woman noted:

> She's the type that would never have found it an issue anyway. She's a strong personality, strong individual and I think you need that to break into male dominated situations in anything in life. And, that's where sometimes there's barriers, and she doesn't have any of those. So it's one of those things that is probably just natural for her.

A woman said she had not really seen any change in the culture, although on the surface changes had been made to language use.

> So we're not changing any behaviors, we're just perpetuating the same one. And we've just gotten much more diplomatic at what we encourage. Right? We've become conscious of not saying words that offend people and we've become conscious of saying things in a nice way, a soft way. But we haven't changed anything, we just say it different.

Men also speculated about the culture of computing and women's enrollment in CS, drawing an analogy to women in engineering:

> Why don't women go into engineering? Is it because it's male dominated to begin with and it's intimidating? Maybe. In my time which was 20 years ago, it was a much more intimidating place probably than it is now. Our class was 10% women - it was totally male dominated. It was very intimidating for women because they were hearing stories from 20 years before that. It was a tremendously male dominated, beat your chest culture.
>
> A lot of times I would say it's probably very uncomfortable for the female, because the occasional jokes will slip by which shouldn't have slipped by. There's always the sex angle mixed in there, like "that's a woman thing," and ha, ha, ha. Jokes will get in there.

4.4.a.iv. Obstacles: Entry requirements

The inflated entry requirements into CS because of a limited number of available spaces were considered obstacles by some women. Although one woman had all the mathematics and science requirements, she felt she was not outstanding enough to be accepted into the CS program. Discouraged by the math and science competition in her final year of secondary school, she went on to do a Bachelor of Arts at university while pursuing her computer interest in her part-time job. She believed it was her part-time job that gained her entry into the software company. Some men also commented on the tough requirements to get into CS, but did not perceive them to be real obstacles or barriers to their pursuing CS education.

Mathematics still appears to be a critical filter into CS, a factor highlighted in some of the early research. Most respondents mentioned their math abilities at some point in the interviews, although they were not asked specifically about them. Those in my study with the strongest technical training (two in CS, one electrical engineer, and one Bachelor of Commerce) had computer classes in secondary school that were associated with mathematics departments.

Some said that you need a strong knowledge base in mathematics and computing to work in computing, and others said that you need confidence that whatever the problem is you will be able to work through it and find the answer. Each situation is new, they argued, so you won't know at first how to answer the question. There will be a learning period and you just need to feel comfortable with that.

> It is not the degree you get that matters, but that you know how to learn, and that you have analytic skills and a work ethic. (woman)

The two computer scientists both entered their field because of their strong mathematics skills, which they believed led naturally to computers.

> I was always good at math - math was my strong subject - and it just sort of seemed to lead to computers. . . . I really liked it, and I think if you're that age, if you are in high school, and you're searching for your identity, I found something I was good at, and excelled at, and so it sort of took off from there. (man)

On the other hand, one woman did not feel mathematics ability was necessary for the kind of technical work she was doing.

> CS is still seen as very demanding with lots of math and so on. I don't have any problem learning the stuff I need and I'm not good at math, so . .

One woman working in a low-tech job had trouble with a CS course she took in university:

> I found it okay. I think it was a bit confusing. It was computer science, but I think it also had a lot to do with the professor that was teaching it, who was whizzing right along, assuming that everyone knew what he was talking about. I wasn't interested in any of the programming parts about it. I was more interested about how to use a computer, which at that time I didn't really know much about.

Most had the mathematics prerequisites, but a few of the women did not. One woman was considering going back to do an OAC math class that would qualify her to get the courses she needed to get a CS degree. Others went to private colleges and

bypassed the entry requirements of universities. One woman believed that the combination of her technical work background and her French language ability, not mathematics skills, got her the job at this company.

> I think my French had a lot to do with it. They needed someone who is bilingual. I had my choice of jobs when I applied here

All of these respondents were fairly confident about their computing abilities although there is a range of technical skills in the sample. Confidence is linked more to the ability to learn than it is to actual technical knowledge. A common comment was that respondents did not feel intimidated by computers. They were willing to try new things, liked learning and had confidence in their abilities.

> I'm not intimidated by it, I think that's the biggest thing. I think a lot of people are intimidated by technology. (woman)

Nevertheless, the confidence women felt about working with computers did not translate to confidence in their ability to meet the tough entry requirements for CS.

4.4.a.v. Obstacles: Family Support

The striking difference between the stories of men and women about their family support is that men do not report being discouraged by their families from pursuing computing work, whereas many women recall feeling they were discouraged by their families from studying and working in computing. Some families were considered obstacles they had to negotiate by women looking back on their education and career decisions.

Women's discussion of family support is more complex. Some women went into computing work after they were married. One was divorced and had older children who

made some sacrifices over the four month period while she took her intensive computing course. Another woman's husband worked in computing and was strongly supportive of his wife's computing work. Some women said their families supported them in whatever they chose to do, but then described a kind of conditional support. One of these women went on to say her mother's frequent comments about the difficulty of mathematics discouraged her from computing work where math was a major component.

One woman said her family gave her unconditional support, but then qualified that to say the support was influenced by the sex-roles considered appropriate by the culture of her traditional, European immigrant family.

> No. The only thing, my parents were immigrants . . . they're European descent and men traditionally had certain roles, women had traditional roles. But my parents were pretty open about that, they weren't as bad as some others but my culture around me was like that. I remember I won some biology thing in high school and my parents were telling relatives "[she] did this and this," well - why would you want to get into biology? -- It's stupid. But that was around me. My brothers traditionally are engineers and traditionally very scientific and mathematical and the daughters in the family - there's 5 kids and the 3 daughters - are all more traditionally business, and psychology, sociology, that kind of role. So, yes I think subtly maybe we were reinforced that way but not really directly from our parents but from people around us.

Some women said their parents supported them specifically in computing, but none of the these women actually pursued computing directly. They went through business, arts and social sciences. These women are in sales positions where they express comfort with the technology, but see technology as secondary in their work.

Other women said definitely that they had no support to go on in computing work. These women chose human resources and sales work over direct computing. One woman who came later to computing received mixed messages from her father, an engineer.

Although he told her that she should take computing courses in high school, her father really wanted her brother to pursue technology either in engineering or computing. She believes he had trouble accepting that it was his daughter who had the technical ability and interest, and not his son.

Another woman told of the obstacle of having parents who did not have university degrees and were therefore unable to prepare her for university experience generally, and CS in particular. While they did not actively discourage her, she felt they expected her not to go to university, but rather, to take a more traditional role in her marriage, staying home to care for her children. In her case, her parents' attitudes may have had an effect opposite to their intentions. She did go on to get her CS degree, and said that she was highly motivated to be the first one in her family to get a university degree.

> So I never put it together that they were trying to block me, I just put it that they didn't think I was necessarily doing the right thing, and maybe that's what's driven me more to work. Even the way our families view us, my Mom says that our kids are a business proposition, they're not our children, because everything's 50-50. I see that as balance. My mother sees it as I'm being irresponsible.[5]

The extent of the impact of parents' support on women's career decisions is not really clear from these interviews. Some who had support pursued computing, others did not. In cases where parental support was lacking, sometimes respondents saw pursuing computing as an act of independence or defiance; other times respondents conformed more to their parents' expectations. Often there were other factors that combined with, or overrode, parents' influences. The parent/child relationship is complex, and these women's histories show the less than predictable effect of parents' support or lack of

support on their children's educational choices.

4.4.a.vi. Obstacles: Curriculum

If, as some respondents suggest, you need to get a "kick" out of technology to work in it, and if the computing applications taught at elementary and secondary schools do not appeal to women's interest, then some women may not pursue computing because of curriculum and resource problems. Respondents speculate on whether it is androcentrism in the teaching of computing that is problematic.

> You have to have already done the basics and gotten a kick out of something around science -- trying to abstract the concrete, and trying to make concrete the abstract, back in high school. Right? And so many women are just not getting as much out of it. Why is that? I don't know. When I was talking about the first lab that got my interest, we were writing code to control model train sets. And it was really -- wow! I don't honestly remember, 20 odd years ago, if the women in the class got as much kick from it as I did. (man)

> Schools need to expand to things that also interest women. We need to add the human perspective and the human element to computing. Right now it still really plays on the math, it still really plays on the science portion. The way our earlier education systems push us as women it still doesn't foster it. (woman)

The next two sections present women's views on the impact of two factors that can be obstacles, or can motivate women to pursue computing education. The comments show how influential high school mathematics teachers can be, both positively and negatively, and how for these women, both good and bad peer experiences motivated them to go on in computing eventually.

4.4.a.vii. Peer experiences

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[4] Mitigating the obstacle of her parents' expectations was a close association with her secondary school mathematics teachers. These teachers encouraged her to go on to university and pursue computing.

Some women described negative peer experiences, but stressed that the impact of those experiences on their career decisions was not negative. One woman experienced a kind of ostracism in high school, for example, where she described being unable to get a date for the prom, other than the school "computer geek." She went on to pursue CS. Another woman in an all-male computing class explained how the men tested her to see if she could stand up to pressure.

> I was the only woman in that class of 16. So I got into it and thought, what am I doing? So it was very intimidating. They tested me - the guys. They tested me a lot, and I really had to know my stuff more than they had to. So that was good for me, because I didn't want to fail in front of them.

The experience of being tested by her peers was motivating to this woman.

Women did not always have the encouragement of their peers when they aspired to go on to university, and in particular, if they felt drawn to CS. The significance of this obstacle came through not only in how they talked directly about lack of peer support, but in the ways they valued a supportive peer network when they did find one.

A woman from a working class town where sex-segregation in work was high, and where pursuing post-secondary education was not the norm, found herself growing apart from friends. They were all marrying and working in clerical occupations when she headed off to college, and then to university. Although she felt the pressure to conform to the norms of her community, she chose to pursue a post-secondary education.

Some respondents were encouraged to pursue computing when peers saw their ability and looked to them for help. Having the respect of their peers encouraged them. In most cases, though, peer support involved having a group of friends who shared an

interest in computing and provided camaraderie and encouragement, usually during the education stages. Both women and men commented on the impact of peers.

The woman who did go through CS described a very supportive peer group throughout her university years.

> And I lucked into a group of women, two engineers, and two were in the bio-med side. So I had people around me that were very strong in the sciences. Now I look back and think, wow, that was a total fluke, but it just happened that way. I had two friends that were two years ahead of me that were both in math, so that helped as well, because I had a circle of friends that were very encouraging, and we really didn't think about being so few female white people in the classroom. It was just my group of friends that I hung around with.

What is clear from the discussion on peer relations is that even negative experiences with peers do not necessarily prevent women from entering computing, nor do they always result in women leaving computing education. Nevertheless, positive peer experiences are highly valued by those who have had them.

4.4.a.viii. Relationships with teachers

Critical to women's experiences in secondary school mathematics was the relationship of respondents to their mathematics teachers. Negative experiences were recounted as very large obstacles, and positive ones were described as highly influencing women's belief in their abilities in mathematics.

One negative and long-remembered experience for women was having had a teacher tell them they were not good at mathematics.

> Like naturally, like one bad math teacher can ruin things along the way.

> So I think a lot of times we're blocking women from the field, because we stereotype them. It wasn't until I got to university that someone ever said to me, "Girls don't do math."

A respondent noted that more recently she had seen the teachers at her siblings' school steer her brother and sister into sex-segregated occupations.

> In school you're not encouraged to understand the maths, the sciences, the physics. I don't know if that's changed in the last 10 years in the education system. I have a sister who's 5 years younger and a brother who's 7 years younger and my sister was encouraged to cook and my brother was encouraged to do accounting. That's not that long ago. So I don't think the education system has changed from that perspective.

One respondent told of a secondary school teacher who made all girls wearing skirts on any given day sit up at the front of the class. She dropped advanced level mathematics after this experience.

> It was mostly the teachers I had were very insulting. Now I look back on it, I can't believe some of the teachers I had. They 'd make fun of you and make sexual comments, and there was one guy, he'd sit women - girls in skirts - at the front.

On the other hand, teachers who take a mentoring role with students can provide guidance that impacts students educational choices.

> I was one of those honor students. I got a lot of teachers saying "You should go to university." So I got guidance. I think more so than other kids because I was an honors student. Other kids never really sought it. I sought it and teachers mentored me as well. (woman)

> So I mean, I had teachers that certainly kept me in that frame of mind, that whatever you do, keep it focused in either technology or keep it focused in the maths and sciences, because from that point on, the technology can just jump forward. (man)

These obstacles in part explain why women came to computing via other routes than CS. Peer relations and the support of math teachers appear to minimize the effect of other obstacles and may, therefore, be the most critical factors in the education stages.

On the other hand, where peer support is negative, and relations with teachers are poor, these are obstacles for women.

4.4.b. Obstacles at work

Many of the obstacles discussed above in relation to education are relevant to women's work experiences also. Not discussed here, but also relevant to women's work experiences are obstacles such as the masculine computing culture, lack of family support and lack of information. When women overcome obstacles in education and pursue work in computing, they face obstacles that sometimes discourage them from continuing in this work. This section will focus on women's discussion of the obstacles of caregiver demands and sexism.

4.4.b.i. Obstacles: Caregiver demands

Some women claim that pressures and expectations of their role as caregivers become obstacles for them. Childcare is a double-edged sword for women. On the one hand, society expects women to take the primary responsibility for children's care. One woman who returned to work after her first child was born met with disapproval from her boss:

> I've had lots of blocks. The first time I came back from maternity leave, my boss sat me down and he said he never really met any working mother that had normal children. (sigh) So I've had things that you just sit and stare and go . . .?

On the other hand, women feel they are not to expect any support or sensitivity in the workforce because of their childcare responsibilities.

> I was in a situation when I was pregnant with my second child, that something blew up and it was all men in the room, and I basically went home crying . . . because on top of it all I was five months pregnant. My boss' attitude was, well

> it's your fault you're pregnant. If you can't like handle the hormones, then you shouldn't be here.

While this issue is not exclusive to women in computing, the dominance of men working in computing who do not have those same childcare constraints means the norm for working behaviour is geared more to men than both men and women. One woman noted, however, that once men have children, if their partner is working, they become more sensitive to women's needs. Nevertheless, one woman's very supportive husband would not take paternity leave for fear of the ridicule he would receive from his colleagues. She commented that, despite a good parental leave benefit for fathers, only two men in her husband's company had taken advantage of the benefit and both had suffered in some way in their careers from that choice. It was a common joke among the other men working there.

4.4.b.ii. Obstacles: Sexism

Both men and women commented that sexism is part of the computing work environment. Women working in technical computing work have to be able to handle the sometimes hostile and antagonistic behaviour of their co-workers and sometimes those under their leadership. Some women found this too difficult:

> So then I went to a film company as a Manager of Information Systems, and I couldn't stand it. I had seven guys reporting to me and they just made my life hell, so I quit after six months. My sisters pulled me aside and they said, you're bashing your head. I was younger than a couple of the men and they had a chip on their shoulder about that, and that I was brought from outside. The stunts they pulled on me all the time because I was female. . . They just couldn't accept it, which is too bad. I learned a lot and then I look back and think, boy, I was learning a lot at the time about how men were reacting to seeing a female in what was traditionally very much a guys' club.

> . . . but then I found it was all guys that worked there, and they had a real problem with certain people . . . and they were quite rude, and it became a hostile environment, but I kept going in, because I was thinking, "As if they're going to win! What's the point?!" So I just kept going in and it was icky. I didn't feel comfortable towards the end.

> I didn't like the environment. It was very male dominated. I was one of the only females there, and the secretaries were the only other females around, and it was just very male dominated. They would just walk around and kind of belch, and it was just a very male dominated atmosphere.

Some spoke about the "old boys' club" still constituting a strong component of the computing education and workplace.

> And I think in a lot of cases these schools and professional institutions kind of like it that way. They're used to it that way. The old boys' club is still very strong in a lot of cases in a lot of industries. They're not going to change unless they feel there's going to be an advantage from the change. (man)

> I'm finding it's an old boys' club. They play sports, and that sort of thing. You see a lot of the external hiring they're doing . . . and I'm finding it's, well seasoned professionals and most of them are male. (woman)

Other kinds of sexist behaviour at work described by both men and women include the undermining of women's work and knowledge, and dismissing or criticizing women because they are women, not for any lack in their technical ability.

> Things that have been said, the way they're said - guys don't necessarily give you quite the same respect as they would a guy. You hear "the bitch", you hear the hormonal cracks all the time. (woman)

4.4.c. Obstacles related to historical change

The following two sections present women's views of the computing industry as it is evolving in image and reality over time, and how this view impacts on their choices to enter or stay in computing.

4.4.c.i. Geek to Cool

Respondents spoke of historical factors that may have an impact on women's future participation in computing work. They referred to the mainstreaming of the technology industry, the changing image from geek work to a good career, and the expansion of computing education in the public school system. They discussed the way business has brought computing into the mainstream by incorporating it as a key element in business education and practice. The theme of this part of the discourse was the belief in the changing status of computing. These people believed computing had changed from relatively low status work associated with clerical or maintenance occupations, to high status work associated with power, money and creativity. The earlier, geek image of computing was unappealing to women.

Women noted the greater attraction CS would have had for them if it had the same status as the professions.

> I guess if it was almost like a profession, like being a doctor or lawyer, that might have made it a lot more attractive. I think if I knew how much money was to be made and that sort of thing, I probably would have been attracted to it. It being kind of a crude industry, I don't even remember thinking about [it] as an option.
>
> I don't know if a lot of women are encouraged to take that route, because I think you need to bring the intellectual horse power. . . . And there may be more of an attraction for people of that aptitude to lean towards a variety of other courses whether it's a law career or a medical career.

In contrast, one respondent likened the new status of computing work to that of stockbroking and investment banking:

> The image of the kind of people that work in the software industry is basically that you have to be some techy person, sweatshirt, long hair and a beard. That is the image that's projected, but things are changing now. This is a pretty attractive career to get into. It used to be stockbroking and investment banking was the place, but . . . Set yourself up as a software company. You can do very well for yourself nowadays. (man)

Others likened the new image of computing to the professions:

> . . . that's kind of changing around. So it's no longer seen as a secondary school set kind of thing whereas "I wanna be a doctor, lawyer, banker." Now it would be kind of cool to own my own software company. That sort of thing has changed now and there's a lot of young people who've shown that this is a hot area to work in. (man)

Some women stressed the wealth of opportunity and high rewards as indicators of computing's changed status.

> Computers and the whole industry is a real wealth of opportunity has changed a whole lot since I was in university and high school. It really wasn't, "wow, look at how much money there is to make, and how much opportunity. . ."
>
> It was the weight of the company. The name, the reputation and all the rest. But definitely the industry itself is an attraction for obvious reasons. Just a fast moving, forward thinking, . . the fact that it's going to be here forever and a day and these people definitely want to be a part of that.

Part of the change in status appears to respondents to be a shift in education from clerical associations with computing to science or big business.

> In high school there was a data processing course and - they called it computer science but it was a really, really basic course. I took it. Computers weren't my focus then. This was before the introduction of the PC. So people didn't really see computers as being a career. I took it because I was kind of interested in making the machine bend to your will.. . . this was gonna be almost clerical work. So it was still kind of associated more with the business and the typing - things that people do in insurance companies. Big iron, big mainframes, it wasn't. (man)

One woman noted the shift in status as evidenced in the structure of business education:

> I think the technology industry is now becoming more mainstream. It's no longer the new kid on the block. When I went to school you'd probably end up at a packaged goods company if you do marketing. You could end up being an accountant at an accounting firm. Or you're going to human resources for operations. And the computing field was out there somewhere and hadn't been defined. From what I understand now, it's changed. Even in a business program, there's now finance, operations marketing, and - oh look! There's managing

> technology. So I think it's partially evolutionary that as the industry itself becomes a bigger and bigger part of our economic base, I'd like to think that naturally you'll see more and more people will be drawn to it, especially now when there's all this talk about this shortage. So I think there'll be a natural process for more people looking at it, including women, because there are jobs in that field.

Respondents believed that people do not understand the opportunities available to those with computer expertise. Most felt that computing work is envisioned too narrowly by both students and guidance counselors.

> I think that things like technical sales, which would appeal probably to a lot of women, probably to a lot of guys too, aren't even talked about as career options. Typically, when you talk about computer science, you think of a programmer. So I think it's an awareness of how broad the field can be. I didn't know about project managers or project leaders until I was working, and that was never presented as an option to me. For example, do you like the human resources component? Do you like talking to people? Do you like managing people? (woman)

> . . . the real world versus school. Like I said it's all about that disconnect, because when you're in there learning about calculus or whatever, or even programming, you don't see how that works or fits into the scheme of things. By learning programming or computer science - you're not seeing how that component fits into this computer application and how that application is revolutionising this industry. (woman)

> I think just computing in general has become a lot more broad and natural and normal. It's not a specialized field anymore. It's not a scientific field. It's just a huge opportunity for anybody to get into. I don't think it's been properly marketed to tell you the truth. (man)

One woman spoke of the importance to her of the breadth of opportunities open to someone with computing expertise. For her, this knowledge led her to pursue computing after she was laid off from her construction estimating job.

> I sort of liked that part about it. Just the sheer vastness of it. I wasn't going to pigeon hole myself into one area -- that there was a wide area of possibilities in computing.

A recurring theme in the interviews was the application of computing to some other kind of work. The implication of the following selection of comments is that a CS degree can be applied to a broad array of occupations and should, therefore, attract many people with diverse interests.

> The fact is, I couldn't be in my current role as a database marketer without IT experience. So as I saw it, that was my first foray and introduction to how technology, how information can drive your business. So even when I joined Canada Life and I signed on as a programmer, I never saw myself in five years as a programmer. It was my step forward to bigger and better things. (man)

> My interest had a lot to do with Wall St. firms that needed specific quantitative skills that required the use of computing. Really, you can't separate business from computing any more. They are highly computing oriented. When you study finance now there is an emphasis on modeling and to do modeling you are talking about computing and quantitative analysis. So, you are really disadvantaged without any computing background or training. (man)

> Even in other kinds than an IT company, computers are still like a very big part of how the organisation runs. (woman)

What is the effect of changes in status and in the pervasiveness of computing on women's experiences? Are they finding that, with the historical changes, attitudes are changing? Some alluded to the potential for this broadening to become sex-segregated:

> If you look at computer software development, it is primarily male, but outside that there are lots of women. They are redefining what it means to be in computing, because now you have to connect to the end user. This has opened up lots of computer-related jobs that are not necessarily strictly computing. (man)

> I think it's definitely much more common now for women to be involved in computers. Obviously not as much in the technical side. Our systems engineers department here - there's not a woman, right? (woman)

Women are mixed in their beliefs about whether attitudes to women working in computing are changing or not. Some think that, while the company they now work for is fair to women, attitudes generally are not changing:

> I really can't think of anything outside of these walls that would indicate that it's changed at all. Can't think of anything.
>
> There's still a glass ceiling and we're kidding ourselves if we don't think it is. I think the hardest thing though is more the attitudes, because those are more the hidden things that you don't know for sure how people are thinking.

Why do women have these beliefs? Some respondents draw attention to small things like when letters to the technical support department are consistently addressed to "Dear sirs" or "Gentlemen." Others have noticed that technical questions at sales presentations are almost always addressed to men, despite the fact that there may be a woman co-presenting who has more knowledge about the technology. One man noted the use of women in tight clothes and short skirts to attract men to computer displays at technology shows. Once at the display it is men who sell the technology.

Nevertheless, some women thought attitudes were slowly improving:

> As these guys are evolving, they're husbands and they're fathers now. A lot of guys I work with now are dads. They've changed a lot. But the younger ones are still. . .

One woman had experienced strong support from men and felt that with changes in the industry, men's attitudes are changing more rapidly than women's. Only having been in computing a short time, she was quite positive that there had been progress in the acceptance of women in technology occupations.

> I think the government has gone a long way to promoting women into non-traditional occupations. I myself have seen a big change in my male friends, not so much my female friends. My female friends think I'm kind of weird, and techy and that upsets me - except for the women friends I've made at [this company]. But I've seen a bigger change in men's attitudes. I find men a lot more encouraging than women are about getting into the computing industry, getting ahead in the computing industry.

The broadening of computer applications, and the pervasiveness of computing has meant good jobs, and high salaries are more plentiful for men and women with computing skills.

> I think, as the industry develops and becomes more well known to people, I think women's underrepresentation will switch because there's definitely opportunity for reward that way. And I think that starts to make people think maybe I can do that. (woman)
>
> And men and women get drawn into that because it's well rewarded. (man)

Several respondents commented on what they perceived to be the pragmatic thinking of some people:

> Why do Asian women get into computing? I think they see opportunity there. It is significant. They can do well financially, there is less turnover, more stability, etc. (man)
>
> Yeah, cause I think people that have those kind of analytical skills and mathematical skills and science skills that can actually complete a CS degree are fairly analytical about "well, what do I get out of this at the end of it all." I mean that's why I didn't end up with a social work degree. Because my mind suddenly engaged in - "wait a minute, what's the cost-benefit analysis here?" And so I think they have the type of minds that say, "well what does this lead to?" (woman)
>
> One other thing that would benefit women is to think materialistically what this deal can offer you in terms of money. It's very obvious, but I just didn't even think of it. Your parents always tell you to be a doctor or lawyer or one of those traditional professions, but you can make a lot of money in this field. (woman)

Men and women are both motivated to enter computing because of ambitions for a good job with security and a good income.

> The notion that this is where the jobs are going to be for the next many, many years. Any job that you're in, whether it's directly in the computer field or not, requires the skills. (woman)

For most men and women interviewed, the goal of getting a good career, or broadening their career options, brought them into computing. The increased status of computing meant that computing was a promising field in which to work.

4.4.c.ii. Pervasive and narrow

One problem of the present situation in computing is the paradox of a growing pervasiveness in our society of computer technology, and a shortage of workers, coupled with narrow entry into university CS programs. One man described the pervasiveness of computing:

> Technology is very useful because you just can't get away from using computers. You have to, it doesn't matter what you do. On the surface it may be very remote from computers and systems, you still need to be able to find out, inquire, and get data and be able to manipulate it and do market studies and stuff like that. So you have to know enough then about the technology to know what's going on. (man)

More computer scientists are needed, but there is a limited number of spaces in university programs. The immediate benefit for men and women is that they can move into computing careers without getting CS degrees. As discussed above, many learn computing skills in a non-technical workplace, then move into the computing industry. Others have taken private college courses. The private colleges appear to have picked up the slack, training people to fill the labour shortage in computing.

> There's tons of juniors now. In the last year and a half, the colleges and the training schools have really picked up on this and they are just pumping them out. (woman)

Nevertheless, most agree that the current situation is not going to last forever. There will eventually be stricter criteria for getting jobs in computing, and the competition for access through CS that some have already described will intensify.

> I think that if we didn't have this current rush of computers, the computer world has been roaring so fast that we can't fill the ranks quickly enough, so they're basically taking anybody that has any of the skills, but some day that's going to end. At that point they're going to start looking at all of these things that balance the individual and make their hiring decisions that way. (man)

> Because of the competitive nature of computing. Because there is this intense competition. (man)

On a more optimistic note, the government is hoping to open up access to CS to a larger number of students. Universities are being offered substantial grants to increase their enrolments. If Jacobs (1989) is right that more women enter male-dominated fields when they perceive opportunities for access, the tightening of credentials for entry to computing work and this government initiative, acting together, may attract more women to computing education.

4.4.d. Obstacles relating to ideology and beliefs about computing

Some research on women and work, described in the literature review and theory chapters, finds that ideologies are used to manipulate the labour force, either to encourage groups to take work in certain occupations where there is a shortage, or to discourage workers from continuing to pursue work in some occupations where the supply is too great (Milkman, 1987). In this section we examine the comments that express ideologies and beliefs about computing, and explore their impact on women's education and work choices.

4.4.d.i. Geek versus "super-tech"

Computer scientists are at the same time derided and elevated by respondents. I explored stereotypes and beliefs about computer scientists in two ways. First I wanted to know what the general comments of the respondents told me about their beliefs about

computer scientists. Then, I also asked respondents specifically what they think it takes to be a computer scientist. When beliefs about computer scientists came up in general comments, the comments were mostly about negative stereotypes of computer scientists. Being a geek, not caring about personal hygiene, and having few social skills were among the more commonly noted observations.

> Because it was at that time the image of very geeky. Lots of spotty kids. The image of the kind of people that work in the software industry is basically that you have to be some techy person, sweatshirt, long hair and a beard. It's not all hairy, pot bellied geeks. (man)

> Sometimes things get branded and sometimes it's hard to shake that branding and I think that's part of what happened. I think the whole CS, category got branded as being kind of nerdy. I mean, we hear about some of the stories of product development and it's pretty funny. We foster that impression of these people too internally, about how they don't know when it's daytime, and they were pleased if they shower once a month. These jokes occur internally here and I'm not even sure that they're necessarily said in a dishonest kind of way (laughter). Sometimes you wonder about what goes on there! (woman)

One women noted that her secondary school computing lab was near the shop labs. She associated that location with messy, technical kinds of work and the mechanics she called "grease monkeys."

The idea that you can pick a computer scientist out of the crowd was articulated by one woman:

> But I think part of it's evolutionary. I don't know about the dynamics of the males - all the guys are together and doing their technical thing and we notice that at company functions. When we have our world wide meetings you can spot a mile away who's a technical person and who's a sales person. There's the technical, technical - they live it, breathe it, sleep it, eat it. (woman)

On the other hand, when asked specifically what they thought it took to be a successful computer scientist, respondents described "super-technologists" with qualities

to which few could hope to aspire. Descriptions of "super-technologists" included such qualities as having a "passion" or "burning desire" for technology; having a "thirst" for, and "dedication" to continual education and learning; very good communication and presentation skills; the capacity to never give up until you solve a problem; the ability to perceive abstract concepts in three or four dimensions, while also thinking in terms of binaries (yes/no, right/wrong); the ability to do both individual, less social work, and team work involving strong people skills; creativity; brilliance; strong analytical and mathematical skills; and self-motivation. This ideal-typical description of a computer scientist is one that many of the respondents articulated with surprising consistency. The extent to which men and women believe they must live up to this ideal may be a critical factor for decisions about computer science education. Both men and women in this study appear to believe in this ideal. The woman with a CS degree noted this:

> A lot of people think that it is one of those things that just seem so complex, and so ominous, and so overwhelming that it's scary to jump in. And I think maybe if some people took that jump they'd realize maybe it's not as complicated as you think. There's definitely an aura around it.

When people describe both negative stereotypes of computer scientists and "super-technologists," they are distancing themselves from the former, and describing the standards they may be setting for themselves in the latter.

One woman brings together the two, rather contradictory, descriptions of computer scientists as a butt of jokes, and as holders of highly prestigious occupations:

> I think it's a stigma that's attached to it, and also, a role of precision associated with the University of Waterloo. And getting into the computer science program is so very prestigious and it's very difficult to get in there, there's not a whole lot of positions. I think it's also a stigma attached to computer science, the male geeks kind of deal. (laugher) On the campus at Waterloo and going to the

> computer science library is like, "Wow, do I want to be one of those people? No!" (woman)

Both the computer scientists I talked to were very cognizant of the negative stereotypes about their field. The man said: "this is the furthest thing from, this is not a cool area to be in let me tell you!" The woman also felt that she was not cool, but in her case it was her success in the male-dominated area of math that she believed made her uncool.

> We have to get females past the look, because so many females fall into the trap in high school of "I want to be cool, I want to be liked, I want to be . ." . . . and being top in your math class is not necessarily cool. When I went to the grad ball I went with the computer geek because no one else was going to touch me. I think if you're not a very strong personality we sometimes fall into the trap.

Both said they were able to ignore others' opinions of them.

One common theme in the descriptions of computer scientists is that they have a special, or different, mindset compared with the rest of the population. What is this mindset respondents believe is required for pursuing CS?

> It's a very technical kind of field and people who work in it, there's a particular mind set that works in there and so you have to fit into that mode of doing things. (man)

> It's gotta be one where you're kind of curious to know how things work. An interest in building things and tinkering around with stuff. Taking it apart, putting it together. . . . So it has to be a kind of a curiosity there in doing it and a mindset to want to get things running. That's the kind of mindset. That's where you get a sense of satisfaction out of doing a job as a developer. You start from a blank file, you create something and it runs and it does something, but you have to like to build things like that, get a sense of satisfaction out of things. (man)

> Some people just don't have that kind of mind set. But you need the ability to absorb and act on what you've learned in terms of breaking it down to the smallest components and then being able to work with that. But I think you need to have that kind of a mind to do that. (woman)

Men spoke of an additional requirement on women to be superwomen technologists. Relating computing to his engineering experience, one man said he believed only the best women succeeded in male-dominated education.

> And so few women took three math's and two sciences. Women just weren't there. In engineering it was totally male dominated. It was very intimidating for women. The women that were in my class were very, very strong women. Of the four top students or top three students in the class two of them were women. The class was only 10% women, so . . Completely skewed. The women were all skewed toward the top of the range. But I think the reality is that the women who would have been in the middle were all filtered out because it was too awful a place to be. They'd heard that it was awful, because they were hearing stories from 20 years before that. But it was tremendously a male dominated, beat your chest culture. I think that's changing now. (man)

Others agreed that there was additional stress on women to perform above and beyond their male colleagues when working in computing.

> In order to be successful as a female in some of those roles you don't have to be good, you have to be great. (man)

> I really had to know my stuff more than they had to. (woman)

The contradictory stereotypes of computer scientists described in this section reflect the historical changes taking place in computing. Although the geek stereotype was consistently discussed by respondents, that stereotype is often described as changing in status. The "super-tech" stereotype reflects the higher status of computing associated with big business, high rewards and power.

4.4.d.ii. <u>High tech/low tech</u>

One commonly held belief of both women and men interviewed is that women are more suited to the "softer" skills used in the computing industry, such as marketing, and education. Part of this thinking is that there are certain kinds of work that are "natural"

for some people and not for others. In this section I explore the career paths of men and women as they move in and out of high and low technological computing jobs, and the beliefs about men and women associated with their high or low-tech work.

A low-tech computing job is characterised by an extensive use of computers, where the computer is used as a tool to accomplish some other task. Low-tech computing jobs include teaching computing, management, call screening for phone support, desktop publishing, and so on. In high-tech computing jobs, the work is quite technical and directly involves the computer: for example, programming, systems analysis, computerising a company, setting up a system for automated banking, and so on. The career histories of respondents show that most have chosen a career in either a low-tech or a high-tech computing career path. There is little movement between these two career paths.

Table 4.3 Career paths

H=High-tech L=Low-tech

	All H	Other->H	H->L->H	L->H	H->L*	L->H->L	All L
M	3	1	1	0	2	2	1
F	0	1	1	0	2	2	7

*This includes one male and one female whose paths were H->L->H->L. They both have CS degrees.

Table 4.3 shows the career paths of respondents with respect to whether their computer-related work has been high-tech computing or low-tech computing. Most came to some kind of computer-related work right after school. The table shows that in this

group, men are more likely than women to have worked in high-tech computing throughout their careers, and women are more likely than men to have worked in low-tech computing throughout their careers.

The two respondents who vacillated from high- to low- to high- to low-tech computing work both hold high status positions in the company and have CS degrees. They both enjoy interaction with people. The man moved from technical work eventually into sales, whereas the woman moved from technical work eventually into directing an educational division offering courses at colleges and universities across Canada. She described her career path:

> And I've always struggled with that, and if you look at my career, I jumped into technology and then jumped into the people side and back and forth, and I think that's rounding me out, but some people in the past saw that as very schizophrenic.

No respondents moved from low- to high-tech computing work and stayed there. The respondents who moved from high- to low-tech computing work were moving from technical work to management positions.

In this company, greater status is given to consulting and sales positions. Men tended to be strong in both of these positions. Women in this sample who were in high status positions were in sales. No women in my study held consulting positions. At the time of the interviews there was only one woman consultant working at this company, alongside 36 men consultants.

When it comes to being qualified for computing work, human resources personnel

said women applying tend to be stronger in the "soft skills," meaning "the interpersonal skills, the teamwork relationship skills, the listening-understanding-responding type. All the soft skills they tend to be very strong at." Where they are lacking is in the "hard core technical skills, the hands-on experience." Some respondents recognised women's educational shortcomings as a barrier to moving up in the organisation:

> From a career perspective, if I ever wanted to go higher within an organisation at executive levels, then education can come into play. So I wanted to keep my doors open once again so they wouldn't shut because of an education requirement. (woman)
>
> There was a problem there with senior women IT people. I think that was because in order to get to that position you had to have 20 years' experience. You didn't get there because you were a star; you had to put the time in.(man)

4.4.d.iii <u>Computing myth #1: "Burning curiosity is a male thing"</u>

The belief that it takes a real "passion for technology" to be a successful computer scientist was articulated by almost every respondent except for the two computer scientists! The widespread use of the phrase suggested to me that this was an ideology about computing work to which these workers were being exposed. This intuition was confirmed by one respondent who noted:

> You've probably heard it a 100 times, 'cause I didn't hear the language until I got here, but you need the passion for technology. To constantly be learning what the latest possibilities are and to be a part of that. (woman)

The fact that the two computer scientists never really mentioned any of the stereotypical descriptions voiced by the others also suggests that respondents may have been articulating an ideology. The two computer scientists said only that computer scientists need a basic knowledge of computing, and that they may be interested in either the

technical or sales side of computing depending on whether their personalities are introvert or extrovert.

Respondents believed that computer scientists need an inquisitive nature, burning curiosity, and desire to learn. Men used very strong language to describe this characteristic of their image of a computer scientist. One respondent used the phrase "real thirst for continual education" to describe the desire to always be learning new things. Some respondents suggested that these qualities characterize men more than women. Both men and women spoke of natural differences between the sexes and the consequences of that in education and career decisions. That there is something "natural" about working with technology for some people, and not for others, and that this is connected to a stronger curiosity in men than women are common themes.

> But I've noticed a lot of women don't care as much about what makes something work, for example, whether it be a car or a computer. If it works, fine. But I personally like to know how things work, why it works, what makes it work. And I notice a lot of women I meet really don't like that. (man)

> As a general observation, I'd say that men are better for some reason with the hard-core engineering, fix-it-up, pull it apart, nuts and bolts kind of thing. They like taking apart motor cars and all that sort of stuff. I think the women, are very good with the team development, the manager kind of role. (man)

> It just always seems that women were never that interested in the maths and sciences. You know what I mean? . . . it's sort of like girls don't play with cars and stuff like that. They do other stuff. (man)

Some expressed male/female differences as a product of both natural and social forces:

> Given my personality and the whole sales thing, it was probably one of those natural sort of things. But . . . even at that time you were never encouraged to take math, you were never encouraged to go all the way through in biologies and physics and all that kind of thing. It was more - stick with the art side. (woman)

> It has a lot to do with our society and how women are viewed as getting more into the arts, you know? . . . not so much mathematically or engineering inclined. I think that starts from when we're born. They treat us differently. And I think that women have personality traits that are good for certain jobs, and I don't think that's being stereotypical, because I do think that women have more of a nurturing character. I don't know. More of a sensitive nature and so perhaps they are inclined to go into other fields. (woman)

Others spoke of primarily social causes for gender differences they thought had an effect on women's pursuit of technological education and work.

> I think traditionally those subjects for some reason or another don't appeal that much to females and maybe it's easier just to express yourself or something in English or History. (woman)

> I think it probably starts with infancy. When they're given the dolls instead of the building set. I don't think it has anything to do with any kind of biological difference. . . I can't think of a reason why they wouldn't, other than conditioning. (woman)

I was curious about whether in fact women do or do not display evidence of the kind of burning curiosity described by respondents as critical to being a computer scientist. The most striking finding when looking at respondents' education histories is the lack of private, or additional training of the men compared with the women. Although this is not a truly representative sample, it may be significant that ten of the 13 women interviewed had taken additional training beyond their degrees whereas only one of the ten men had done so. Why have the women in this sample chosen to continue their computer education? Overwhelmingly they explain that they take ongoing courses for the sake of their careers. Sometimes extra training was taken for a specific assignment, such as to explain something technical to a client, and other times there was no specific reason given for the training other than just to keep learning in order to stay up to date

with the technology. For some, additional training was taken to prepare for a career change.

Clearly if ongoing learning indicates "burning curiosity," women have more than proved themselves curious. Not every woman in the sample will demonstrate this curiosity, nor will every man. For one man, the move to management was an attempt to reduce the amount of new learning required in his consulting work.

> And the most arduous part of consulting is keeping up with the technical changes, and so maybe managing consulting for me is a way to avoid some of that arduous learning process, because in managing, it's a little more stable. (man)

Some respondents described potential sources for the myth that women are just not as curious or passionate about technology as men.

> Boys tend to pick up math earlier, and you felt kind of intimidated by what they knew, and with puberty . . . All those different elements are there. So here you are thinking oh, I like that boy, but I don't want to be looked at like I'm smarter than that boy. Girls tend to play it down too. (woman)

> I even hear this from my nieces and nephews. It's still the thing about not wanting to appear too bright, not wanting to stand out like that. (man)

Whether believing this myth affects women's decisions about computing education and work is not clear from these interviews. It appears more likely from the comments, that it affects men's beliefs about how well-suited women are for work in computing and other kinds of technological work.

4.4.d.iv. Marketing computing careers: Information about IT

Given all the stereotypes and beliefs about computing, how are people to learn what is really involved in computing work? This section looks at the role of guidance counselors, teachers, mentors and non-work experiences in marketing computing careers.

I explore how these informants have affected the career decisions of the men and women I interviewed.

The women interviewed repeatedly spoke of the need to show girls the variety of jobs associated with computer technology. Although these women were in computer-related work, many of them still held negative or inflated stereotypes of computer scientists and of the more technical kinds of work available in the computing industry. Most would not choose to be more technical, although all of the women interviewed were comfortable with the level of technology required for their occupations.

4.4.d.v. Guidance counselors

None of the respondents found secondary school guidance helpful to them in making their career choices. Most were fairly critical of the guidance offerings in secondary school.

> Guidance counseling we had in high school was pretty poor. It was a fledgling school, so it was like, "OK you don't have something to teach so you can be guidance counselor for the next period." If I could go back and say "you were wrong," it was when they said wanting interaction with people would close the door to CS. And at that point, the perception of a computer scientist was someone locked away in a room, coding all day, walking out at night. Nobody had a concept that you might work in a customer service field centered around computers. I was very conscious that I like interaction with people, so I probably saw that as a door closing. (male)

> I have a recollection that they were of no help to me whatsoever in terms of deciding what I was going to do. I had no direction, I had no idea what I wanted to do coming into high school and I often thought that they really needed to improve that part of the system. I remember at the time thinking it was a useless process. You were pretty much on your own to figure it out. (woman)

> And I don't think they give enough counseling in schools to really help people understand what their strengths are. (woman)

Most women believed that guidance counselors were far removed from the reality of the

labour force.

> And all of the things that you look at in those fields were so, opposite. ...even in English - you can be an English teacher or you can be a creative writer. Right? They never talk about all the things that fall in between that in the career perspective. It's still very removed from reality.

> I don't think that they really showed what the options were at that moment. I think they're just concerned with getting you to a post-secondary school.

> Yeah, I didn't give any thought to computing, but I think (and this goes basically for a lot of things in terms of high school guidance), you didn't see where it was going to lead. They just said, this is how you fill out the form.

Guidance was most helpful in two situations. First, if a teacher suggested to a student to pursue a field of study this generally had a strong impact. Second, guidance was critical for those students who took private college training in order to change their careers. Evaluations conducted by these colleges gave respondents confidence that they could be successful in computer work.

> I got very turned on to this course because I did well on the aptitude test. It boosted my ego a little bit and I thought, "Hey, I'm good at this course in this place, who knows what will happen somewhere else." (man)

> They had skill testing, aptitude testing, all the tests you could go through, and what showed up on my test because I have very logical mechanical thought patterns, was computer programmer, network analyst, stuff like that. So I thought, ooh, that kind of appeals to me. I have it right in my hands that this is what I'd be suited to. (woman)

Guidance could be useful for identifying people with strong aptitude for computing work, but these respondents uniformly found secondary school guidance teachers not to be helpful. The next section outlines respondents impressions of the positive impact of teachers and others who provide guidance through mentoring.

4.4.d.vi. Mentors and role models

Women told about how they floundered around until they found their place in computing. At critical points, when they knew they needed to be moving along in their careers, they felt they needed some career guidance and did not get it.

> There's not a whole lot of nurturing going on. Where do I go from here? I don't know. (woman)

> I'm torn about staying with the technology, because there are limits. Now in my department I'm as high as I can go in technology. The question is, do I want to go to a different department where there's technical jobs but they're not the same, or do I want to go in a completely different direction and do management or something? I'm not sure where I want to go. (woman)

Most women respondents believed that having mentors would help women to be more confident and comfortable entering male-dominated work. Nevertheless, only a few men or women in this sample reported having had a mentor. One of the consultants who had always been in a leadership position since school actually changed jobs so he could have a mentor. He chose his employment based on whether there would be someone at the company who could mentor him. The woman with a CS degree also had good mentoring through high school. Her mathematics teacher encouraged her when she was the only female in a computing class, and discussed with her some of the issues women face entering a male-dominated field. She also had strong peer support through university. Likewise the man with the CS degree had parents who went out of their way to support his interest in computing. Unlike the women above who found themselves floundering, one man spoke of the benefits of mentors at work. He told how this kind of mentoring was common throughout his career.

> The second manager I had kind of laid out my roadmap before me. He said, you're going to get to a stage where you're going to decide to become a technical person or a project manager. And then beyond that. . . (man)

A woman told of her delight at having a female mentor, and disappointment when she moved out of head office.

> I find that the female managers, all the females kind of migrate towards them. . . . Yeah, we used to have a female manager in our [section] . . . and she was a really great mentor, just sort of someone to look up to, and say, "Wow, I'd love to be able to be like her." But she's moved on. (woman)

A man described a hypothetical scenario where a manager is deciding how best to use his mentoring time.

> Whereas you'd say with a guy, "Ok, I'll spend another hour with you in office time to get you there." If you've got that thing in the back of your head that's saying, "She probably just won't get it," you . . .(shrug). (man)

There was talk of role models in the interviews. Some thought they were critical to increasing women's representation in CS.

> I really think that somewhere along the line you need to be able to look and actually see someone who you identify with and think, "I can do just what they're doing." When I wanted to be a teacher, I had female teachers who were great but the ones who I was modeling myself after were the guys. And I don't know how important gender is in that, but I really do think that so much of what shapes where you end up in a career happens in those years of high school when you're picking those courses and you're so confused about gender. You're wondering what's going to happen at the dance and things like that. (man)

Role models were discussed as a part of a larger CS marketing strategy.

> Good commercial out there. You need a good poster that shows women doing computing. I don't often see that anywhere. (man)

Have role models made a difference to those women interviewed who had role models to look at? Women who told of seeing other women in technology did not necessarily follow their lead. They tended to come to computing work when they

realized they could have a good, high-paying career there, not because they saw other women working in computing.

> It definitely was around me. There's people that are very proficient at computing and I always envied those people. It always seemed one of those things that you can learn but it took a lot of time and I just never seemed to have the time.
>
> My parents are programmers and things like that. No degrees in computer science. My father went to a community college. He's been involved in computers for about 20 years. So, he goes into the industry and is more into management. My mother had a series of careers but she ended up at a control data, which was like a [research] type of institution, and she did that kind of part-time and ended up with very hands-on training in computers. She's been doing programming work since then.

Whether, in reality, role models help or not, there does appear to be a deep-seated belief that more female role models in computing will positively impact women's choices to move into computing. Both men and women articulate this belief, and some of those interviewed volunteered their free time to speak to girls' clubs and to school groups.

4.4.d.vii. Experience

Most respondents, both male and female, had some kind of exposure to computers through a work placement. This work experience generally acted as a motivator or catalyst to take extra computing courses, or to gain more computing experience in some way. For some respondents there were also non-work experiences with computing that influenced them to consider computing as a career. The one male respondent with non-work experience had the opportunity to build a computer with a friend, and was asked by teachers at his school to create banners for special events. These experiences gave him confidence and an interest in doing computing work.

Some women sought non-work experience in computing because they already recognised that computing would help them further their careers. One woman was laid off from her job and took the unemployed time to teach herself to use several computer programs. Another volunteered to serve on the executive of a student organisation that provided and ran a computing facility for business students at her university. Some women were in positions where they observed computer work. For example, one woman's brother-in-law took her to his workplace which was a computer facility; another woman went on several one-day placements to job-shadow various people, and saw the impact of computers on business.

4.4.d.viii. Computer myth #2: "Working with people versus machines"

Both men and women in this group like working with people and have to some degree based their career decisions on their desire to work with people. From the most technical to the least technical employees at this company, social interaction is a part of the job. This may take the form of getting end-user feedback, giving telephone assistance, managing, teaching, selling, administrative work, or teamwork. The social interaction in these jobs is motivating to respondents.

> I had a lot of fun the first year that I got the real job and started playing with computers and dealing with people that were working with computers. End user populations. It was fun helping people more than anything else. (man)

> I'm a consultant right now. As a consultant your job is to help people. So, I'd say for most of the consultants that's the kick they get. But working with people isolated and alone is not, you know, not nice. (man)

> I probably wouldn't want to be 100% away from people. It's not just the people I talk to, it's the people I interact with on my job too. (woman)

For those who like working with people - a preference noted by almost all women respondents and many of the men - the stereotype of working away, locked in a room was discouraging.

> My aptitude is not to sit behind a machine and actually program at all. (man)

> I see that as a person who's got to sit in front of a computer and focus and program or whatever. They get the bad rap of not having any people skills. (woman)

The woman computer scientist in the study had much the same feelings toward sitting in front of a computer as the other respondents:

> And that might not be attractive to a lot of people, because when you think about it, that's not attractive to me. I don't want to sit and look at a screen all day. I want to interact with people. I really like staying on the technical side, but I don't really want to be a programmer any more. I know that I need the interaction with people, so I know what my limits are. (woman)

Most jobs in this company involve a mix of people and machine interactions. The woman computer scientist stressed the importance of dispelling the "programming only" myth.

> I think that things like technical sales, which would appeal probably to a lot of women and guys too, aren't even talked about as career options. Typically, when you talk about computer science, you think of a programmer. So I think it's a lack of awareness of how broad the field can be. I didn't know about project managers or project leaders until I was working, and that was never presented as an option to me. So I think first of all we've got to get the message across that computer science is more than just looking at a computer screen. There are opportunities with that background that make sense.

Women reported not really understanding exactly what computing was about. In fact, both men and women said they either currently or in the past believed programming work was the aim of CS education. Others criticized secondary school programs that

presented CS as primarily programming rather than as part of a career that may involve periods of high- and low-tech work.

> To make computing attractive you need more successful advertising and involvement at the computing management level in recruiting people. If girls don't have exposure, and parents don't know . . they need to be informed, need to see what people actually do. (woman)

> I don't think it's marketed well as to how it can actually be applied to business once you've graduated. What are the jobs available once you leave there? (woman)

> And some people don't even know if they love it. We close ourselves off before we've even had exposure to it because of a bad teacher, or because the stuff isn't interesting or whatever. It's always taught from such an idealist perspective that it's very hard, once you get out in the real world, to maintain that. (woman)

Once in business jobs, many commented on their recognition of the salience of computing to all facets of business.

> Technology is very useful because you just can't get away from using computers. You have to, it doesn't matter what you do. On the surface it may be very remote from computers and systems, but you still need to be able to find out, do an inquiry, and get data and be able to manipulate it and do market studies and stuff like that. So you have to know enough then about the technology to know what's going on to be a translator through to businesses. (man)

Given the stereotype of women having a more natural inclination to working with people, and having better people skills, misunderstandings about computing careers may have stronger effects on women than men. This myth misinforms people in two ways. First, many people who are not computer scientists sit in front of a computer all day working. Second, many computer scientists do other kinds of work than programming. The next two quotations are from a woman who described her aversion to sitting in front of a computer all day as an explanation for her decision to work in human resources

rather than do more technical computing work. Then she described what she did in a normal working day.

> I couldn't picture myself getting into a computing, computer scientist role because I like much more to interact with people and to talk to people directly rather than sitting in front of a computer all day.
>
> But I mean . . . I use my computer for everything, for everything. Everything I do is on the computer. When I think about what it was like before computers were around, to have that kind of accessibility, or even now, using the internet. How do people survive without the internet? I use it constantly, even though I am interacting with people and even interacting on email. But I spend a lot of my time on the computer . . .(woman)

Others spoke of that contradiction between what people think is part of computing and the reality:

> Maybe women didn't look at that field seriously for the same reasons I didn't. Just because it's a science, it's deep, it's technical, you have to sit in the lab and code all the time. And the industry's not like that. It's a huge, broad industry. (man)

The second kind of misinformation arising from this myth is that once you are a programmer, you are a programmer for life. In fact, programming may only be one step in a varied computing career. One man described his career progression beyond programming.

> Well I think I've done the coding thing. It's a career thing more than anything. And I've got a family and I've got to think about the fact that I don't want to just be doing a job that'll have a ceiling. . . (man)

Speaking of his own career and that of his computer scientist friends, the man with a CS degree described a career path with varied intensities of technological work.

> But I would say everybody was sort of following the same basic direction. They started out in the technical side, they jumped to sales, some of them were pursuing more executive type roles. There are a couple of them who are at VP levels today. What they would do is work from a programmer up into management roles like team leaders, project managers, taking on more and more responsibility

> for managing the delivery of a project to a client. That would be the more natural path for them. And if I go over to those companies, the guys my age aren't still coding. They're doing project management, they're assuming different roles within the organisation - they are still being themselves as techie or delivery guys but they're using computers to solve business problems. (man)

These obstacles at school and work sometimes sent women off in directions other than CS, caused them to switch jobs, or made them more determined than ever to succeed in computer-related work. Most women had earned university degrees, but not in CS. What are the alternative routes to computing careers they followed? Many took the route of becoming an expert in a non-technical setting. Some fell in love with technology after trying many other kinds of work. Some believe they came into computing by chance. The next section describes these three alternative routes to computing careers.

4.5. Findings: Alternative routes

4.5.a. Becoming experts in a non-technical setting

Many came to this software company having learned computing skills at workplaces that are not computing companies. The typical scenario recounted by many respondents began when they worked at various non-computing companies. They indicated that they were more comfortable with computers compared with other employees, so they were given significant computing responsibilities. These responsibilities gave them experience and confidence with computers and made them good candidates for employment by the software company I studied. It is evident from the following quotations that those who have come to computing by learning on the job usually found themselves in the right place at a critical time, with much-needed

confidence in working with computers. In addition, these respondents usually described an increasing interest in and satisfaction from their computer experiences.

> They did a lot of work on spreadsheets and most of their work at that time was in DOS based applications and they had got one Windows machine at that time and I found it more exciting and easier to use a mouse than using the keyboard so they got me onto a windows machine. I ended up being their troubleshooter for problems in the office for everybody because most of the people there had been in the industry for a while and were new to computers themselves. They were intimidated by it. So I was put in as the key person to help them out if they got into problems. (woman, construction estimating company)

> And I started in April. In June of 1980 they delivered computers. And I worked with veterans of the bank, so most of them had 20-25 years and they were just terrified of these computers. I was doing trial balances back then for them online, and I got to do queries on the computer because no one else would touch it. So I taught each one of them, and then got a lot more management responsibility just because everyone else was afraid to touch the computer. So it was sort of circumstance that it fell into my lap. (woman, bank)

> At the ad agency where I worked we had a Mac system. The secretaries tried to use it and messed everything up. Everyone was very frustrated with it. I helped them get the system networked, and set up the data-base so everyone could use it. I even put more into it than was there when I started. I decided that my career needed to move in another direction, and I seemed to be able to do the computers when others couldn't, so . . . (woman, advertising agency)

A HR consultant had noticed this pattern of developing computer expertise. He summed up this phenomenon of computer workers learning their skills in non-technical settings:

> I think our more successful technicians have always been the people who came to know computers through something else. They were the one in the office when this thing arrived. Nobody else wanted to take the boxes out. "Well, it looks like just IKEA directions. I can do that." That whole element of threat was gone because nobody else would do it anyway. So even if you fail you're not standing out. There was never a person looking at you and saying, "Well you have to make this work or else we're all in trouble." (man)

For women this route to computing was particularly friendly as it eliminated the pressures of working in a male-dominated environment, and of competing with men to be the "expert" on computers in the workplace. By taking these alternative routes they avoided some of the obstacles described above, such as sexism, competition for entry into CS and their parents' disapproval. Once into computing work, however, there were still the obstacles of the computing culture and the issues surrounding childcare.

4.5.b. The conversion: Falling in love with technology

One pattern in the alternative routes respondents followed to computing is what I call the "conversion." In these cases computing was a complete career change. Converted respondents had gone through a series of unsatisfying jobs that offered minimal rewards and limited mobility prior to taking their computer training. They all expressed having lacked interest in computing when they took their post-secondary education. Their disinterest arose from what they perceived to be a clash between their own identities and the stereotypical computer scientist. The one man who was converted to computing described himself as a jock, the women identified more with the arts, or went through university when CS was not well known. They previously had few computer skills, but had gradually developed a sense that there were good jobs available for those with computing skills. Each attended a private college for computer training. Once they started into their private college intensive courses, these respondents all fell in love with computing. They were passionate converts to the field:

> The instant I got my hands on the computer it grabbed me. I love, I really, I love the technical stuff. I get a real kick out of it. (woman)

> Oh yeah, cause once I started the course I really could get my teeth into it, and it was just like, these concepts were just snapping. (woman)

> I was so turned on to it when I got into it. I finally found - I really knew that I had found what I loved within the first month. I was just so keen on the whole thing. (man)

Two cases of conversion are particularly interesting. Both respondents (one male, one female) have university degrees: the man has a BA, the woman has her Masters in Science. He worked in quite a wide variety of jobs before making a dramatic new start in computing; she worked in the same job for ten years, stayed home with her children for ten years, and then returned to her previous job for a further five year period. Both of these respondents actively pursued the possibility of careers in carpentry. Both were assessed and found to have an aptitude for computing work, and both enrolled in very intensive, short-term computer training programs. She wanted to get away from the kind of academic work she was doing in her previous job and do more practical, physical work. He wanted to get away from the practical, physical work he had done in his previous job and do something more intellectual!

> I was tired of doing things where I required my hands all the time. I wanted to do something more intellectual. (man)

> I think after 15 years in a academic environment I wanted out of anything that looked like academia. And I wanted, I only wanted, I wanted to do something that was . . . with [my] hands. (woman)

Clearly computing work requires both practical and intellectual skills, but it is interesting that these respondents were motivated by the desire to use different skills. After his training, he worked for another two companies before being hired as a senior consultant at this software company. At the time of the interview he had been working in

computing for nine years. She was hired by the software company immediately after completing her intensive training. She works as a principal technician and had been working in computing for four years. Both expressed an ongoing love of computing.

4.5.c. Serendipity

Many women explained their good jobs as the product of good luck, circumstance, or being in the right place at the right time. They spoke of serendipitous factors that led to their success in computer-related work:

> I happened to fall into computing.
>
> I fell into that out of university.
>
> It was more timing and interests . . . the product manager was ill or something so I had to see the president . . . and he ended up hiring me . . . my female colleagues here, they all somehow by accident got into this industry.
>
> It's just all about circumstances that happens to you along the way.
>
> By chance. . . . happenstance . . . right place, right time . . . they needed someone else and I was again in the right place at the right time and very lucky, very lucky.
>
> I feel like it's luck.
>
> And I lucked into a group of women . . . that was a total fluke, but it just happened that way .. . part of it was just circumstance.

Men also attributed some of their success to serendipity. One described the element of luck involved in getting put into good projects that give you the kind of experience that helps you rise in the company. Others used such terms as "sheer luck," "boondog," "tripped and stumbled into [this company]," and "whether by skill or luck" to describe their experiences gaining work in computing.

What is the significance of the recurring mention of luck as a factor in these people's careers? I believe it has to do with taking alternative routes to computing. Since they have not taken formal CS education they believe there is more of a chance element involved in their career paths. There would be less "luck" involved in their careers if they had degrees in CS. In a sense, luck or chance signifies experience in this context. These computer workers cannot count on a CS degree to get ahead in this field. It is their experience that will get them ahead, and part of gaining experience has to do with being in the right place at the right time, and taking advantage of opportunities that come their way. The man with a CS degree made this point well:

> At entry level, you're basically going to get the same opportunities. The difference, though, is the guy that's coming out of the Waterloo program, is viewed as being promotable. There's long-term potential for that individual as opposed to some guy that might have just attended a 6-month training course to get his Microsoft Systems Engineering certification. Truthfully, the guys come out with the same skills. They would be put on a job day one, the same thing, and then it's your abilities that speak beyond that. So - I've got a university degree so sometimes I'm a little biased - but I've seen lots of people that came the other routes, but they had skills separate from those that they just inherently had and were able to leverage off that and be very successful. So it really depends more upon the person. Once you get that diploma, or whatever, it gets you in the door and the rest is up to you as to what you want to do with it type of thing.

In contrast, the woman with a degree in CS described the reaction of immediate respect she received once she told people that she had a CS degree from Waterloo.

> It's funny because a lot of times men would say to me, "So what's your background?" Just like that! And I'm thinking, I'm a University of Waterloo grad, they'd just calm down. It is so stupid, because me as a human being what credibility I bring here. So I have a Waterloo degree!

The degree satisfies clients that this woman can do her job well. Those who have to prove themselves in other ways tend to feel lucky to have succeeded in getting and staying in computing work.

The consequences of taking alternative routes to computing are not clear. Not having a university degree can prevent a person from moving to this company's head office in the United States, but will not necessarily prevent her or him from mobility within Canada. Women tell how the other obstacles have real consequences for their careers, however. There is support for the social control model here: many women are discouraged by their family socialisation; then if they pursue technical training anyway they may be discouraged by the computing culture and competitiveness in their area; if they persist, they may face sexism, sex-role expectations and other obstacles at work. Even when they reach higher status positions, respondents describe sexist jokes at meetings, and men who "can't handle" a woman being "up there." Some respondents suggest that men are better at the technical work and women at management, but looking at the distribution in this company, more men than women are still leading in the technical, male-dominated divisions. This company has a good history of hiring women. In part, women's virtual absence in the more technical jobs is a result of too few women with the required credentials applying for these positions.

4.6. Conclusions

This chapter explores to what extent societal values and ideologies concerning women working in computing have changed over the last several years. The findings suggest that there is a relationship between changes in the computing industry as

described by respondents, and beliefs about computing work. Changes such as the improved status of computing work, the broadening of applications of computing as it becomes more pervasive in society, the shortage of workers, and the narrow entry into computing affect beliefs about computing and who should be doing computer work.

The labour force shortage in computing has not directed more women into CS in part because of the limited number of spaces available in CS programs, the intimidating entry requirements and the "super-tech" stereotype. Nevertheless women are finding alternative routes to computing careers. The high rewards of computing work have attracted women to working in computing, but entry via alternative routes appears to mean that women are not highly represented in the most heavily technical divisions of this company. The alternative routes do not lead to the full range of work open to those with CS degrees.

The shift in the status of computing over the last two decades as perceived by respondents is from lower status, clerical associations to higher status, big business and science associations. The ideological shift in respondents' thinking associated with the change of status is a kind of masculinization of computing, since clerical work and lower wages are associated with women, while powerful technology and big business are associated with men. Nevertheless, for those women who are exposed to computing either through a mentor, guidance counselor, work or non-work experience, or through a teacher, computing work is very appealing. Since there is a shortage and access is wide open right now, women are entering computing via alternative routes than a CS degree.

Women's proportional enrolments in CS may increase if access to computing work becomes more closely regulated, particularly if the status of computing becomes on a par with the professions. Two things are needed for this to happen. First, women need to understand what a computing career is like. In other words, sources of information about computing work must improve. Secondly, more spaces must be made in CS programs so that the entry requirements are not perceived as so intimidating and competitive. Women show strong willingness and commitment to formal learning. If the government is able to succeed in opening more places in CS departments, women may move into those spaces in larger proportions when they are no longer able to access high status computing work without a CS degree. That trend would be consistent with Jacobs's (1989) finding in a study of medical education: women's participation increased significantly at key historical points where the profession opened the door to more, and more diverse, students.

The belief that computer scientists are both geeks and super-technologists may be limiting women's entry to computing through CS. That women identified the competitive entry into CS as an obstacle to entering computing, but men did not, suggests that women may be intimidated by the super-technologist image. The stereotypes articulated by respondents suggest that they do not enter computing in part because of their real or perceived lack of ability, but also because of their beliefs about what it takes to be a computer scientist. Although both men and women share these ideologies, they also believe women have to be better than men to prove their ability to work in this field.

Men and women I interviewed believed myths that stopped them from entering CS. The myth that computing involves very little human interaction was articulated by many respondents. Identifying themselves as "people-persons," and lacking information to dispute this myth, they turned to other programs. Women more than men are socialized to see themselves as nurturing, sensitive to people, and in need of human interaction in their work. For these reasons, this myth may have a stronger sway over women's decisions than men's, although both men and women used it to explain why they did not enter CS education.

Women also are believed to lack the kind of curiosity required of a computer scientist. In computing, curiosity is commonly measured by the extent to which someone will work long into the night to solve a problem, or to learn a new program. Women in this study have chosen more formal ways of satisfying their curiosity.

Looking at the social closure/control model, we do find support for the general theory that factors over the life course impact decisions to enter and leave computing education and work. Some of the factors are at work at times other than those hypothesized in the model, however. Experience can play an important role in motivating women to enter computing even when they have already finished school. For example, the route to computing through a non-technical job shows that gaining experience even in the workplace can affect one's career path. Also, it seems clear that historical factors play a more significant role than was expected. Rather than the labour force shortage bringing about a change in ideology that encourages women to enter computing, as expected (as during World War Two), the ideology associated with the

labour shortage reflects the limited number of places in CS programs, and the competitiveness to enter these programs. This ideology has a negative impact on women's enrolments, rather than a positive one. Other historical factors not included in the model, such as the increased status of computing, its pervasiveness, and the growth in ways computing education can be used in applied contexts, all have potentially important ramifications for women.

Chapter 5: Trends in computer education, occupation and industries

5.1. Introduction

The computer workers I interviewed described several historical shifts in computing work. Respondents identified changes such as the improved status of computing work, the broadening of applications of computing, the shortage of workers, the narrow entry into computing, and the changing stereotypes of computer workers from geeks to super-technologists.

This chapter looks at education, occupation and income patterns over the time when these changes were believed to be occurring. The quantitative data provide a picture of Canadian education, occupation, and industry over the last two decades. I explore whether there is a connection between the beliefs and stereotypes that came to light in the interviews, and patterns of computing education and employment. The question this chapter addresses is:

> Are there recent changes found in educational, occupational, and industrial statistics that may correspond with the changes in beliefs about computing that were expressed in the interviews?

I address this question with a general descriptive analysis of education, occupation, industry and income statistics over the past decade. I also test some hypotheses arising from the interviews and the literature on sex-segregation. The analysis focuses on changes over time in sex-segregation in education, work and industry, and in skill and income levels as indicators of trends in job status of men and women

computer workers.

Past research on sex-segregation of technology workers points to trends that need to be examined using more recent data. For example, in the United States, Wright (1997) finds that within computer professions, sex-segregation of computer workers is divided along engineering/non-engineering lines: women are more likely to work in non-engineering specialties like programming and men are more likely to be computer or electronic engineers. Using 1984 data she calculates that 18% of women would have had to change computer specialties to be distributed like men (or vice versa).

For all occupations, Burnell (1993) examines industry-related sex-segregation using 1980 data for the United States. She addresses the question of whether occupational sex-segregation is affected by location within high- or low-technology industries. Finding higher sex-segregation within high-technology industries than low-technology industries, she then analyzes women's representation in high-technology industries in relation to women's overall representation in the labour force. She finds women are underrepresented in high-technology industries.

Although lacking the detail of Wright's (1997) and Burnell's (1993) data, this study provides more recent data from the 1990s on the sex-segregation of computer workers, and on occupational-segregation by high and low-technology industries. In addition, the data are Canadian and therefore allow for comment on the Canadian computer-related labour force specifically.

5.2. Data

Nine data sets were used in the following analysis (see Appendix 3): four of these

used Census data from 1991 and 1996 Canadian Censuses. Two of the education data sets were produced by Statistics Canada using education and demographic data. The third education data set comprised 1991 and 1996 Census data on the Canadian population over 20 years of age with university degrees, or non-university certificates or diplomas, in post-secondary computing education. Industry data from 1984 to 1995 used the new COPS (Canadian Occupation Projection System) model of industry classification from Human Resources Development Canada. Data on average earnings from 1981 to 1996 came from the Survey of Consumer Finance. Finally, the 1994 General Social Survey (GSS) was used to identify occupational groups that have high computer use.

The 1991 and 1996 Canadian Censuses collected data on all Canadian citizens and landed immigrants over 15 years of age, residing in Canada or abroad, on a military base or a diplomatic mission[1]. In 1991, 13 million full time, full year workers answered questions on their occupation and industry location, their sex, and province of residence. In 1996 the corresponding figure was 15 million. The data are aggregated.

Statistics Canada Educational and Demographic Data provide information on university graduates in Canada, from 1976 to 1996, in all fields of study, by sex, level of study, and province. The number of cases varies by year, from about 108 thousand in 1976 to about 178 thousand in 1996. Statistics Canada also provides enrolment data for all computing fields of study at universities, from 1990 to 1999, and at community colleges and trade and vocational schools from 1990 to 1997. These data are collected

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[1] "Excludes institutional residents, residents of incompletely enumerated Indian reserves or Indian settlements and foreign residents, namely foreign diplomats, members of the Armed Forces of another

through institutional surveys of universities, community colleges and post-secondary trade and vocational schools. Total enrolments in computing programs in non-university institutions range from approximately 44 thousand enrolments in 1990/91, to 52 thousand in 1997. Total enrolments in computing programs in universities (all degree levels) range from approximately 19 thousand in 1990 to 30 thousand in 1999.

The Survey of Consumer Finance tracks average yearly incomes for the Standard Occupational categories coded according to the 1980 coding system. In this data-set, statistics are reported by age and sex for full year, full time workers only. The sample sizes for the years 1981 to 1996 range from approximately 24 thousand to 33 thousand.

The GSS for 1994 surveyed a random sample of 11,500 non-institutionalized (see note 1) individuals over 15 years of age, in the ten Canadian provinces. The response rate to the telephone survey was 83%.

5.3. Measures

5.3.a. Taxonomy: who are computer workers?

Wright (1997) argues that although many men and women use computers at work, only a small percentage of those should be considered "computer workers." Drawing on the work of Denning (1991), Wright defines a computer worker as "someone whose main function is providing support for *other* people's usage of computer systems" (Wright 1997, p.9). She identifies seven categories of computer workers: "computer

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country who are stationed in Canada and residents of another country who are visiting Canada temporarily." (Statistics Canada, Census data user documentation)

programmers, computer systems analysts, other systems analysts, computer engineers, systems engineers, computer scientists, and other computer specialists" (p.67).

Most recent research about computer professionals adopts the above definition and looks at the highly skilled computer *providers* rather than computer *users*. The Steering Committee on Human Resources in Computer Science and Technology (1993) is concerned about the problem of dealing with different data using many different occupational titles for similar kinds of computing work. They argue that occupations considered computer work will vary depending on who is doing the labeling. Academics and researchers tend to focus on the highly skilled computer occupations, but from a commercial or industry perspective, other groups should also be defined as computer workers. In industry, the Steering Committee notes the use of different job titles by organizations that are major users of information technology, compared with job titles used by organizations that develop computer-related products.

The goal of the research also affects the taxonomy used, the Steering Committee finds. If the research concerns the supply of workers, the categorization of workers may focus on skills and education, whereas research on the demand for workers may focus more on "functional responsibilities" and job titles to describe computer workers (p.17). The Committee agrees that occupational categories should be related to skill levels and, in the face of the rapid changes in computer technology and the kinds of work required in that field, broader categories might be more useful than narrow ones. They also argue that a "taxonomy for individuals is needed to partition workers into groups with sets of embodied skills that are equivalent" (p. 27).

Some argue that professional occupational groups tend to define themselves in ways that reinforce the male character of the professional community (Tijdens, 1997). One way of accomplishing this is to define "professional" occupations as those in which men dominate. Consistent with social closure theory, this process sets up a structure where female-dominated work is not considered "professional," has less status and commands lower pay.[2] Using Wright's basis for defining computer workers (the definition used by computer professionals) tends to exclude the computer work in which women dominate. For the bulk of the analysis, I follow Wright and others (Burnell, 1993; Reskin & Roos, 1990) in specifying computer occupations as those that require high skills. For comparison purposes, since I am interested in comparing the distributions of men and women of all skill levels working in computer-related occupations, I expand the definition of computer workers from supporters of computer technology to include some occupations that require heavy use of computer technology.

To identify occupations in which computer use is heavy, and in which a large proportion of people use computers, I use the General Social Survey data for 1994. Respondents were asked, among other things, whether they use computers at work, and the average number of hours per week that they use computers at work. Results were coded into 33 occupational categories. Although these are general occupational groupings rather than detailed categories, they are useful for establishing in which occupational categories computers are used by high proportions of workers, and how heavy computer use is within those occupational groups.

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[2] For example, many highly skilled female-dominated occupations such as nursing or teaching are

I calculate a measure of high computer use (HCU) using the formula:

HCU_i = Mean weekly hours using $computers_i$ x Proportion of workers using $computers_i$

where i represents the occupational category, and the potential range is 0 to 40[3]. Higher values of HCU indicate that large proportions of workers in that occupation are using computers, and they are using them, on average, for many hours of their work week. Lower values indicate that smaller proportions of workers use computers, or that those using computers use them for only a few hours per week, or that both situations are true in an occupational grouping. Appendix 1 presents the HCU values for men and women in the 33 occupations provided by the GSS[4].

The HCU values show the general occupation groups in which there is high computer use[5]:

Management/Administration related
Life Sciences/Maths/Computers
Architects/Engineers/Related occupations
Stenographic/Typing
Bookkeeping/Account-recording
EDP operators/Material Record
Reception/Info./Mail/Message
Library/File/Other Clerical
Sales/Services

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considered semi-professional.

[3] Based on the assumption of a 40 hour week. If there were a situation where high proportions of workers in an occupation work over 40 hours/wk the range could be higher. In these data the highest HCU occupation is Life Sciences/Maths/Computers at HCU=23.1. This is a rough measure since many occupational titles are grouped under each general occupational category.

[4] These occupational categories are based on the 1980 Standard Occupational Codes. Each occupation comprises several more detailed occupational codes. In consultation with Statistics Canada, the detailed occupations were translated into 1991SOC categories for comparison with the NOC classification job descriptions provided by Human Resources Development Canada.

[5] HCU values were calculated for males and females separately for each occupational group. These values were then ordered from high to low and two thirds of the highest value was chosen as the cutoff point (15.7). Although the cutoff was arbitrary, the occupation groups above the cutoff are well-known to require high levels of computer use, and those under the cutoff are less clearly linked to computer use (e.g., the next occupation below the cutoff is "Other crafts and equipment" at HCU of 15.3).

Within each occupational group where HCU values are high there are a number of occupations, some with potentially higher computer use than others. The GSS data do not allow me to distinguish the more detailed occupational categories within the broader occupational groups. To identify a subgroup of detailed occupations where computer use is high from within the general occupation list, I consulted Human Resources Development Canada's (HRDC) labour force information documentation for descriptions of occupations which fall under the general occupational classifications.

There are two problems with this method for selecting occupations with high computer use. First, since the two-digit level of occupation detail used in the GSS averages together the computer use of occupations that may vary quite significantly in use, some high computer-use occupations may be missed. For example, where only a few people hold jobs in an occupation with very high computer use, these occupations may be missed if they are in a category where most other occupations do not entail computer use. Second, since the HRDC descriptions do not systematically measure computer use in their occupational descriptions (descriptions may emphasize other qualifications), this means the selection of detailed occupations is not as systematic as would be desired. Nevertheless, this method provides a rough list of occupations where computer use is high and enables us to extend the analysis beyond the high status, high skill occupations typically analyzed in relation to computer work. Occupations identified by this method will be kept separate in the analysis from those professional occupations identified in the earlier literature on computing occupations.

The National Occupational Codes, and the 1991 Standard Occupational Codes identify occupations by both skill type and skill level. Of particular interest to this research are skill level identifiers. I was able to identify occupations at the top three skill levels (no computer-related occupations fell into the lowest skill level) in which the work was principally related to computer technology. Under some of the occupational categories not selected there were job titles that fit the criteria for inclusion[6], but since those specific jobs were only a small portion of the occupational category these occupations were not included.

In light of the above arguments, and given the purpose of this research, the three skill groups I have identified include both supporters and users of technology. I treat the occupations as distinct, and I group them into the three skill levels as identified by the 1991 SOC codes and HRDC in their occupational classifications. In the top skill level – computer professionals – the embodied skill requirement is a university education. I include:

systems analysts
programmers
electrical and electronic engineers
computer engineers
information systems and data processing managers

All of Wright's categories fall into the highest skill level. Although the titles differ somewhat, the categories of Computer Engineer, Computer Systems Analysts, and

[6] For example, under "college and other vocational instructors" there are computer science college teacher, computer trainer, and computer programming instructor, as well as instructors in many other disciplines.

Computer Programmers basically subsume the categories Wright identifies as computer workers.[7]

At the second skill level, the embodied skill requirement for occupations is two to three years of post-secondary education at a community college, an institute of technology or CEGEP *or* two to four years of apprenticeship training *or* three to four years of secondary school and more than two years of on-the-job training, training courses or specific work experience. Occupations I identified in this category include:

supervisors, general office and administrative support clerks
electrical and electronics engineering technicians
drafting technologists and technicians
technical sales specialists, wholesale trade

At the third skill level, the embodied skills required are: one to four years of secondary school education, and up to two years of on-the-job training, training courses or specific work experience. Occupations at this skill level include:

typists and word processor operators
computer operators
data entry clerks
general office clerks
accounting and related clerks
administrative clerks

5.3.b. Industries

Some have argued that women earn less income than men because they work in large numbers in industries that tend to pay less for both men and women (Strober & Arnold, 1987; Donato & Roos, 1987). Others have found that whether an industry is

[7] For example, Computer Engineer includes computer applications engineer, computer hardware engineer, computer software engineer, and so on.

high-technology or low-technology has a significant effect on occupational sex-segregation: high-technology industries have higher levels of occupational sex-segregation than low-technology industries (Burnell, 1993). Based on this finding, I hypothesize that women are segregated not only into the lower paying computer occupations, but also in the low technology industries employing computer workers.

Since I do not have data that allow me to stratify industries by male wages, a technique used by Donato & Roos (1987), I use an adaptation of Riche, Hecker & Bergen's (1983) group III definition of industries that are high technology. Their definition basically identifies those industries that hire more technology workers than the average for all industries, and that have a higher than average expenditure on research and development. Following Burnell (1993) I adapt this definition, calculating the proportion of computer workers (high skill categories) in all industries, then flag as high technology those individual industries with proportions of computer workers at least one and one-half times the overall average. Using this method with 1991 Census data, I find 15 high technology industry groups out of 76 major industry groups in the 1980 Standard Industrial Classification (SIC), and 13 high technology industries out of 67 industries in the Canadian Occupational Projection System industry classification (COPS). Appendix 2 lists the high technology industries in each of these classification systems. Most of the analysis of industries uses the COPS classification.

5.3.c. Fields of study

All computer-related fields of study offered at university or non-university institutions were included in the educational analysis. Depending on the data source, not

all fields were available for all data. The following fields of study are included in the analysis:

Computer science teaching[8] (both university and non-university programs)

University:
- Computer engineering
- Electrical/electronic engineering
- Computer science

Non-university
- Word Processing
- Data processing – general
- Computer science technology
- Electrical/electronic technology
- Computer programming
- Computer science system design and analysis

5.3.d. Segregation measures

5.3.d.i. Index of dissimilarity

The index of dissimilarity is a commonly used measure of sex-segregation which measures the extent to which men and women are similarly distributed across occupational categories (Jacobs, 1989). For the index of dissimilarity (ID) the following formula is used:

$$ID = \sum_{i=1}^{n} \frac{\left|\left(W_i/W\right) - \left(M_i/M\right)\right|}{2} \times 100$$

W_i is the number of women in occupation i, W is the total number of women, M_i is the

[8] This field of study refers to those enrolled in programs where they are training to be CS teachers.

number of men in occupation i, and M is the total number of men. The index is interpreted as the percent of women that would have to change occupations to be distributed similarly to men (or the percent of men that would have to change occupations to be distributed similarly to women). The measure is symmetrical.

5.3.d.ii. Index of concentration and relative concentration

Another dimension of sex-segregation is the extent to which women and men are concentrated in a small number of occupations. Rather than comparing women's proportions in an occupation relative to men's, this measure compares women's proportions in an occupation to an equal distribution of women across all occupations (Jacobs, 1989). For the index of concentration (IC) the following formula is used:

$$IC = \sum_{i=1}^{n} \frac{\left|\left(W_i/W\right) - \left(1/n\right)\right|}{2} \times 100$$

The symbols here are similar to the index of dissimilarity; n refers to the total number of occupations of interest. This measure is interpreted as the percent of women who would have to change occupations for women to be evenly distributed across all occupational categories.

A similar index can be calculated for men, substituting the following formula:

$$IC = \sum_{i=1}^{n} \frac{\left|\left(M_i/M\right) - \left(1/n\right)\right|}{2} \times 100$$

In this case, the index can be interpreted as the number of men who would have to change occupations in order to be evenly distributed across all occupations.

The index of concentration measures the extent to which women or men are clustered in a small group of occupations (Jacobs, 1989). To find the relative concentration (RC) of women to men, the rate is calculated using the following formula:

$$RC = \frac{IC_W}{IC_M} \times 100$$

where IC_w is the Index of Concentration for women, and IC_m is the Index of Concentration for men. Relative concentration measures the extent to which women are more or less concentrated in a small group of occupations than men. A value under 100 percent means that men are more concentrated than women, and a value over 100 percent means that women are more concentrated than men.[9]

5.4. Trends in computer-related education, work and incomes

5.4.a. Educational trends

Gadalla (1998) has documented women's declining proportions in university programs in Canada. She uses a "parity"[10] measure to examine the trends in women's enrolments in CS in relation to their overall university enrolments. Her finding that women's proportional enrolment in university CS programs is declining supports the

[9] Jacobs (1989) uses a different method to calculate RC. He subtracts IC_W from IC_M to calculate relative concentration as the difference in concentration between men and women.
[10] She divides men's and women's enrolments in CS by overall university enrolments for men and women, to control for overall trends in education that may be affecting CS enrolments also.

question that motivates my research. To expand on her analysis I look at three datasets: yearly enrolment counts in university and non-university post-secondary programs from Statistics Canada's surveys of post secondary institutions; counts of the Canadian population, 20 years and older, with university degrees, non-university certificates or diplomas in post-secondary computing education from the 1991 and 1996 Canadian Census data; and institutional data on the number of yearly graduates from university programs.

First, the latest enrolment data are used to extend previous analysis such as that done by Gadalla (1998) on women's proportional enrolments in CS. Then, to examine sex-typing within computing fields of study at both levels, I calculate the index of dissimilarity to see what would have to change to make the distribution of men and women enrolled in computing education equal. The enrolment data run from 1990 to 1999 for universities, and from 1990 to 1997 for college programs. I look at trends in enrolments at both levels over this time period.

With the Census data, the index of dissimilarity is again calculated to see what percentage of degrees or certificates would have to change to make the distribution of men's and women's computing qualifications equal at both university and non-university levels. Comparing students in 1991 and 1996, I look for changes over time in sex-segregation by institution and program. Finally, I look at measures of concentration to see the extent to which the computing credentials of women and men are clustered in certain fields of study, rather than being spread evenly over those fields.

Using institutional data, I look at the yearly number of university graduates of Computer Science and Electrical Engineering[11] over time. I identify trends in sex-segregation in these fields of study using the index of dissimilarity over 20 years (1976 – 1996) for women and men in all levels of university study.

Wright (1997) found that women are more likely than men to undertake ongoing studies relevant to work. Women I interviewed also were more likely than the men I interviewed to have taken additional training beyond their university degrees. If women are taking alternative routes to computing careers, this should show up in the education data by an increase in other kinds of computer education, specifically non-university computer education[12]. This potential trend suggests the following hypothesis:

> *Over time there will be an increase in women's enrolments in, and graduation from, non-university computer science education.*

Camp (1997) found that women in the United States were less likely to take CS in universities where the CS department was housed within the engineering faculty. She argues that women avoid the masculine culture of engineering, preferring to take CS where it is affiliated with other faculties such as Business or Science. Her finding yields the following hypothesis:

> *Women in computing education will be concentrated in the non-engineering fields of study.*

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[11] I include Electrical Engineering because in these data the fields of study are coded so that Computer Engineering would be subsumed under Electrical Engineering.

[12] The numbers of those who have taken non-university education after completing a university degree may be underestimated in the data reporting degrees granted, since respondents were asked to identify the field of study for their highest degree or certificate or diploma. Those who took non-university computer training after getting a university degree may still report their university degree as their highest degree. The enrolment data, where there will not be an underestimate, are also used to test the hypothesis.

5.4.a.i Enrolments in university and non-university programs

Figure 5.1 shows the percentage of women enrolled in CS and Electrical Engineering at Canadian universities from 1990 to 1999. Women's proportional enrolments in Electrical Engineering have steadily increased through the 1990s, although overall proportions of women are smaller in Electrical Engineering than CS. In CS, women's proportional enrolments, declining since the mid 1980s, and holding constant at around 20 percent through the early 1990s, dropped further between 1994 and 1997, but have begun to recover somewhat according to the latest enrolment data for 1997/98 and 1998/99.

Table 5.1 presents the latest enrolment numbers for Canadian university and non-university post-secondary computer education, the percentage of women in each program, relative to the total number of women in all computing education programs for each level and similar numbers for men in each program. At the university level, a larger percentage of women in computer education are enrolled in CS than in Electrical Engineering. Although women's proportions relative to all students enrolled in Electrical Engineering have been steadily growing (see Figure 5.1), the increase has not kept up to the overall increase of women enrolled in computing studies at universities: the percentage of all women in university computer studies (CS and Electrical Engineering) that are in Electrical Engineering declined from about 31 percent in 1990/91 to 27 percent

Figure 5.1 Percentage female enrolled in university undergraduate Computer Science and Electrical Engineering programs in Canada: 1990 to 1999

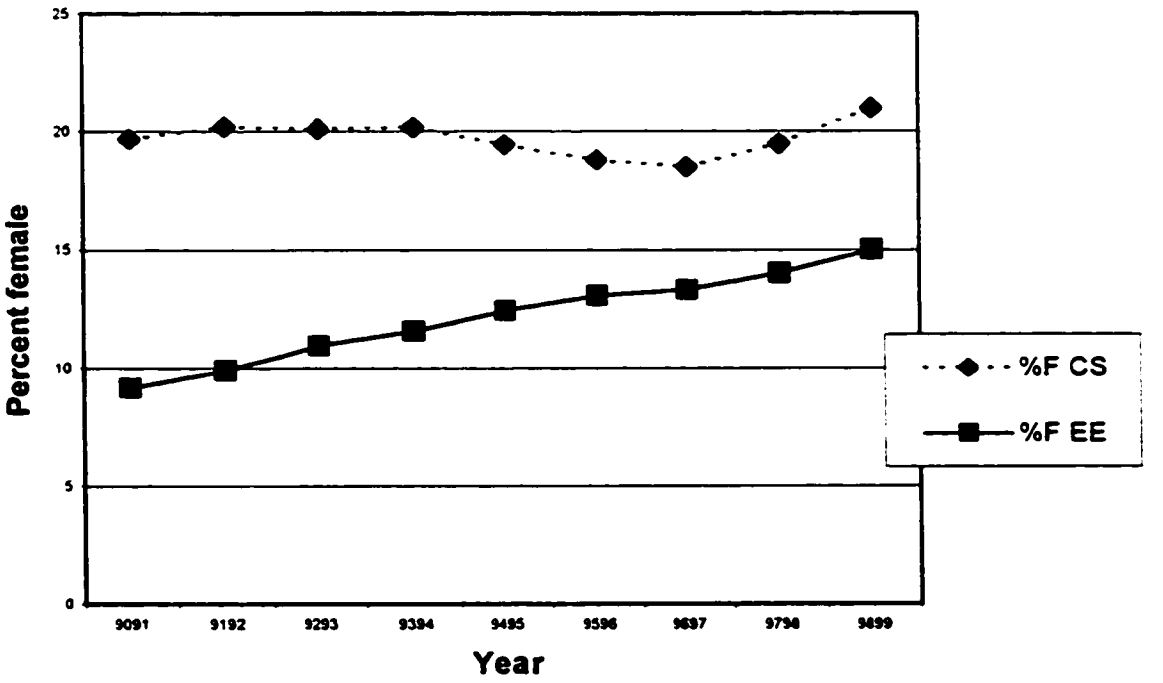


Table 5.1: Enrolments in Computing education, 1990 to 1999

University		9091	9192	9293	9394	9495	9596	9697	9798	9899
Electrical Engineering (men)	% of men	52.05	50.51	48.00	46.22	43.65	42.10	40.16	37.65	35.62
	count	*7270*	*7361*	*7434*	*7395*	*7228*	*7260*	*7334*	*7428*	*7662*
Computer Science (men)	% of men	47.95	49.49	52.00	53.78	56.35	57.90	59.84	62.35	64.38
	count	*6698*	*7213*	*8052*	*8605*	*9331*	*9983*	*10926*	*12299*	*13848*
Electrical Engineering (women)	% of women	30.86	30.71	31.05	30.72	31.25	32.00	31.20	28.91	26.88
	count	*733*	*809*	*912*	*965*	*1024*	*1088*	*1124*	*1210*	*1352*
Computer Science (women)	% of women	69.14	69.29	68.95	69.28	68.75	68.00	68.80	71.09	73.12
	count	*1642*	*1825*	*2025*	*2176*	*2253*	*2312*	*2479*	*2976*	*3677*
Non University		**9091**	**9192**	**9293**	**9394**	**9495**	**9596**	**9697**		
Data processing (men)	% of men	12.78	12.35	17.19	15.35	14.35	10.35	9.14		
	count	*1172*	*1291*	*2211*	*2123*	*2084*	*1683*	*1728*		
CS-system design and analysis(m)	% of men	25.54	26.26	25.81	26.94	26.98	27.64	20.57		
	count	*2343*	*2746*	*3319*	*3727*	*3918*	*4497*	*3889*		
Computer programming (men)	% of men	43.13	47.37	45.23	45.76	48.82	49.45	42.69		
	count	*3956*	*4953*	*5817*	*6330*	*7089*	*8044*	*8071*		
Word processing (men)	% of men	0.49	0.40	0.47	0.79	0.62	0.45	0.93		
	count	*45*	*42*	*60*	*109*	*90*	*74*	*175*		
Computer science technology(m)	% of men	12.25	9.93	7.74	7.58	7.46	8.85	15.83		
	count	*1124*	*1038*	*996*	*1049*	*1083*	*1440*	*2994*		
Electronic technology (men)	% of men	5.81	3.70	3.55	3.59	1.77	3.26	10.85		
	count	*533*	*387*	*457*	*496*	*257*	*530*	*2051*		
Data processing (women)	% of women	24.40	24.54	41.12	36.19	28.36	20.17	18.69		
	count	*1105*	*1171*	*2777*	*2345*	*1724*	*1146*	*1206*		
CS-system design and analysis(w)	% of women	16.78	17.15	12.53	14.14	18.25	23.67	23.78		
	count	*760*	*818*	*846*	*916*	*1109*	*1345*	*1534*		
Computer programming (women)	% of women	40.56	45.11	34.56	36.95	38.73	43.07	33.99		
	count	*1837*	*2152*	*2334*	*2394*	*2354*	*2447*	*2193*		
Word processing (women)	% of women	13.71	9.39	9.40	9.09	9.43	6.55	5.74		
	count	*621*	*448*	*635*	*589*	*573*	*372*	*370*		
Computer science technology(w)	% of women	4.26	3.69	2.28	2.47	4.24	6.27	12.74		
	count	*193*	*176*	*154*	*160*	*258*	*356*	*822*		
Electronic technology (women)	% of women	0.29	0.13	0.10	1.16	0.99	0.28	5.05		
	count	*13*	*6*	*7*	*75*	*60*	*16*	*326*		

$$\% W = \frac{\text{no women in field of study}}{\text{no women in all computer FOS}} * 100$$

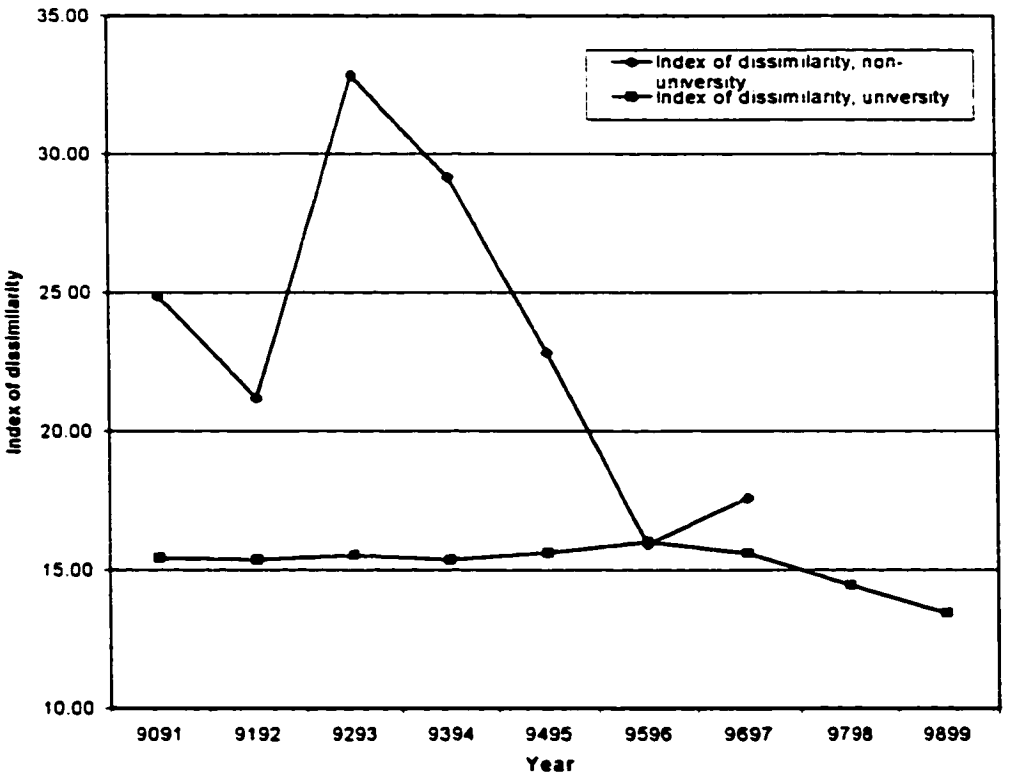
$$\% M = \frac{\text{no men in field of study}}{\text{no men in all computer FOS}} * 100$$

in 1998/99. A larger percentage of women studying computing are in CS, and this percentage is growing (from 69 percent in 1990 to 73 percent in 1999). This finding supports the hypothesis that women will be more likely to enroll in the non-engineering computer programs than the engineering programs.

At the non-university level, the percentage of women enrolled in clerical computing programs such as Data Processing and Word Processing, relative to all women enrolled in non-university computing programs, has declined, while the percentage of women enrolled in technical computing programs such as CS system design and analysis, and CS technology has increased from 1990 to 1997. Women's enrolments in Computer Programming have fluctuated in recent years, but the latest count from 1996/97 shows a smaller percentage of women enrolled in Computer Programming than in any of the previous six years. The percentage of women in Electronic Technology has also fluctuated over this time period, but increased in 1996/97. The trends seen here provide only partial support for the hypothesis that enrolments in non-university education are increasing. The increase in women's enrollments in CS-system design and analysis (a 41 percent increase in the percent of women enrolled in this field of study), CS technology enrolments (a 199 percent increase), and Electronic technology (a 1600 percent increase[12]) supports the hypothesis, but women are not increasingly enrolling in all non-university computer fields of study to the extent that they are in these fields.

[12] These numbers are small. A large increase in 1996/97 reflects the new offering of this program at Community Colleges.

Figure 5.2 Index of dissimilarity: Enrolments in university and non-university computing education



The index of dissimilarity shows the percentage of men or women who would have to change enrolments for men and women to be equally distributed across the computing fields of study. Figure 5.2 shows this measure over the 1990s for both university and non-university enrolments. In universities the index remains fairly consistently around 15 percent until 1994/95 when it increases slightly, then begins to decrease. The decrease can be explained by a shift in men's enrolments over this decade, to a pattern more like women's. In 1990/91 men's enrolments in computing education at universities were close to 50 percent in CS and 50 percent in Electrical Engineering. By 1998/99 that distribution had changed so that only approximately 36 percent of men in computing studies were in Electrical Engineering, and approximately 64 percent were in CS. Throughout this time, women's enrolments remained predominantly in CS, (from 68 percent to 73 percent of women in computing studies were in CS).

The index of dissimilarity for non-university enrolments was much less stable than for universities throughout the 1990s. Peaking in 1992/93 at around 33 percent, the index has fallen fairly steeply since then until 1995/96 (approximately 16 percent) when it increased slightly. A large increase in the percentage of women enrolled in Data Processing in 1992/93 when men's increase was much smaller, and concurrent decreases in the percentage of women enrolled in CS-System Design and Analysis and Computer Programming when the percentage of men enrolled remained the same, explain the sharp increase in the index for that year. The decreasing index after 1992/93 indicates that sex-segregation in non-university computer programs is becoming lower over time.

In sum, the enrolment data for 1990 to 1999 provide partial support for the hypotheses. At the university level, larger proportions of women studying computing are in CS than engineering, supporting the hypothesis that women will be concentrated in the non-engineering fields of study. The slight increase in women's proportional enrolments in 1997/98 and 1998/99 may mark the beginning of a response by women to the demand for highly skilled computer workers. Further observation of enrolments and degrees granted in subsequent years will be required to see if a change in the trend is ongoing.

The two trends seen in non-university enrolments - the decrease in women's percentage enrolments in clerical computing studies, and the increase in the percentage of women enrolled in CS-systems design and analysis, CS technology, and Electronic technology – partially support the first hypothesis, that over time there will be an increase in women's enrolments in non-university CS education. Clearly, women are shifting from clerical courses to more technical computing courses.

Enrolments only provide part of the picture in education, especially since previous research has documented the "leaky pipeline[14]" in Science and Technology education (Camp, 1997). The following two sections look at data on graduates of computer fields of study. The first section looks at the total number of graduates in the population: the following section looks at the numbers of graduates from these fields each year.

5.4.a.ii. Graduates from university and non-university programs

[14] This term refers to the loss of women from science and technology education from the elementary school years through to the Ph.D. level of study. At each level, women drop out of science and technology programs, leaving a small proportion of women at the higher levels of science and technology education.

Table 5.2 shows the number and percentage distributions of men and women with credentials from university or non-university institutions. Computer Science teaching is the only field of study offered at both university and non-university institutions. Like Camp (1997), the table shows the distinction between engineering and non-engineering studies: women are less likely to be highly represented in the engineering fields of study than other fields, and than men. There is support for the second hypothesis here, but while women's numbers are small, the trend over time is for greater proportions of women holding credentials in these engineering fields of study.

The overall segregation of men and women with both university and non-university qualifications has declined from 1991 to 1996 (Figure 5.3). Similarly, for computing fields of study there has been a decline in sex-segregation from 1991 to 1996. The decline in sex-segregation at the level of university qualifications reflects a proportional increase in women's attainment of degrees in the computer-related engineering fields: although their numbers are still quite small in those fields they have increased substantially (e.g., close to a 200 percent increase in the number of women in electrical engineering from 1991 to 1996).

As with enrolment data, at the non-university level, the declining sex-segregation in computing fields can be explained by a shift in women's credentials from clerical fields of study such as word processing and data processing, to computer science technology, where women's proportions increased from 52 to 74 percent between 1991 and 1996. The growth in women's proportions in computer science technology supports

Table 5.2 Number and percentage distributions of men and women over 20 years of age with degrees, diplomas or non-university certificates, 1991 and 1996

	University				Non-university			
Field of study	% of women 1991[1] (n)	% of women 1996	% of men 1991	% of men 1996	% of women 1991	% of women 1996	% of men 1991	% of men 1996
Computer science teaching	1.25 (220)	1.35 (375)	0.25 (220)	0.30 (360)	0.04 (35)	0.12 (125)	0.01 (10)	0.02 (50)
Word processing	0	0	0	0	16.64 (14,030)	8.43 (9,115)	0.14 (265)	0.14 (315)
Computer engineering	1.61 (285)	3.59 (995)	2.91 (2,600)	4.29 (5,160)	0	0	0	0
Electrical/ electronic engineering	15.37 (2,715)	19.40 (5,375)	55.04 (49,095)	49.96 (60,140)	0	0	0	0
Data processing – general	0	0	0	0	16.52 (13,925)	11.80 (12,765)	2.55 (4,800)	1.66 (3,790)
Computer science technology	0	0	0	0	61.78 (52,080)	73.84 (79,845)	34.59 (65,045)	43.84 (99,800)
Electronic technology	0	0	0	0	5.02 (4,230)	5.81 (6,285)	62.71 (117,920)	54.34 (123,695)
Computer science	81.77 (14,440)	75.65 (20,955)	41.80 (37,280)	45.46 (54,720)	0	0	0	0
Totals	100.00 (17,660)	100.0 (27,700)	100.0 (89,195)	100.0 (120,380)	100.0 (84,300)	100.0 (108,135)	100.0 (188,040)	100.0 (227,650)

[1] % of women = $\frac{\text{no. of women in field of study}}{\text{no. of women in all computer-related fields of study}} * 100$ % of men = $\frac{\text{no. of men in field of study}}{\text{no. of men in all computer-related fields of study}} * 100$

Figure 5.3 Index of dissimilarity: All fields of study, university and non-university education levels, 1991 and 1996

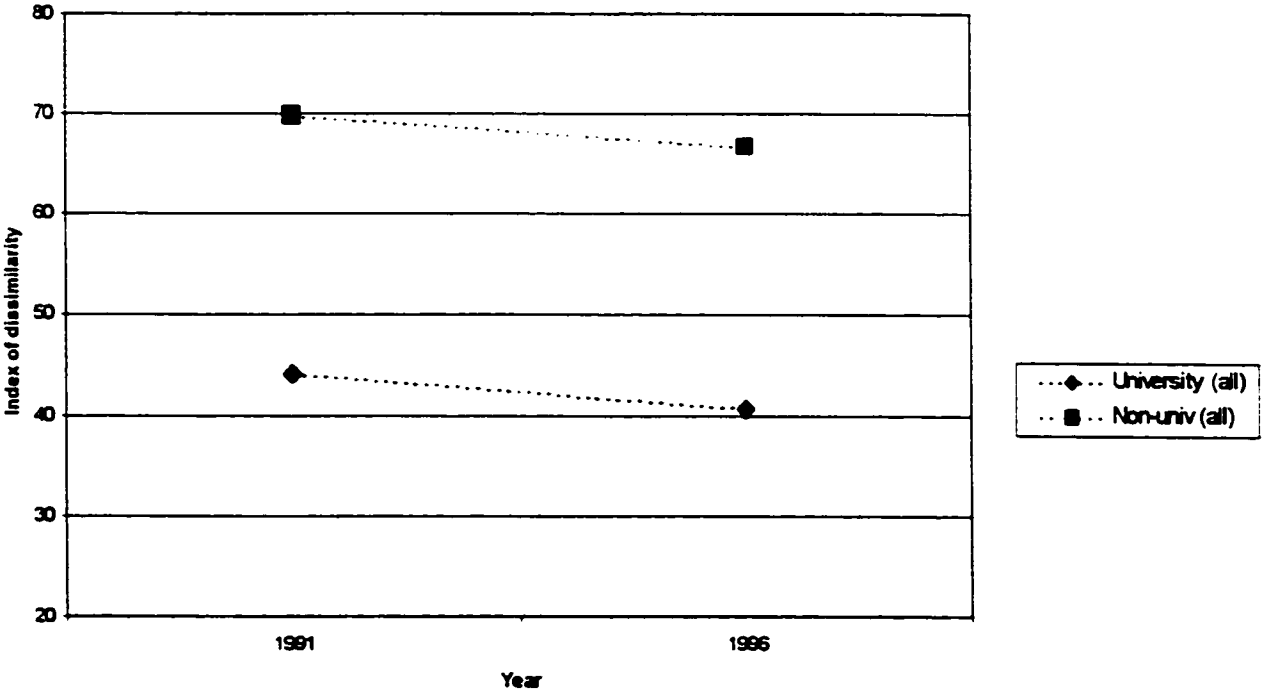
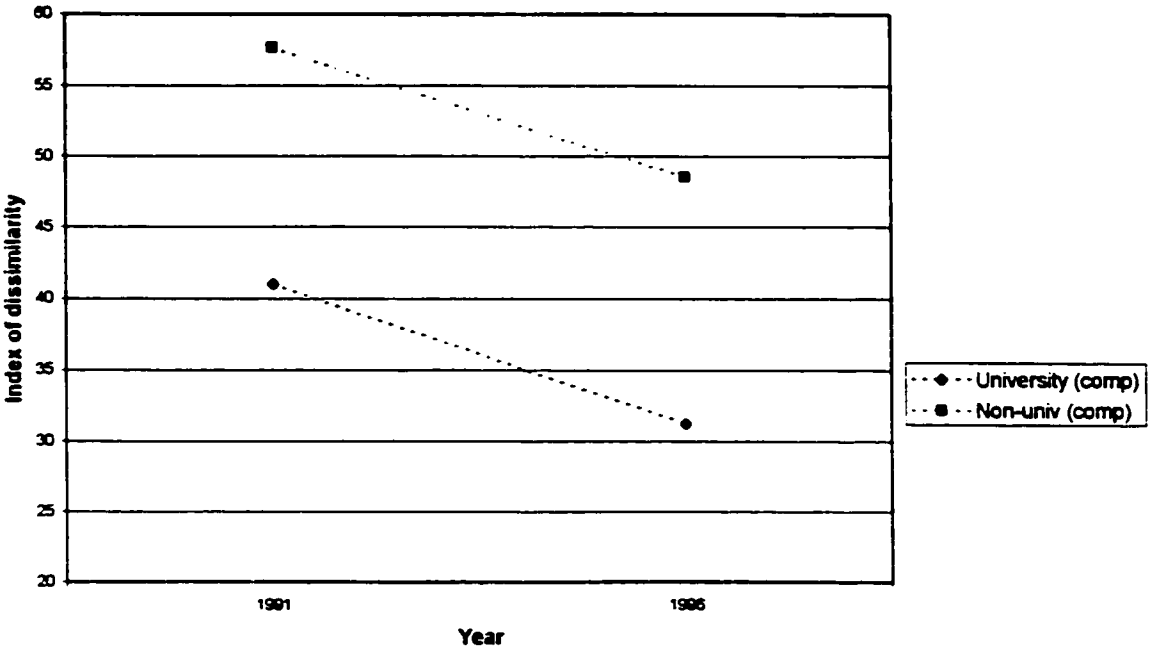


Figure 5.4 Index of dissimilarity: Computer-related fields of study, university and non-university education levels, 1991 and 1996



the first hypothesis, that if women are taking alternative routes to computing careers it will be reflected in increasing numbers of women with non-university computer qualifications. Growth in women's representation in electronic technology was small, but also in support of the first hypothesis in this time period.

Sex-segregation is higher at non-university institutions than at universities, for all fields of study and for computing fields alone (Figures 5.3 and 5.4). In 1991, 58 percent of women would have had to change fields of study to be distributed similarly to men with non-university computing credentials, whereas the parallel index for university qualifications is only 41 percent. By 1996 the index of dissimilarity had decreased for non-university credentials to 49, compared with 31 for university.

On the other hand, women's non-university credentials are much less concentrated in particular fields of study than is the case for men from those institutions (See Table 5.3, Concentration Index of 61 for women in 1996, 73 for men), or for men and women with computing credentials from universities (70.42 and 70.06 respectively). Relative Concentration (RC) shows the percent of similarity in levels of concentration for men and women. The increasing similarity in RC of non-university credential holders from 1991 to 1996 is due to women's increasing concentration (57 to 61) while men remain fairly consistently concentrated at around 73 percent. Women were more concentrated in computer science technology in 1996 than 1991, as mentioned earlier, so the increase in concentration may reflect women upgrading from clerical to computer skills, or it may indicate that the non-university institutions are absorbing some of the people who could otherwise have taken a university CS program. Men with non-

university computer credentials are clustered in computer science technology and electronic technology, although in 1996 men's concentration is more equally divided between these two fields of study than in 1991.

Table 5.3 Indices of Dissimilarity and Concentration, degrees or certificates granted by university/non-university education for 1991 and 1996

Year		Dissimilarity	Concentration		RC
			W	M	
Computer fields of study only					
1991	University	40.97	72.14	71.84	100.40
1996	University	31.25	70.06	70.42	99.49
1991	Non-univ	57.69	57.44	72.30	79.45
1996	Non-univ	48.53	61.34	73.18	83.82
All fields of study					
1991		44.09	70.14	70.67	99.25
1996		40.70	69.04	70.03	98.59

Although the extent to which women would have to be redistributed across fields of study to be distributed in the same manner as men has decreased, women's concentration in fields of study relative to an equal distribution across all fields of study has remained essentially the same at the university level (1991: 72 percent, 1996: 70 percent). In other words, approximately 70 percent of women would have to change fields of study for women to be evenly distributed across all computing fields of study at

the university level.[15] The limited decline in the index of concentration means that women remain concentrated in certain computing specialties although overall sex-segregation is declining. Women's degrees remain more concentrated in CS rather than the engineering fields, but proportions are increasing in engineering and decreasing in CS. Men with university degrees in computing tend to be fairly equally concentrated in both electrical and electronic engineering, and CS. Supporting Wright (1997) and Camp (1997), the data show that the concentration of women and men with university credentials divides along engineering/non-engineering lines. Men's credentials are concentrated to a similar degree to women at the university level (RC 1996 = 99.49), but men's credentials are more heavily concentrated in electrical and electronic engineering and women's credentials are more concentrated in CS than engineering.

5.4.a.iii. University graduate trends, 1976 to 1996

Although men and women with university credentials differ in concentration along engineering/non-engineering lines, the sex-segregation index for graduates is decreasing over the long term. The decline in segregation at the university level found between 1991 and 1996 (see Figure 5.4) is part of a longer trend in declining sex-segregation in computing fields of study at the university level from 1976 to 1996 (see Figure 5.5).

[15] This is not to suggest that an equal proportion of women in all fields is necessarily desirable, but the measure is useful for identifying whether women or men are not well-represented in a wide range of occupations and may suggest the usefulness of an examination into where women and men are dominant in the labour force.

Figure 5.5 Index of dissimilarity: University graduates of Computer Science and Electrical Engineering 1976-1996

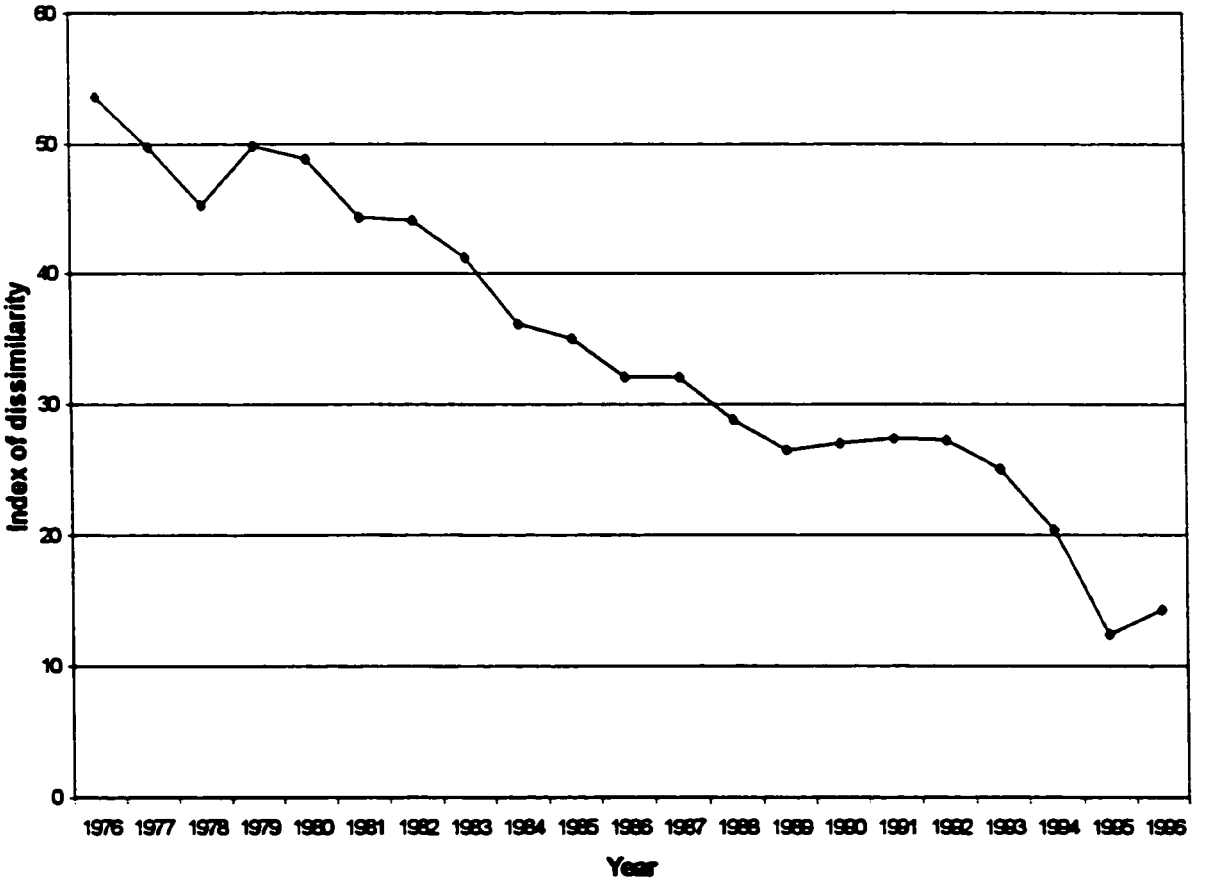


Figure 5.5 shows the decline in the sex-segregation of people earning CS and electrical engineering degrees from 1976 to 1996. The trend indicates a weakening of the engineering/non-engineering division over time, so that women's and men's distributions in CS and electrical engineering programs in 1996 are more alike, and more evenly distributed, than in 1976 (approximately 14% segregation in 1996 compared with 53% in 1976). So, while there is support for the second hypothesis, that there is an engineering/non-engineering divide for men and women, the long term trend shows that this division is weakening over time.

5.4.a.iv. Conclusions about educational changes

The data suggest two changes in computing education in the 1990s. First, sex segregation is declining in computing education at both university and non-university levels. At the university level this decline can be traced to women's increasing proportions in computer and electronic engineering, and women's decreasing proportions in CS. At the non-university level, the decline has come about because women are increasingly moving away from the typical, female-dominated clerical programs (such as word processing) to more technical kinds of studies where jobs are plentiful. Therefore, the change at both levels is toward more engineering and technical kinds of training for women. Although the second hypothesis is supported, this pattern of few women holding engineering degrees is changing.

Second, there is partial support for the first hypothesis in these data: non-university institutions are increasingly training women for computer work, but only in some fields of computer study.

5.4.b. Occupational segregation

My purpose in this section is to examine changes in sex-segregation and the distribution of men and women in high, medium and lower skill level computer occupations from 1991 to 1996. Data combined from the 1991 and 1996 Censuses allow for comparisons of occupations by sex at two time points. For this analysis I look at the five high skill computer occupations, and at all 15 computer occupations as defined above. I calculate the index of dissimilarity to measure differences in distributions of men and women across occupations, and the index of concentration to measure the extent to which women and men are concentrated in particular computer occupations.

In the interviews, respondents discussed women's preference for working in computer applications rather than development. Taking alternative routes to computing careers could also mean women are less likely to move into the most technical kinds of work. Consistent with the interviews, Wright (1997) found that higher proportions of women are working in the non-engineering computer specialties in her sample. To what extent is this pattern in computer work still prevalent and relevant to Canada? The interviews and Wright's research suggest the following hypothesis:

> *At each level, women work more in the applied or less technical computing occupations.*

5.4.b.i. Distribution of computer workers

Table 5.4 presents the distributions and the percentage of computer workers who are female for high, middle and lower skill levels. The percentage female for all occupations, and computer occupations by skill level, show a pattern of little change.

Women's proportions in the lower skill computer occupations remain close to 80 percent, whereas the medium and higher skill computer occupations remain dominated by men. Within the five high skill computer occupations, electrical and electronics engineers have the smallest proportion of women. Computer engineers are also predominantly men. Women's proportions in all high skill occupations increased in 1995, except for computer programmers, where the proportions decreased from 28 percent in 1990 to 24 percent in 1995.

As with education, and supporting the third hypothesis, women's work divides along engineering/non-engineering lines. At the high skill level, a lower proportion of electrical and electronics engineers and computer engineers are women in both 1990 and 1995 than for any of the other high skill occupations. At the middle skill level sex-segregation is along technical/clerical lines. Women are most highly represented among supervisors, general office and administrative support clerks, whereas men tend to work as electrical and electronics technologists, drafting technologists, or technical sales specialists.

The technical/clerical division is strong at the lower skill levels also. Most of the

Table 5.4 Distribution, and percent female[16], of all workers in computer-related occupations: 1990, 1995

High Skill Computer Occupations	All90 n	Male90 n	Female90 n	% F90*	All95 n	Male95 n	Female95 n	% F95
Computer systems analysts	60,165	43,090	17,080	**28.39**	70,130	49,755	20,375	**29.05**
Computer programmers	38,420	27,760	10,660	**27.75**	46,580	35,480	11,100	**23.83**
Information systems and data processing managers	23,395	18,385	5,010	**21.42**	17,490	13,640	3,855	**22.04**
Computer engineers	7,210	6,460	745	**10.33**	12,490	10,870	1,615	**12.93**
Electrical and electronics engineers	26,220	24,825	1,395	**5.32**	26,235	24,385	1,855	**7.07**
% F all High Skill Computer Occupations				**22.45**				**22.44**
Middle Skill Computer Occupations								
Supervisors, general office and administrative support clerks	23,985	7,950	16,040	**66.88**	21,720	7,745	13,975	**64.34**
Technical sales specialists, wholesale trade	46,840	37,725	9,115	**19.46**	54,665	43,405	11,260	**20.60**
Drafting technologists and technicians	26,565	21,715	4,850	**18.26**	21,670	18,325	3,340	**15.41**
Electrical and electronics engineering technologists and technicians	20,785	18,670	2,115	**10.18**	26,990	24,135	2,860	**10.60**
%F all Middle Skill Computer Occupations				**27.18**				**25.14**
Lower Skill Computer Occupations								
Typists and word processing operators	19,450	785	18,665	**95.96**	9,130	420	8,710	**95.40**
Data entry clerks	46,415	6,805	39,610	**85.34**	45,795	7,355	38,440	**83.94**
Accounting and related clerks	155,275	28,615	126,660	**81.57**	159,745	28,535	131,215	**82.14**
General office clerks	111,810	22,230	89,580	**80.12**	106,305	18,315	87,995	**82.78**
Administrative clerks	34,340	7,135	27,205	**79.22**	43,745	7,605	36,140	**82.62**
Computer operators	24,470	10,790	13,675	**55.89**	20,045	10,825	9,215	**45.97**
%F all Lower Skill Computer Occupations				**80.51**				**81.01**
%F all computer occupations				**39.05**				**39.87**

$$*\%F = \frac{\text{females in occupation}}{\text{Total in occupation}} * 100$$

[16] Note the different way of calculating % female in this table versus table 5.1.

lower skill level occupations are clerical and all are dominated by women. The one exception is computer operators: men comprise about 50 percent of computer operators, arguably the most technical occupation included in the lower skill computer occupations.

5.4.b.ii. Segregation and concentration of computer workers

If more women are coming into computing occupations, one would expect sex-segregation to decline. On the other hand, if taking alternative routes to computing occupations means that one's work opportunities are restricted compared with the opportunities associated with getting a university CS degree, then the increase in women taking alternative routes would coincide with an increase in women's concentration in a few occupations. These arguments yield two hypotheses:

> *Sex-segregation is decreasing among computer-related occupations with the increase of women in computing work.*
>
> *Concentration is increasing in computer-related occupations if taking alternative routes to computing means that one's work opportunities are restricted.*

Table 5.5 presents the indices of dissimilarity and concentration comparing all occupations with computing occupations only. Looking at the changes in sex-segregation and concentration from 1990 to 1995 for all occupations, segregation decreases slightly in this time and concentration remains almost unchanged. For all occupations, women are more concentrated in occupations than men (63 percent and 49 percent respectively).

Table 5.5 Indices of Dissimilarity and Concentration, all occupations and computing occupations only, three skill levels for 1990 and 1995

Year		Number of occupations	Dissimilarity	Concentration		Rel. C
				W	M	
1990	All occupations	513	55.96	62.89	48.84	128.77
1995	All occupations	513	53.90	62.12	48.15	129.01
1990	All computing	15	57.11	47.35	26.13	181.21
1995	All computing	15	59.59	50.25	28.38	177.06
1990	High skill comp.	5	20.72	39.51	19.39	203.77
1995	High skill comp.	5	17.58	41.12	23.55	174.61
1990	Medium skill comp.	4	40.70[17]	28.32	19.07	148.51
1995	Medium skill comp.	4	36.18	30.28	22.15	136.70
1990	Lower skill comp.	6	11.22	35.23	33.25	106.96
1995	Lower skill comp.	6	11.86	36.99	30.80	120.10

(1990: 63 percent of women would need to change to be equally distributed across all occupations, versus 49 percent of men): the relative concentration of women to men is around approximately 129 for both years.

For all computing occupations the index of dissimilarity increases from 1990 to 1995, meaning that computing occupations become slightly more segregated over this period. In comparison, sex-segregation for all occupations decreases slightly over the same time period. The relative concentration is also higher for computing occupations than all occupations, staying at about 180 percent: relative to men, women are more

[17] The index of dissimilarity and concentration are contingent on the occupations included in each of the skill categories. The choice of medium and lower skill level occupations is based on the GSS analysis and

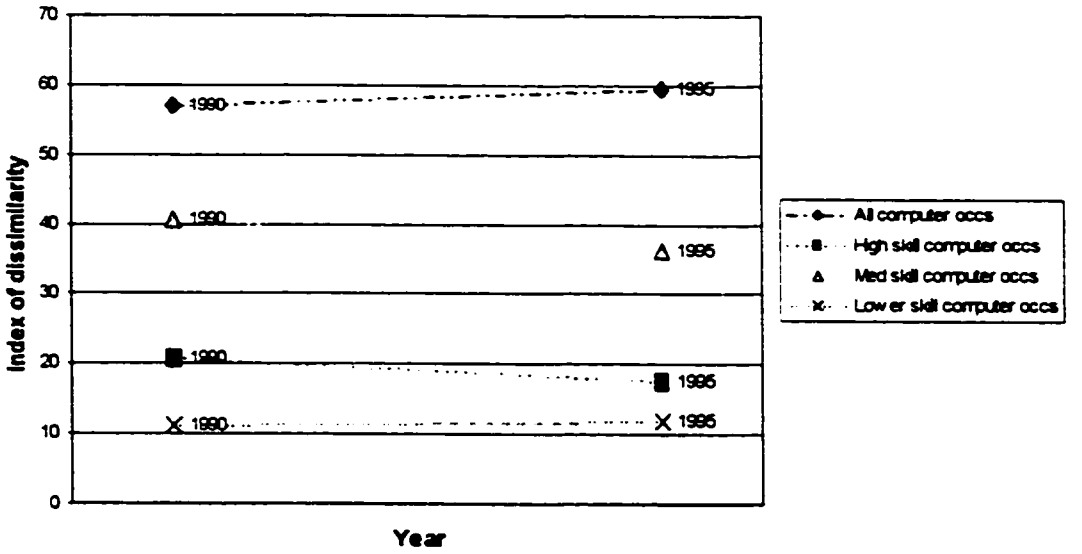
concentrated among the computing occupations. These differences are less trivial than they appear, given the much larger number of occupations in the "all occupations" group than the "all computing" group, and the index's sensitivity to the number of categories included (more categories means a higher value of the index).

When computations are broken down by skill level (Figure 5.6), the index of dissimilarity decreases from 1990 to 1995 at the high and medium skill levels and increases very slightly at the lower skill level. At the same time, there is an overall trend toward slightly higher levels of concentration, except for lower skill computer occupations for men who have become slightly less concentrated in a few occupations than they were in 1990. Relative concentration is highest among high skill computer occupations (1990, 203.77; 1995, 174.61), although it appears to be decreasing somewhat: in 1995 substantially more Canadian women than men were concentrated in a few computing occupations.

There appears to be some support here for both hypotheses – that sex-segregation is decreasing in computer-related occupations, and that concentration is increasing in computer-related occupations. There is a decrease in sex-segregation at each skill level, although there is an overall increase in segregation. There also is an increase in concentration except for men in the lower skill level.

HRDC descriptions so the occupations included could be different using another selection criteria. Readers should be aware of this contingency when interpreting the results.

Figure 5.6 Index of dissimilarity: All computer occupations, and computer occupations by skill levels, 1990, 1995



5.4.b.iii. Conclusions on the distribution, sex-segregation and concentration of computer workers

Within computing occupations, women dominate the lower skill occupations and men dominate the high skill occupations. Within these skill categories men dominate in the engineering and more technical occupations and women dominate in the non-engineering and clerical occupations, supporting the hypothesis that women work in the applied, or less technical, computing occupations. Little change has occurred in the sex-segregation found in these occupational groups from 1990 to 1995. Although high skill computer occupations have become slightly less sex-segregated from 1990 to 1995, women remain concentrated in the non-engineering occupations and overall sex-segregation in computing has increased slightly. Nevertheless, the lower value of the dissimilarity index for high skill computer occupations reflects women's slightly increasing proportions as electrical and electronics engineers through this time period and their slightly decreasing proportions as computer programmers.

5.4.c. Location of computer workers in industry

High technology industries are defined as those industries that employ over one and one-half times the average number of highly skilled computer workers for all industries, based on 1991 Census data. Given the preference stated in the interviews for the applications of technology over the machine fascination of more technical work, at each level women would be expected to work more in the applied or less technical industries. Burnell's (1993) findings for all occupations also lead us to expect that women will be underrepresented in the high technology industries, and lead to the following hypotheses:

Women computer workers will be more likely to work in low technology industries than high technology industries.

Within high technology industries, there will be occupational segregation by sex.

Figure 5.7 shows the percentage of highly skilled computer workers working in these high technology industries over the 12 years from 1986 to 1997[18]. The data show consistently high percentages of highly skilled computer workers employed in the high technology industries over the 12 year period. The percentage of systems analysts, computer programmers and related occupations working in high technology industries has increased by about 15 percent over this period. Despite some inconsistency between 1988 and 1991, a similar trend of increasing representation in high technology industries is true for technology management occupations also. Proportions of electrical engineers in high technology industries have remained consistently high over this time period, ranging between 80 and 90 percent.

What percent of these workers are men, and what percent are women? Using 1991 Census data, Figure 5.8 shows the breakdown of men in high technology industries as a percentage of men in all industries for each of the five highly skilled computer occupations. Similar data are shown for women. Electrical and electronic engineers are most likely to work in high technology industries according to the COPS industrial classifications, whereas using the SIC classification, computer engineers are slightly

[18] The data shown in Figure 5.7 use the 1980 Standard Occupational Classification so the occupational categories are somewhat different from the five highly skilled occupations of the 1991 SOC used elsewhere.

Figure 5.7 Percentage of high skilled computer workers working in high tech industries, 1986-1997

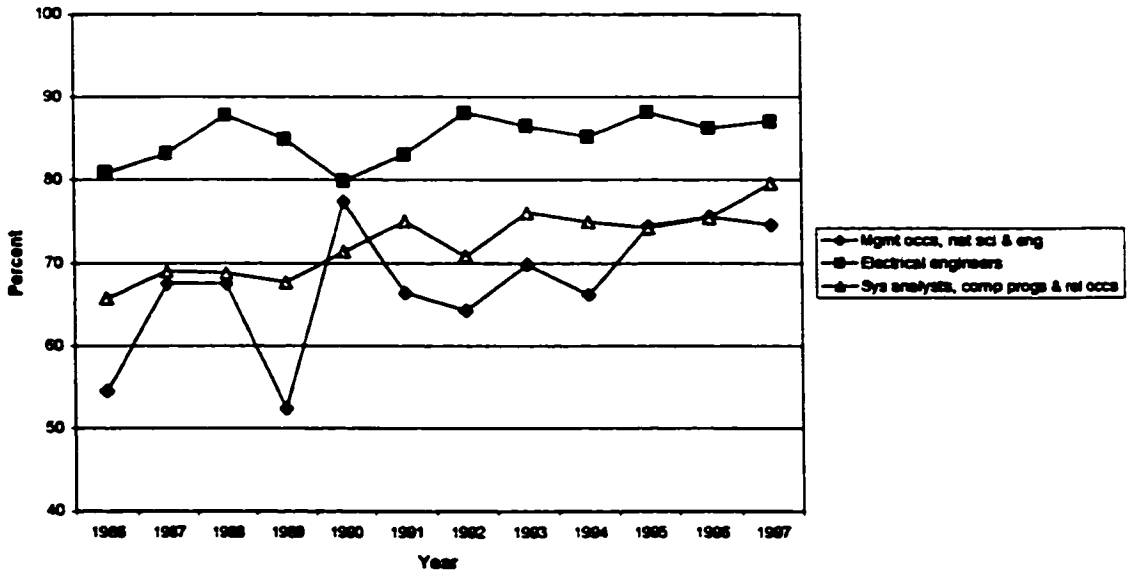
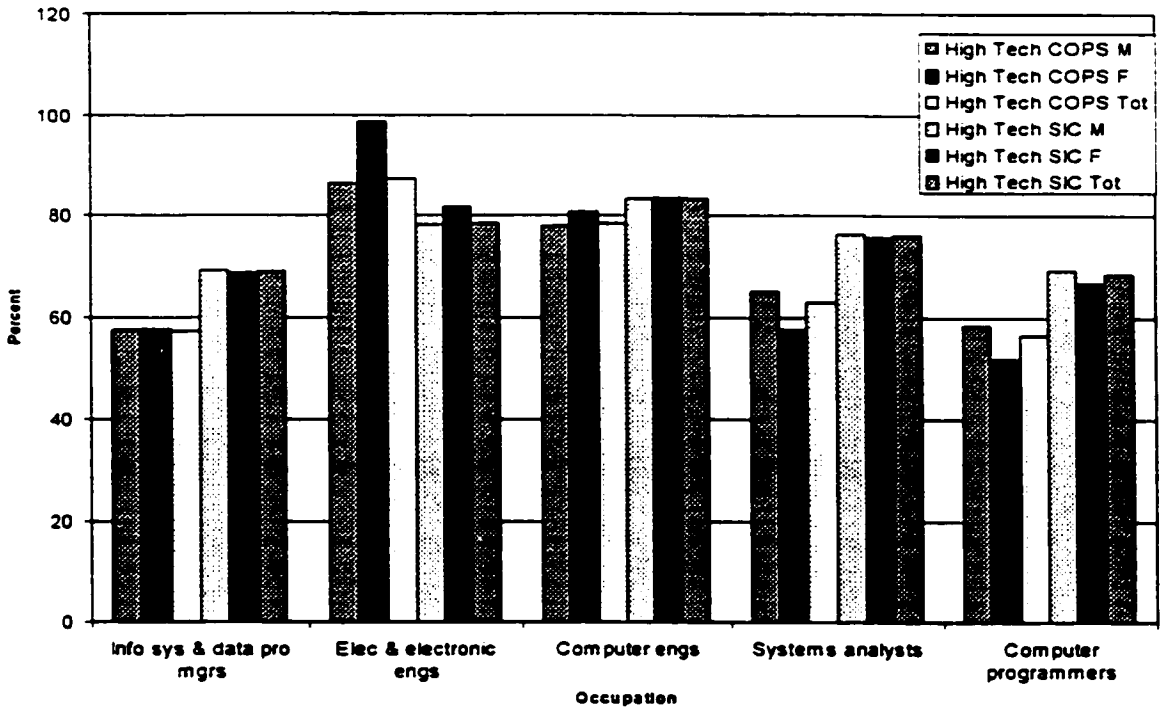


Figure 5.8 Percent of computer workers (male/female) in SIC and COPS high tech industries, 1991

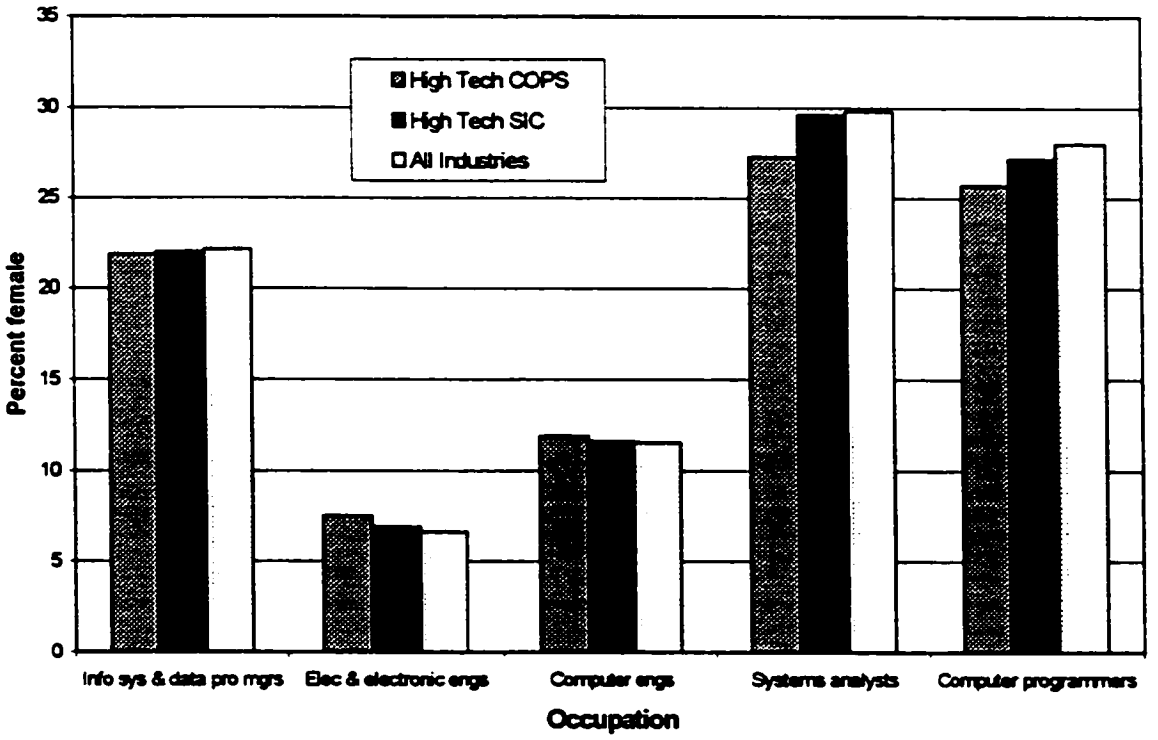


more likely to work in high technology industries. The other three occupations have somewhat lower representation in the high technology industries than the two engineering occupations.

Interestingly, although women are concentrated in the non-engineering fields of study, and the non-engineering occupations, higher proportions of women who are engineers work in the high technology industries compared with men engineers. In comparison, where women are more plentiful, as systems analysts and computer programmers, they have lower proportions in the high technology industries compared with men in those occupations. The findings do not fully support the hypothesis that women computer workers will be more likely to work in low technology industries than high technology industries, although there is partial support in the findings for systems analysts and computer programmers here.

Figure 5.9 shows what proportions of women worked in high technology industries in 1991, relative to the total number of men and women working in each of the highly skilled computer occupations. Compared with their representation in all industries, highly skilled women computer workers are similarly represented in the high technology industries. For example, women comprise only around six percent of electrical and electronic engineers in all industries, and about seven percent in high technology industries. There are small differences for women systems analysts (30 percent for all industries, versus 27 percent for COPS high technology industries) and for computer programmers (28 percent for all industries, versus 26 percent for high technology industries).

Figure 5.9 Percent of all industry and high technology industry computer workers that are women, 1991



Women's proportions are lowest in the two engineering occupations in high technology industries, but their low proportions mirror their overall proportions in all industries. As noted above, there are smaller percentages of women overall in the engineering specialties of computer work than there are in systems analysis, programming and management. Nevertheless, almost all of those women who are electrical and electronics engineers work in high technology occupations, as seen in Figure 5.8.

5.4.c.i. Percentages of workers in occupation and industry combinations

To get a better idea of the distribution of women and men in the more detailed industrial categories, two multinomial logit models were fit[19]. The first gives the probability of being in an occupation given industry and sex. I present here only the findings for the high technology industries. The second model gives the probability of being in an industry given occupation and sex. For this model I present all industries where there are percentages over 1.0 for any of the high skills computer occupations.

Table 5.6 presents the partial[20] results of the first multinomial logit model showing the conditional probability (presented as percentages) of being in one of the five highly skilled computing occupations, given sex and industry. This table shows the extent of sex-segregation within high technology industries. In general, women have a higher conditional probability of working in systems analysis in high technology industries, whereas men have a higher conditional probability of working either in

[19] The limited number of variables in these data mean that the logit models are essentially an efficient way of calculating cell percentages.
[20] I only present here the results for the COPS high technology industries.

Table 5.6 Logit model results showing the conditional probability of being in an occupation given industry and sex (high technology industries only), 1991

Industry name (COPS no.)	Probability Male % (count)					Probability Female % (count)				
Occupation No.	213	2133	2147	2162	2163	213	2133	2147	2162	2163
Refined Petroleum and Coal (22)*	17.26 (50)	22.39 (65)	7.01 (20)	29.23 (85)	24.1 (70)	23.43 (20)	.57 -	.57 -	63.43 (55)	12.0 (10)
Finance, Insurance and Real Estate (53)	15.45 (1995)	1.24 (160)	1.36 (175)	46.82 (6156)	35.12 (4535)	10.85 (805)	.14 (10)	.88 (65)	56.19 (4170)	31.94 (2370)
Federal Public Admin. (57)	19.61 (1615)	12.08 (995)	3.95 (325)	38.55 (3175)	25.8 (2125)	17.36 (525)	2.16 (65)	1.01 (30)	48.24 (1460)	31.23 (945)
Provincial and Territorial Public Admin. (58)	16.25 (930)	4.9 (280)	1.67 (95)	52.74 (3020)	24.45 (1400)	11.68 (310)	.77 (20)	.58 (15)	61.35 (1630)	25.61 (680)
Gas Distribution (49)	11.59 (45)	20.51 (80)	6.5 (25)	37.07 (145)	24.33 (95)	6.89 (10)	6.89 (10)	.33 -	49.51 (75)	36.39 (55)
Professional Services (55)	7.05 (790)	54.12 (6065)	8.17 (915)	19.01 (2130)	11.65 (1305)	11.06 (200)	17.41 (315)	6.1 (110)	43.34 (785)	22.1 (400)
Aircraft and Parts (30)	8.47 (120)	33.43 (475)	4.96 (70)	28.15 (400)	24.99 (355)	10.93 (20)	0.27 -	8.27 (15)	58.93 (110)	21.6 (40)
Mining, Crude Petroleum and Natural Gas (7)	12.12 (230)	13.96 (265)	1.87 (35)	48.12 (915)	23.94 (455)	6.48 (45)	0.07 -	0.07 -	60.57 (425)	32.81 (230)
Pipelines (43)	15.93 (70)	21.58 (95)	5.76 (25)	43.05 (190)	13.67 (60)	0.29 -	6.09 (10)	6.09 (10)	64.06 (110)	23.48 (40)
Electric Power (48)	3.6 (260)	67.73 (4895)	3.05 (220)	17.58 (1270)	8.03 (580)	4.84 (55)	26.19 (300)	0.92 (10)	50.15 (575)	17.91 (205)
Telecommunication Carriers and Other (46)	9.23 (735)	44.37 (3535)	4.46 (355)	24.98 (1990)	16.95 (1350)	12.80 (305)	19.92 (475)	2.74 (65)	34.37 (820)	30.18 (720)
Electrical and Electronic Products (34)	10.47 (1075)	43.44 (4460)	12.86 (1320)	19.24 (1975)	13.98 (1435)	9.81 (170)	19.31 (335)	8.95 (155)	36.00 (625)	25.93 (450)
Other Business Services (56)	13.23 (4820)	2.33 (850)	6.67 (2430)	45.78 (16680)	31.98 (11650)	12.31 (1255)	0.69 (70)	3.53 (360)	51.76 (5280)	31.71 (3235)

* High tech. industries listed in order from low to high within high technology cutoff (see Appendix 3).

Legend: 213 = Information systems and data processing manager
2133 = Electrical and electronic engineers
2147 = Computer engineers
2162 = Computer systems analysts
2163 = Computer programming

systems analysis or electrical and electronic engineering in high technology industries. With the exception of mining/crude petroleum/natural gas (COPS 7) and pipelines (COPS 43), as the industry becomes more highly technological, men's probability of working as engineers is higher than their probability of working as systems analysts, whereas women always have a higher probability of working as systems analysts in the high technology industries. Therefore, there is support for the hypothesis that there is sex-segregation within high-technological industries in 1991[21].

Table 5.7 gives a different perspective on the employment of highly skilled computer workers in industry. We know that computer workers are more highly represented in the high technology industries than the average for all industries since that fact was the basis for the high/low technology industry designation. In this table we see the conditional probability of women and men being located in an industry, given their occupation and sex. In other words, we see the odds of men and women computer workers being segmented in the COPS industries. The table only presents the percentages over 1.0.

Women who are information systems and data processing managers have a higher probability of working in the high technology industries of telecommunication carriers, gas distribution and professional services than men. The highest percentages for women information systems managers are for advertising, and wholesale trade industries, neither of which are high technology industries. In contrast, the highest percentages for men in

[21] There is only one time point for these data, so any trend in women's segregation is not discernable.

Table 5.7 Logit model results showing the probability of working in an industry, given occupation and sex, 1991 (percentages shown)

COPS No.	Industry name	Info sys managers		Elec & electron eng.		Computer engineers		Systems analysts		Comp. programmers	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
COPS 7**	**Mining, Crude Petroleum & Natural Gas**	**1.18**						**1.8**	**1.97**	**1.22**	**1.6**
COPS 11	Other Food Processing						1.0				1.08
COPS 19	Pulp and Paper			1.1			1.47				
COPS 21	Printing and Publishing	1.13								1.01	1.49
COPS 22	**Refined Petroleum and Coal**										
COPS 23	Chemicals	1.51				1.1		1.05			1.7
COPS 24	Wood						1.00				
COPS 26	Ferrous Metals						1.00				
COPS 29	Machinery, Except Electrical			1.08	1.22						
COPS 30	**Aircraft and Parts**			**1.66**			**1.47**				
COPS 31	Motor Vehicles, Trailers and Parts			1.17	1.22		1.95				
COPS 34	**Electrical and Electronic Products**	**5.5**	**3.05**	**15.54**	**16.06**	**17.01**	**14.76**	**3.88**	**2.9**	**3.85**	**3.12**
COPS 36	Other Manuf. Inds.			1.5	1.7	1.68					
COPS 37	Construction		1.08	2.72	2.18						
COPS 39	Rail Transportation						1.47				
COPS 43	**Pipelines**						**1.00**				
COPS 45	Radio and TV			1.29	1.22						
COPS 46	**Telecommunication Carriers and Other**		**5.46**	**12.32**	**22.77**	**4.58**	**6.22**	**3.91**	**3.81**	**3.62**	**4.99**
COPS 48	**Electric Power**			**17.06**	**14.39**	**2.84**	**1.00**	**2.49**	**2.67**	**1.56**	**1.42**
COPS 49	**Gas Distribution**		**5.1**								
COPS 50	Water and Other Utilities		2.87								
COPS 51	Wholesale Trade	7.24	14.39	3.29	2.9	7.99	4.79	3.94	3.09	3.97	4.71
COPS 52	Retail Trade	2.87					1.95	2.13	2.6	3.11	3.68
COPS 53	**Finance, Insurance and Real Estate**	**10.21**	**3.58**			**2.26**	**6.22**	**11.87**	**19.34**	**12.17**	**16.42**
COPS 54	Advertising		22.43								
COPS 55	**Professional Services**	**4.04**	**9.39**	**21.13**	**15.11**	**11.79**	**10.49**	**4.18**	**3.64**	**3.5**	**2.77**
COPS 56	**Other Business Services**	**24.67**	**5.55**	**2.96**	**3.38**	**31.31**	**34.22**	**32.75**	**24.49**	**31.27**	**22.42**
COPS 57	**Federal Public Admin.**	**8.27**	**2.15**	**3.47**	**3.14**	**4.19**	**2.9**	**6.23**	**6.77**	**5.7**	**6.55**
COPS 58	**Provincial and Territorial Public Admin.**	**4.76**	**3.13**			**1.23**	**1.47**	**5.93**	**7.56**	**3.76**	**4.71**
COPS 59	Local and Other Public Admin.	2.31	2.96			1.81		1.66	1.9	2.24	2.74
COPS 60	Education	3.81	1.35	1.36	1.7		1.47	3.71	4.34	4.87	5.06
COPS 61	Hospitals	1.1	1.97				1.0		1.81	1.06	1.7
COPS 67	Other Service Industries						1.0				1.15

*Only percentages over 1.0 presented in table. Where industries are omitted, no occupation had a percentage over 1.0

**Bolded industries are high technology industries.

this occupational category are for the high technology industries of other business services, and finance/insurance/real estate. For information systems and data processing managers, the hypothesis that men are more likely to work in the high technology industries, appears to be supported here.

Women electrical or electronic engineers have a higher probability of working in the high technology industries of electrical/electronic products, telecommunication carriers, and other business services than men. The highest probabilities for both men and women electrical and electronics engineers are that they will work in one of the high technology industries. For this occupation, therefore, the hypothesis that women are more likely to work in low technology industries than men is not supported.

The probability of women computer engineers working in high technology industries is higher for women than men in aircraft/parts, pipelines, telecommunication carriers, finance/insurance/real estate, other business services, and provincial/territorial public administration. The highest probabilities for both women and men computer engineers are for working in other business services, electrical and electronic products and professional services, all of which are high technology industries. Again, there is no evidence here to support the hypothesis that women are more likely to work in low technology industries than men.

Women systems analysts have a higher probability than men of working in mining/crude petroleum/natural gas, electric power, finance/insurance/real estate, federal and provincial public administration. Most men and women systems analysts work in finance/insurance/real estate and other business services, with men having higher odds of

working in other business services and women having higher odds of working in finance/insurance/real estate.

Women computer programmers working in high technology industries have a higher probability than men of working in mining/crude petroleum/natural gas, telecommunication carriers, finance/insurance/real estate, and federal and provincial/territorial public administration industries. The highest probabilities are that women and men programmers will work in finance/insurance/real estate and other business services, both of which are high technology industries. The pattern is similar for computer programmers and systems analysts: men have higher odds than women of working in other business services industries and women have higher odds than men of working in finance/insurance/real estate, although the odds are high for both men and women in these occupations to work in these industries.

5.4.c.ii. Conclusions on trends in occupation and industry

From the data on high skill computer workers working in high technology industries from 1986 to 1997, we know that there is a consistently high proportion of information technology managers who work in the high technology industries (Figure 5.7). However, information systems and data processing managers is the only occupational category where women and men differ substantially in their representation in high technology industries. Men have the highest probability of working in the high technology industries as information systems managers, whereas women in that occupation have higher odds of working in low technology industries.

This finding supports the hypothesis that women computer workers will be more likely to work in low technology industries than high technology industries. The finding supports past research on neo-patriarchy (men supervising men and women, women supervising women), and may mean power and income differences between men and women information managers. On the other hand, for none of the other occupations do men and women differ substantially in their location in high or low technology industry as is the case with information managers. The support for the hypothesis is partial.

The hypothesis that within high technology industries there will be occupational segregation by sex is supported in the data. There are more women systems analysts and computer programmers than engineers, but slightly smaller proportions of them work in COPS high technology industries compared to their male counterparts (see Figures 5.8 and 5.9). That women are more likely to work as systems analysts and men are more likely to work as engineers in the high technology industries also supports this hypothesis.

There is some suggestion in the data that the small number of women who do go on in electrical and electronics engineering are exceptional, given that almost 100 percent of them worked in COPS high technology industries in 1991, compared with approximately 84 percent of men (Figure 5.8).

5.4.d. Income

Two aspects of income are of interest here. First, the general trends in income may provide a rough measure of the changing status of computing work and should reflect the different status of work by skill level. Secondly, in the interviews some

expressed concerns about women earning lower incomes for similar work, taking significant financial losses if they take maternity leaves, and so on. What is the gender wage gap for computer workers, and is it increasing or decreasing over time? These two aspects of income yield the following hypotheses:

> *If the status of computing has increased over the last number of years, as respondents expressed in the interviews, incomes reflect that change in status by increasing over time.*
>
> *Income is stratified based on skill level.*
>
> *If women computer workers are being treated more equitably than in the past, the gender wage gap is decreasing over time, taking explanatory factors into account.*

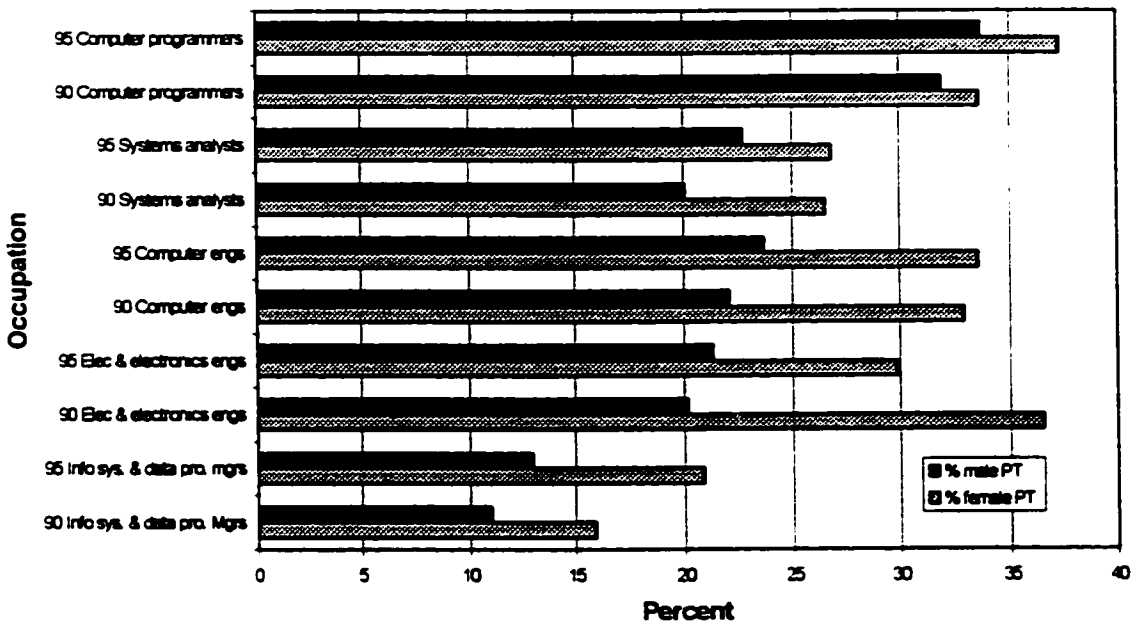
Looking at incomes of software workers in the United States, Heywood & Nezlek (1993) find that the gender wage gap has not decreased from 1975 to 1990 despite an increase in women's participation in this kind of work, and a general trend toward a smaller wage gap when looking at all occupations. Wright (1997) is able to explain 63% of the wage gap of computer professionals in the United States in the 1980s. She found that structural factors associated with the engineering/non-engineering divide, such as industry location, specialties, and education majors explain 21 percent of the wage gap (non-engineering industries, specialties, and majors are associated with lower incomes). Other explanatory variables in her analysis were educational differences (five percent), age and experience (28 percent), other background differences (five percent) and period effects (four percent) (p.153-4).

Another important consideration in measuring the wage gap is how income is measured – by hourly wage or annual income. Strober & Arnold (1987) find that measurement by annual income produces a larger wage gap. Anywhere from one percent to ten percent of the wage gap can be explained by measuring hourly income rather than annual income, depending on the occupation, they find. These findings provide an important background to this analysis, since the data used here do not have the variables required to explain the wage gap in detail. What we are more interested in here is finding the trends over time in incomes for computer workers at the different skill levels, and comparing incomes of men and women. Knowing that as much as 63 percent of the gap can be explained by the factors discussed above, and an additional one to ten percent can be explained by hours worked, enables us to better understand the real, unexplained gender wage gap remaining.

Figure 5.10 shows the percentages of men and women in high skill computer occupations who work less than full time for the full year. Consistent with Wright (1997), women more than men tend to work part time. Most notable is the large number of women electrical and electronics engineers who worked part time in 1990. That amount declined by approximately seven percent between 1990 and 1995, from 37 percent to 30 percent. In all other occupations, the trend is toward greater proportions of both women and men working part-time.

Comparing women's part-time involvement relative to men's in these data, women's proportions in part-time work exceed men's proportions by from five to 12

Figure 5.10 Percent high skill computer workers working less than full time/full year, 1990, 1995



percent. Women are more likely to work part-time than their male counterparts in all occupations across both years.

To eliminate the problems with making accurate comparisons that arise from combining part-time and full-time workers in the analysis, the remaining analysis focuses only on computer workers who are employed full time/full year.

Figure 5.11 shows a consistent upward trend in average incomes of workers in Mathematics, Statistics, Systems Analysis and related fields from 1980 to 1996[22]. The dollar difference between men and women respondents also remains fairly consistent: women have earned approximately seven to ten thousand dollars less than men in annual income from 1981 to 1996 in these occupations. The female/male ratio increases over this period from women earning approximately 71 percent of the average male salary in 1981, to approximately 80 percent in 1996[23].

When yearly incomes of workers in highly skilled computer work are generated in constant 1996 dollars (see Figure 5.12), both males and total workers have experienced a small decline in average income, but women's average income has slightly risen over the years from 1981 to 1996.

With respect to the hypothesis that incomes reflect a change in status in computing work, the status of computing does not appear to have changed if the basis for

[22] The SOC 1980 was used in this survey, therefore the occupational categories differ somewhat.
[23] This reduction in the wage rate difference reflects the overall increase in average salaries for men and women, while the dollar difference in men's and women's incomes remains fairly constant.

Figure 5.11 Average yearly incomes of people working full time/year in occupations in Mathematics, Statistics, Systems Analysis and Related Fields, 1981-1996 (non-constant dollars)

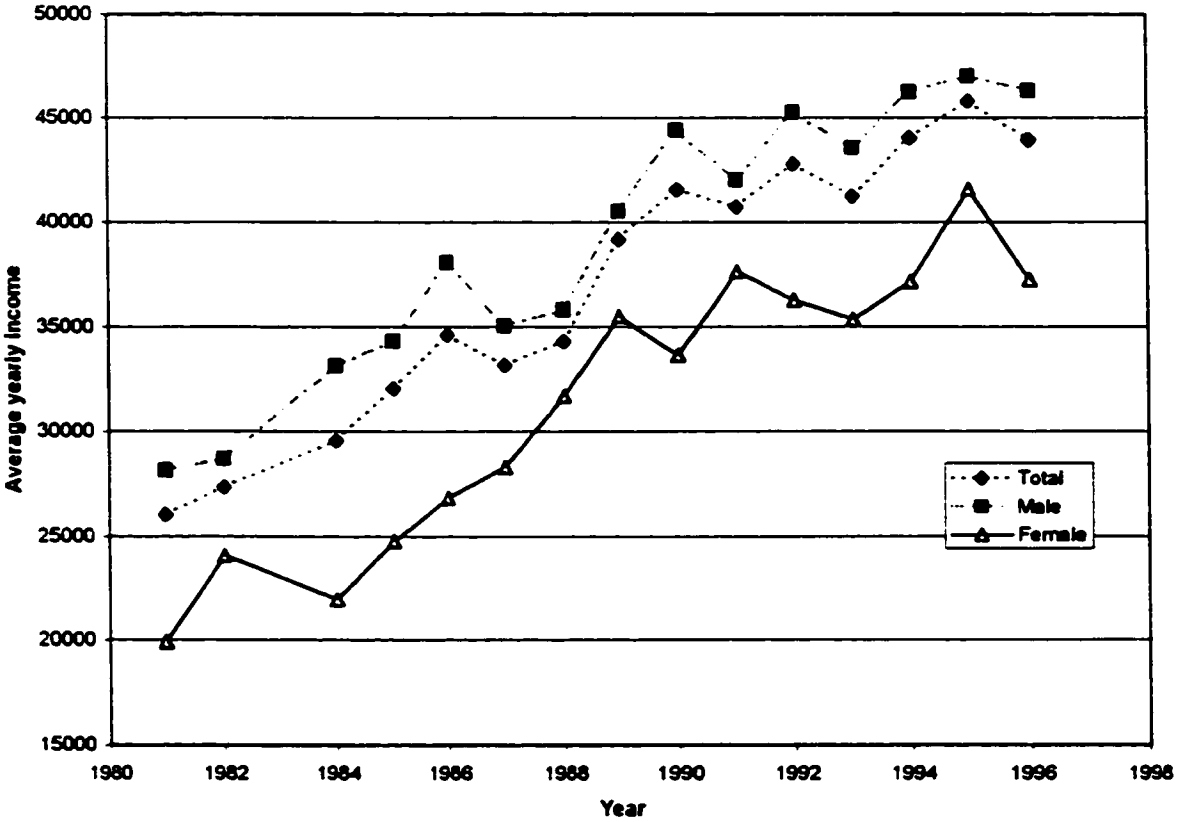
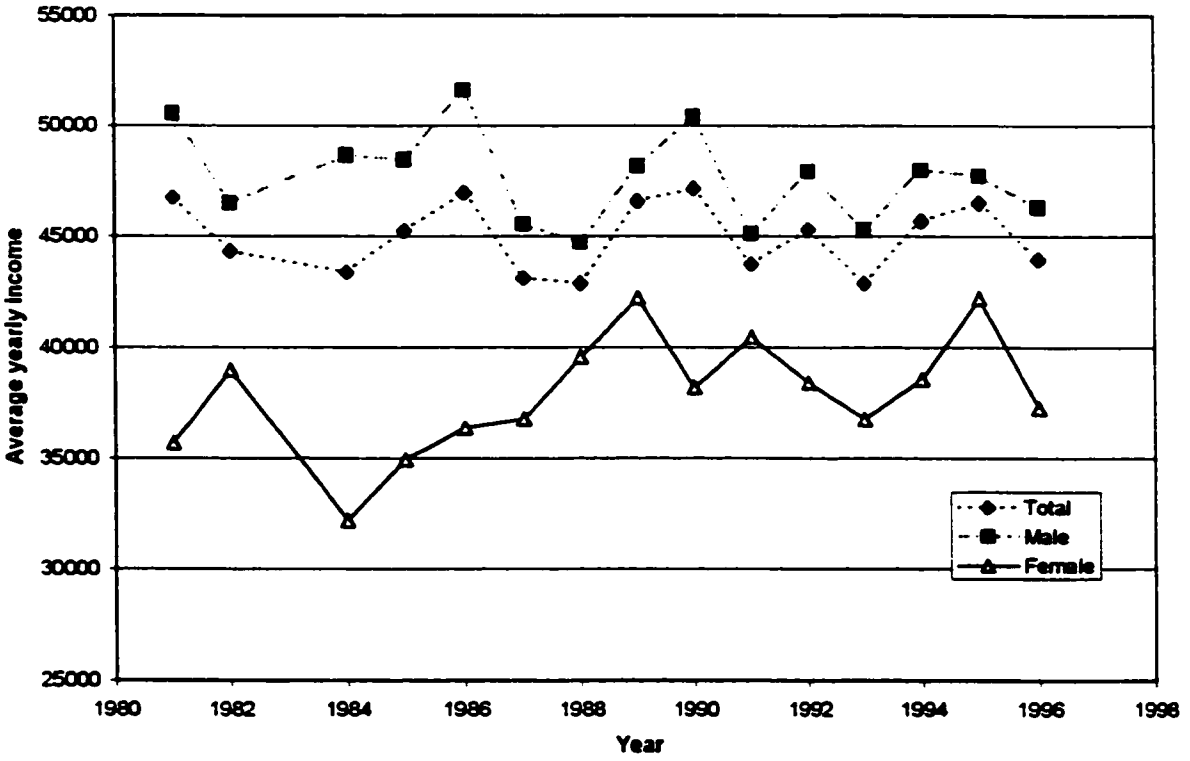


Figure 5.12 Average yearly incomes in constant 1996 dollars of people working in occupations in Mathematics, Statistics, Systems Analysis and related fields, 1981-1996



comparison over time is constant dollars[24]. High skill computer work has always paid fairly well and continues to do so. More importantly, perhaps, for the belief that the status of computing has changed, is the increase in the number of computer workers generating good incomes. Whereas in the past, that number was quite small, the opportunities have grown substantially in the last decade, providing good, high-paying jobs to a larger number of workers.

The findings show that incomes are stratified by skill level, supporting the hypothesis that this would be the case. The gender wage gap is decreasing over time in all occupations except computer engineering (Figure 5.14), and accounting and related clerks (Figure 5.18), giving support to the hypothesis that a decreasing gender wage gap reflects women's more equitable treatment in computer occupations. Nevertheless women are in the lowest paying jobs at all levels, and continue to earn less than men within those levels, taking explanatory factors into account.

5.4.d.i. Highly skilled computer workers

Highly skilled computer workers earned good incomes in 1990 and 1995. Using 1991 and 1996 Census data, the change over time in incomes of highly skilled computer workers is minimal (Figure 5.13). The figure clearly indicates women's lower level of income than men's in each occupational category, and shows very little change in incomes from 1990 to 1995 either for women or men.

Figure 5.14 tracks the percentage difference in men's and women's incomes in

[24] This pattern is consistent with total incomes over this time period, and for incomes of Canadians with occupations in the physical sciences, or life sciences.

Figure 5.13 Average yearly incomes for men and women in high skill occupations, 1990, 1995

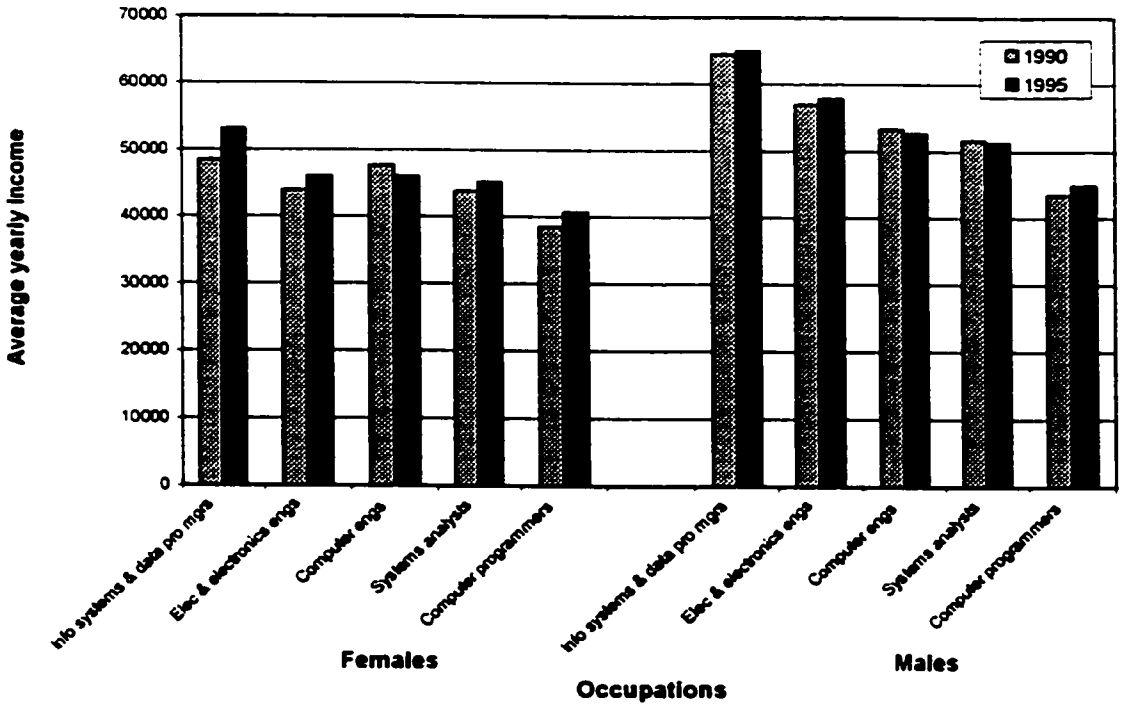
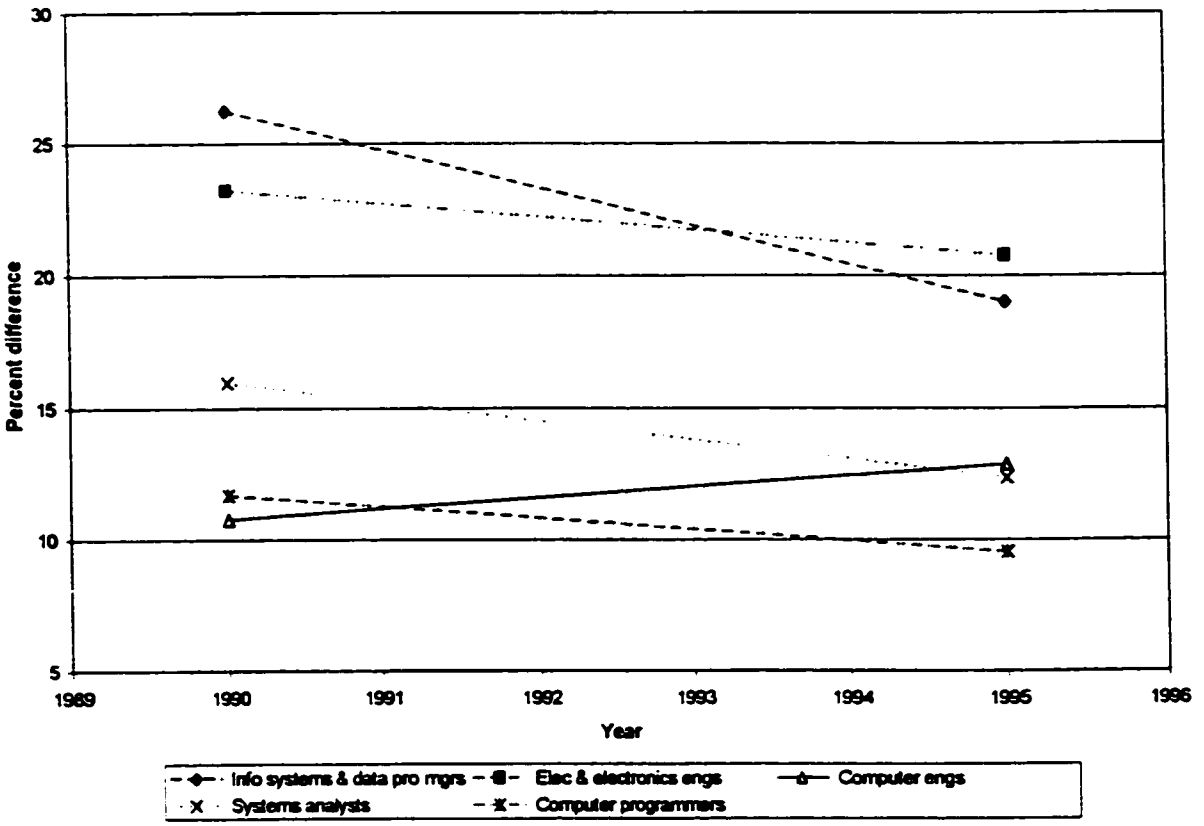


Figure 5.14 Percentage difference in men and women's incomes, high skill computer occupations, 1990, 1995



highly skilled computer occupations (1990, 1995). In all highly skilled computing occupations, the percentage difference has declined, except for the category of computer engineers where the gap between men and women's incomes has grown.

5.4.d.ii. Medium skilled computer workers

A similar look at the incomes of men and women working in computer-related work with medium skill levels finds that once again women earn much less than men, on average (see Figure 5.15): the gaps for each occupation are larger at this skill level than for the high skill level. Again, the gap between incomes remains fairly consistent from 1990 to 1995, except for electrical and electronics engineering technologists and technicians, where the gap has decreased from roughly 30 percent to 18 percent. Figure 5.16 shows that the wage gap for electrical and electronics engineering technologists and technicians has declined, whereas the three other occupations in this group continue to have wage gaps of from 20 to 33 percent.

Figure 5.15 Average yearly incomes medium skill level computer workers, full year, full time, 1990, 1995

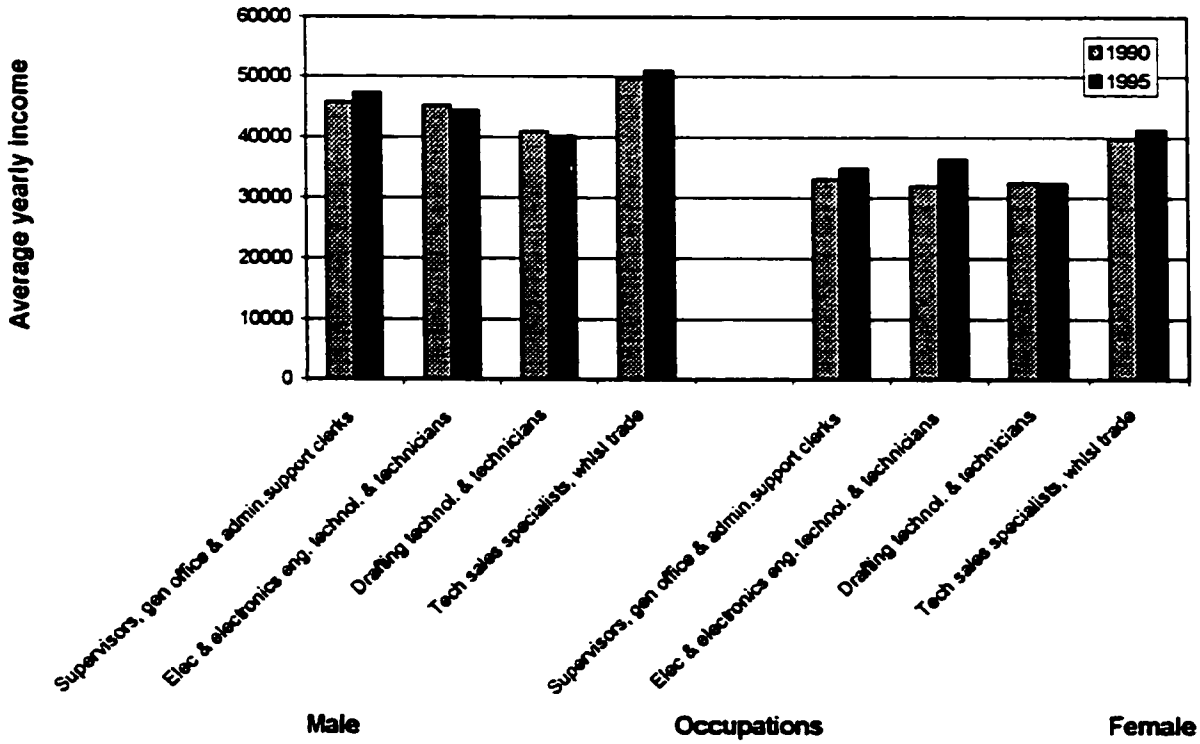
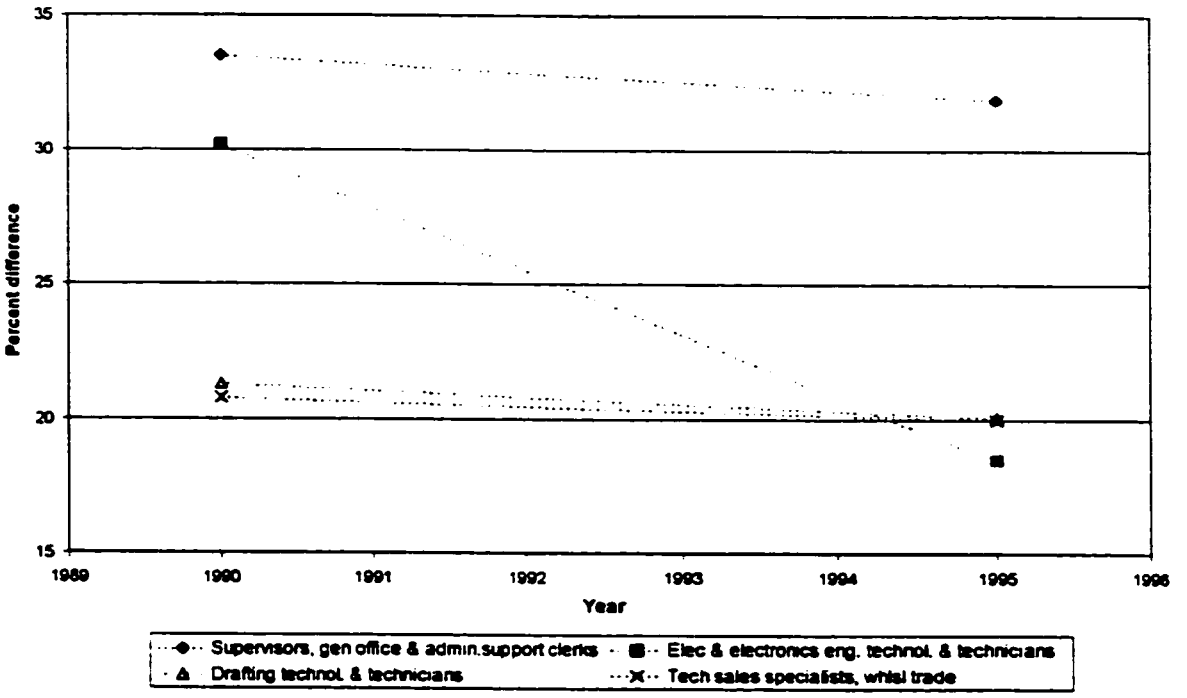


Figure 5.16 Percent difference between men's and women's incomes, medium skill level computer occupations, 1990, 1995



5.4.d.iii. Lower skill computer workers

The wage gap is highest among the lower skill computer workers, compared to medium and highly skilled computer workers, with men consistently earning higher incomes than women. Figure 5.17 shows the difference in average yearly incomes of lower skill computer workers for 1990 and 1995. There are some changes between 1990 and 1995 at the lower skill level of computer expertise. Average yearly incomes of men typists/word processor operators have declined somewhat between 1990 and 1995 from $35,000 to approximately $30,000, as have men administrative clerks ($39,000 to $37,000). On the other hand, average annual incomes of men computer operators and accounting and related clerks have increased slightly from 1990 to 1995. Women computer operators also experienced an increase in average annual income from approximately $28,000 to $31,000, but for women none of the other lower skill level occupations had increases or decreases in income worth noting.

The difference between men's and women's incomes at the lower skill levels decreased dramatically, from a 35 percent to a 16 percent gender wage gap for typists and word processor operators (Figure 5.18). The gender gap in the other occupational categories decreased slightly, except for accounting and related clerks, where the gap widened somewhat.

5.4.d.iv. Conclusions on income findings

Like Heywood & Nezlek (1993), I find for computer workers in Canada that the income gap has either remained the same, or decreased only a small amount in most

Figure 5.17 Average yearly incomes of lower skill computer workers, full year, full time, 1990, 1995

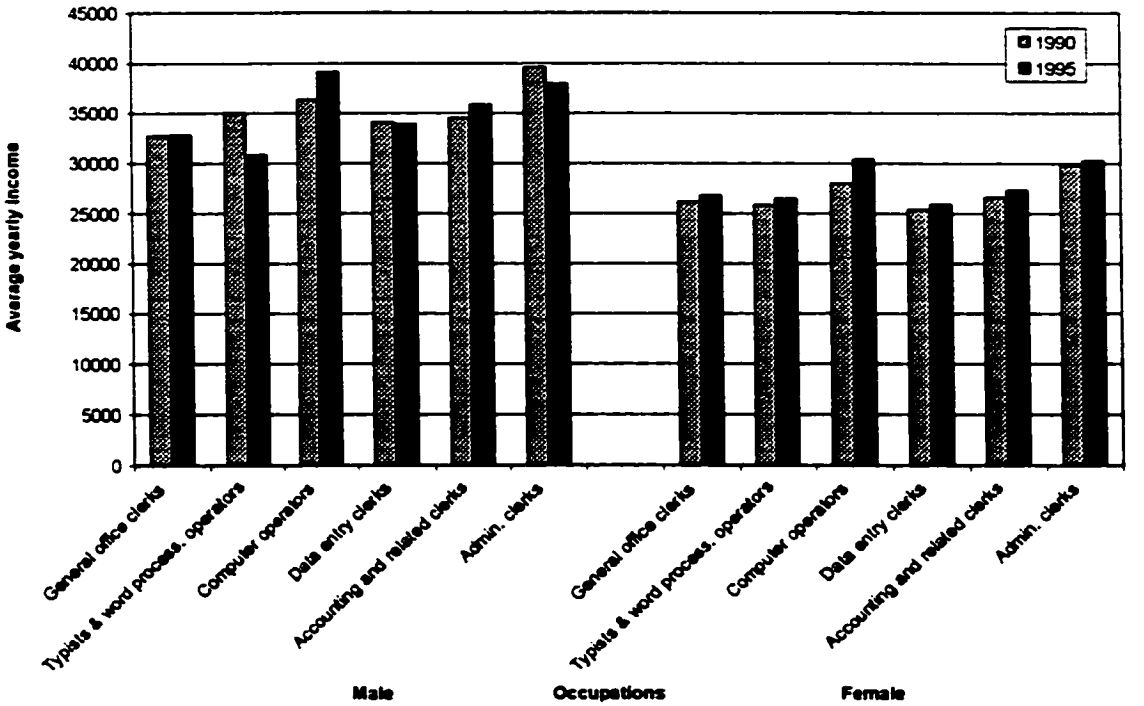
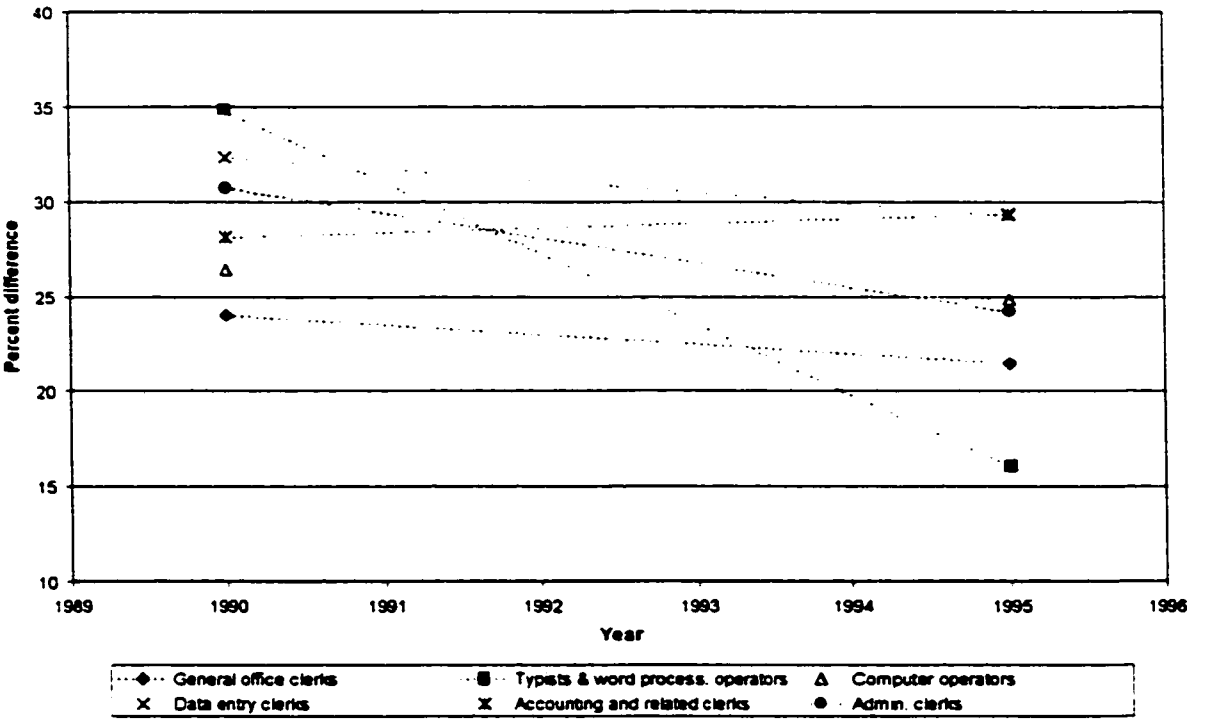


Figure 5.18 Percent difference in incomes of men and women working in lower skill level computing work, 1990, 1995



computer occupations from 1990 to 1995. Exceptions to this finding are information systems and data processing managers at the high skill level, electrical and electronics engineering technologists and technicians at the medium skill level, and typists and word processing operators at the lower skill level. These three occupations had a more substantial decrease in the gender income gap from 1990 to 1995.

The reduction in the gender income gap for information systems and data processing managers, and for electrical and electronics engineering technologists and technicians came about because of an increase in women's average annual income in those occupations from 1990 to 1995. On the other hand, men typists and word processing operators earned less income in 1995 than 1990, bringing their average income closer to women's incomes in the same occupation.

Comparing the percent difference figures for all three skill level groups, the gap is smallest at the high skill levels and larger at the medium and lower skill levels. We know that about 63 to 73 percent of the income gap can be accounted for by human capital, structural and measurement variables. For example, in 1990 the income gap for computer programmers was $4,923. Accounting for 68 percent of the gap with the control variables found in previous studies (63 percent plus five percent average for annual earning versus hourly wages), the remaining gap is approximately $1,500 per year. Although the gap is not a substantial amount, it does estimate the extent to which women are not treated equally to men in compensation for their work in computer programming.

Women earn less and are more likely to work in the lower-paying jobs at each skill level. On the one hand, the gender income gap is problematic for women at all levels, and women in the interviews expressed their concern over the perception of income differences between men and women. On the other hand, the gaps are larger at the medium and lower skill levels: men computer workers earn increasingly more than women as the skill level decreases.

Aside from the obvious advantage of earning a higher income, it would also appear be more advantageous for women to work at the higher skill levels where the gap is smaller and is decreasing in most cases, than the lower levels where the gap is larger.

There is little support in these data for the hypothesis that there is an increase in incomes for computer workers, reflecting an increase in the status of computing work over the last decade. Although incomes do show a steady increase between 1981 and 1996, when comparing incomes in constant dollars, income levels stay fairly consistent. This pattern seems consistent with other occupations in the sciences.

5.5. Conclusions

This chapter began by posing the question of whether there are historical changes found in educational, occupational, and industrial statistics that correspond with the changes in beliefs about computing that were expressed in the interviews. The goal of the chapter has been to test some hypotheses yielded by the interviews and other research

on sex-segregation in education and work, and to present a picture of computing work and workers in the last ten to twenty years.

Looking at education, support was found for the hypothesis that there will be an increase in proportions of women graduates of non-university computer education as women's proportions in CS are declining. While overall sex-segregation is declining in computing education at both the university and non-university levels, concentration is still high, with women concentrated in the non-engineering fields at university, and in computer science technology at non-university institutions. There is partial support for the hypothesis that there is a gendered engineering/non-engineering divide.

Following on women's concentration in non-engineering fields of study at university, I found support for Wright's point that women are more likely to work in non-engineering computer specialties. This finding supports the hypothesis that women taking alternative routes to computing careers will work in the less technical occupations.

I did not find full support for Burnell's (1993) finding that women tend to work in low-technology industries. In computing work, except for information systems managers, women in the other high skill computing occupations tended to be concentrated in the high technology industries as did men in those occupations. Although electrical and electronics engineers had higher proportions in high technology industries, and systems analysts and computer programmers had slightly lower proportions in high technology industries, they were still very similar to the proportions of men in those occupations. That women information systems managers were concentrated in low technology industries may reflect the neo-patriarchal situation of managers generally,

where women tend to manage other women but men manage both men and women (Gutek, 1993; Clement & Myles, 1994).

There is some support for the hypothesis that there will be occupational sex-segregation within high technology industries, because women are more likely to be analysts, not engineers working in high technology industries. Although the status of computing work does not appear to be increasing, hence lack of support for the hypothesis that it is increasing, there are more good-paying jobs in computing available right now. The increase in jobs may be influencing the belief that computing is increasing in status.

The income wage gap for women in any skill level is only slightly decreasing over time, a fact that may be discouraging to women. Women are more likely to work part-time, are clustered in lower paying specialties, and earn less than men. Nevertheless, women with high computer skills are doing better than those with low skills. With high skills, the income gap is smaller and decreasing. Despite the benefits of high skill computer work, women are increasingly preparing themselves for medium and lower skill computing work through non-university education. Currently, with the shortage of computer workers, many of these women will move into the high skill level jobs despite not having university qualifications, and so perhaps at present it is a pragmatic choice for women to pursue non-university qualifications. In doing so they avoid the masculine culture, intimidating entry requirements, and discrimination of university CS programs described by women who have pursued CS education at universities. In light of the push

for professional status by computer scientists in Canada, however, these women may find themselves limited in the future by their choice of educational program.

Chapter 6: Conclusions

This study was motivated by the desire to understand women's declining proportional representation in university CS just at a time when women are increasing proportionally in other male-dominated fields of study and occupations, when skills learned in CS are in high demand and incomes remain good, and when government and industry are pushing for the education of more highly skilled computer workers. The goals of the study were fourfold: 1) to provide a clear picture of the recent research into women and computing education and work, pointing out the strengths, weaknesses, and gaps in the research; 2) to develop in rough form, partially test, and revise a model based on the past research, and the theoretical perspectives of dual-systems theory, social closure, and social control; 3) to assess the impact of social controls on women's choices concerning computing work over the life course by examining the education, work and experience histories of women and men working in computing; and 4) to compare the trends in women's and men's education and work locations over time.

6.1 Model of the social closure/control process for women in computing, revisited.

I begin the summary of the results by re-examining the model of social closure/control (Figure 3.1).

6.1.a. Ideology

In general, the interviews found support for the impact of ideology on women's choices both for education and work. Certain beliefs appear to have a strong impact on

women's educational choices. For example, the belief that they would rather work with people than machines was a commonly repeated reason for not pursuing university CS education, although most respondents had taken non-university computer training of some sort.

Stereotypical perceptions of computer workers as geeks and super-technologists also discouraged women when choosing their field of study. In the interviews, women spoke of the disconnect between university CS education and the realities and needs of the workplace. The belief that what is learned in a CS program would not be very practical in the workplace, and a general sense that CS would be accessible to only the extremely talented students negatively affected women's motivation to enter CS programs. Although education and work are usually thought to be closely linked, women and men are able to enter computing with a wide range of educational backgrounds and experiences, so many women enter through other routes.

It is not clear how the ideology about the increased status of computing work has arisen (it is not linked to a dramatic increase in income), but although one might expect the belief that computer work is increasing in status to draw more women into CS programs, this has been slow to happen. The connection to big business, and the super-technologist ideal associated with the belief about change in status appear to be intimidating to some women. In the company studied, rather than pursuing a CS degree, many have taken advantage of the shortage of computer workers and the resultant openness of the field, have upgraded with non-university computer training or gained

practical experience elsewhere and brought these up-to-date, relevant skills to the company.

In general then, the ideology has not encouraged women to enter computing work via university CS education, contrary to expectations that, at a time of shortage, ideologies would spread to attract women and other underrepresented groups to enter that field. Nevertheless, 1997/1998 and 1998/1999 enrolment data show a small reversal with women's proportions beginning to climb again.

6.1.b. Structural factors and the culture of computing

Structural factors that are situated in the model at the far left may be important over the life course, and particularly at the work stage. The consistent finding that girls and women work best when in same-sex groups in education may have lingering effects in the workplace. At the elementary stage, computer work is better when girls work in all-girl groups; at the secondary stage, attitudes of women are better when they are working in all-female groups; and at the post-secondary stage women cite the positive social facilitation effects of working with other women. The immediate benefits for women may be encouragement to consider computing as a viable option, but may lead to discouragement when women end up working in very masculine environments. Several women interviewed left very good computing jobs for this reason.

This issue is a difficult one, since it relates to various other factors such as the culture of computing environments and stereotypes about abilities of men and women to do computing work. The positive gains in education that have been found through same-sex learning environments should be balanced against preparation for the realities of the

workplace and the potentially positive influence on computing culture and stereotypes that mixed learning groups may have. More research is needed on this factor.

The masculine culture of engineering relates to this issue of the male/female mix in computing work. Camp's (1997) finding that enrolments of women in CS were much lower in the United States when CS departments were affiliated with engineering faculties suggests that women prefer not to be in the strongly macho environments that typify engineering. McIllwee & Robinson (1992) find that women moving into engineering workplaces experience difficulty adjusting to the masculine culture. They have to prove themselves more than capable of the work, and must express readiness to adapt to the culture by accepting the masculine norms without dispute. In computing, the other option for women is to concentrate in the non-engineering, less male-dominated specialties of systems analysis and programming. This appears to be the case for both education and occupation. Although trends over time show that women are increasingly entering the engineering specialties, they are still few in number.

Women's high levels of concentration in certain occupations and industries could in part be explained by women's greater comfort working with other women. Although past research clearly indicates women's avoidance of the engineering culture, the link to early socialization is not clear. This factor needs more research before any real conclusions can be drawn, nevertheless, the model should be altered to show the impact of same-sex grouping and other structural factors[1] at the work stage.

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[1] Other structural factors include such factors as work activity, degree of supervision, and so on. These were included as part of the wage gap explanations found by Wright (1997).

6.1.c. Experience

In Chapter 2 I report research that finds that women are not rewarded to the same extent as men for their experience, or human capital, once they are working. On the other hand, from the interviews, a common theme was the positive reward of entering computing work via other, non-computing work settings where experience with computers was gained. These two findings are not inconsistent with each other as they might appear. In the first place, previous research was looking at the gender wage gap and trying to account for the gap by measuring rewards for education and work experience. Women are not rewarded equally to men for their work and experience. In the second place, women interviewed perceived their work experience as a key to entry into computing work, and thus felt rewarded, in ways other than income levels, for the experience gained at work.

Experience, located near the beginning of the model, is well-placed given the findings from the interviews and past research. It has an important early impact on computer experiences of elementary students, and continues to be important through interests, motivation, and as a means to entering computing via alternative routes.

6.1.d. Historical Factors

Historical factors appear to be more important as a social control than the model specifies. The interviews showed the important link between historical factors and ideology. For example, the perceived status change in computing may have to do with such historical events as the growing pervasiveness of computer technology, the creation

and popularization of the internet, the move from mainframes to the more accessible personal computers, and so on.

Certainly the government has a significant place in the production of ideology through such acts as the creation of computer curriculum and policy for schools. As described earlier, in 1985, for the first time, the Ontario Ministry of Education included in the computer curriculum and policy document a paragraph on gender equity in computing education. While the impact of that documentation appears to be limited, it is nevertheless an example of the work of government in creating an ideology about computing that serves the current labour force needs of the province. The Ontario government's current offer to universities of funds to increase CS and engineering enrolments could also have implications for education ideology: the debate about whether schooling is about getting a broad liberal education or about job skills training, for example.

In light of the link between historical factors and ideologies, the model should place historical factors where they have a broader, more pervasive reach at the education and work levels. Concerning work, specific historical events such as the changing century and the resultant Year 2000 problems increase the need for workers in computing, and the current labour shortage ensures that jobs are available even for those who have not taken formal university CS training. Hence the impact of specific events in time is more far-reaching than first conceived.

6.1.e. Discrimination

Whether women go through a university CS program or come to work in computing via some other route, women persistently receive lower pay and are more commonly located among the lower paying occupations between and within skill levels. Interviewees described their experiences with discrimination, including lack of support from family based on sex-role expectations, inappropriate direction from guidance counselors, sexism in the classroom, and lack of respect from customers and colleagues. Discrimination, therefore plays a larger role than the model suggests, but the impact of discrimination during the education stages is not always to discourage women. Sometimes women's resolve is strengthened when they face discrimination and sexism.

Whether women become discouraged or their resolve is strengthened as a result of discrimination, it has a tangible impact on their incomes. To identify with this tangible impact, discrimination will remain under work factors, with the understanding that women do experience and react to discrimination at various points in the life course.

6.1.f. Other factors in the model

This dissertation does not pretend to test for all links in the model, nor does it make strong causal claims about the links. Factors such as attitudes, early socialization and others have been covered in the literature and are included in the model based on past research. Future research should explore the times in the life course when these and other factors may act as social controls to women's entry into university CS programs.

The interviews do confirm that women experience various controls over the life course that affect their entry to or exit from computing education and work. Respondents who were discouraged at the secondary level from pursuing a computer interest took it up

again in later years by retraining. Historical factors, events that occur at specific times in history, played a role for some: for example, when the government sponsored a course to encourage women to enter non-traditional occupations, one woman took the course and grew interested in computing. Having been told they were not good at math discouraged some women from pursuing math-related studies in university, but a number of years later they no longer believed they could not do math: that obstacle no longer kept them from computing work.

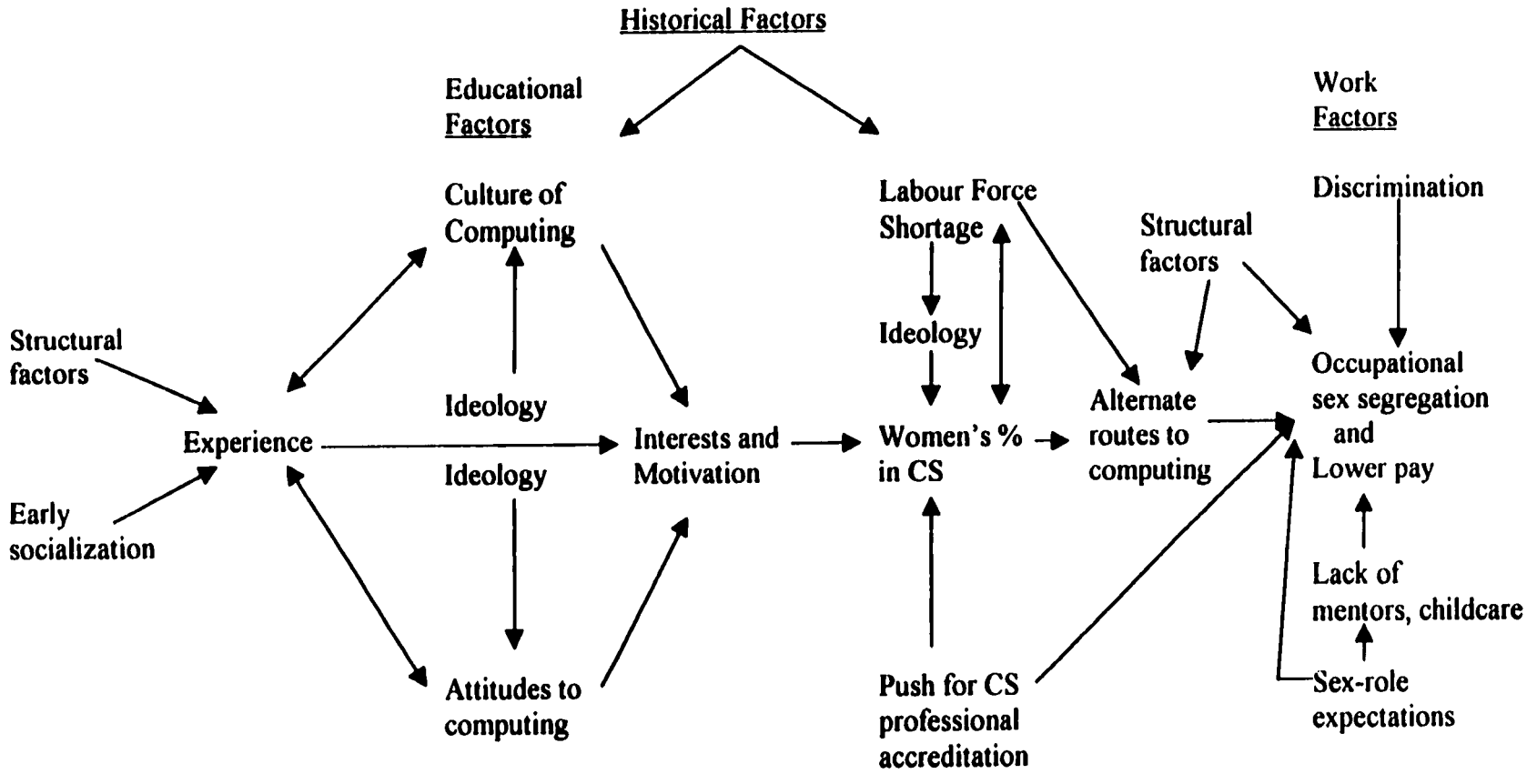
Nevertheless, new obstacles arise at later points to control women's entry into and longevity in computing work. For example, some women spoke of reducing their hours in order to have more time to care for their children. Hence, the social norm learned in childhood that women are the nurturers revisits women when they are mothers. Other women were discouraged by the lack of mentors available for women, and the sense that their careers were drifting without any guidance. Some women went so far as to quit jobs because of the macho culture in the workplace. Getting into computing work is not the end of social controls on women in computing.

In light of the findings discussed above, I revise the model and suggest that future research continue to question the links and factors included as the situation changes over time (See Figure 6.1.).

6.2 Contributions to the literature

6.2.a. General contributions

Figure 6.1: Model of the social closure/control process for women in computing (revised)



This study presents empirical data that help explain women's lower proportional enrolments in CS in recent years. It brings together, in the second chapter, all the bits and pieces of research that have been accumulating on women in computing over the last decade, and establishes where the strengths, weaknesses, and gaps are located in past research.

The study makes a first attempt to directly apply the theories of social closure and control (based on the broad understanding of dual-systems theory) by hypothesizing a model of social closure/control for women in computing, and assessing its usefulness and explanatory power with findings from qualitative and quantitative research.

Whereas past research on sex-segregation of computer workers has been from the United States, and from the 1980s, the quantitative analysis of Chapter 5 looks at Canadian data from the 1990s. Given the rapidly changing nature of computer technology and the labour force it requires, the up-to-date Canadian statistics are important.

In addition, where most studies of computer workers focus on computer professionals (see Heywood & Nezlek, 1993 for an exception), for comparison purposes I seek to define a group of computer-workers who have medium or lower skill levels, but who work extensively on, or with, computers.

Finally, whereas most research takes either a qualitative or quantitative approach, this study brings these two methodologies together to gain from each its unique contribution to our knowledge of the issue.

6.2.b. Life stage classification of factors affecting women in computing

Chapter 2 describes the literature on women in computing over the last decade. The classification will be useful for those engaged in ongoing research about women and computing, particularly education policy makers, curriculum developers, and computing teachers. In general, the research of the 1990s uses predominantly post-secondary students as subjects and most frequently the methodology is survey research. Although the majority of education research is non-comprehensive, the accumulation of small studies that focus on particular aspects of computing education and gender means that some findings are well-supported in the research. Nevertheless, those findings are also contingent on the choice of factors to be studied, and that choice shifts from a general focus on structural factors at the elementary stage, to more of a focus on social psychological factors at higher educational stages.

The main findings from the classification were summarized in the model of the social closure/control process described above. While other factors are important, those included in the model came out of comprehensive research or had strong support from a number of studies. For example, early socialization, structural factors such as curriculum used and equity policies, and experience, beliefs and the culture of computing all impact on women's interest in and motivation to pursue computing education and work.

I also suggest where there appear to be gaps in the research. One of those gaps is the role of ideology in women's choices to enter computing. I explore ideological controls, among other factors that emerge from the interviews, in my qualitative analysis.

6.2.c. Theories of social closure and control

I find support for theories of social closure and the specific application of it to the social control theory of Jacobs (1989). At various points in time some factors are very important influences on women's choices to enter or stay in computing, and at other times those factors lose their influence. The engineering/non-engineering divide found by Wright (1997) and supported here (although the situation is improving), indicates the ongoing power of the macho engineering culture to close women out of highly technical education and work. Those women who succeed in making it through engineering studies may be exceptional, as their high frequency of location in the high technology industries suggests.

The interviews support theories of social control and closure. Women discussed a number of obstacles they faced in pursuing computer education at universities, including sexism, the "old boys' club," mathematics as a critical filter, and so on. Women make choices to avoid these obstacles, some taking alternative routes to computing work, others dismissing computing from their ambitions.

The quantitative analysis gives support to the notion that women are taking alternative routes: the data show that while female proportional enrolments in university CS programs were declining and are very recently just beginning to increase, enrolments in some non-university computer education programs have been increasing for a few years, as would be expected if women are taking alternative routes to computing careers.

6.2.d. Benefits of using qualitative and quantitative analysis

One of the goals of this study was to use both qualitative and quantitative methodologies to explore the question of women's declining proportions in university CS

education. Each method has its advantages and disadvantages. The qualitative chapter is based on interviews of 23 respondents, and two interviews with a Human Resources consultant about the structure of the company and how it rewards its employees. Out of these interviews came rich data from which to build an understanding of the controls and obstacles women face over the life course in relation to computing education and work. The qualitative analysis allowed me to assess the model of social closure/control, and to test whether the theory of a series of controls over women's behaviour through the life course applies to women's computer-related experiences. As described above, I did find support for this theory.

Therefore, the benefits of the interviews are to be found in the rich concepts, ideas, and connections that emerge from the biographies of respondents. As rich as the qualitative data are, they do not allow for generalizations because the sample is not randomly selected, and the sample size is small; moreover, all respondents worked at one company. On the other hand, the quantitative data are Canadian, either population data or large representative samples, and therefore allow for more generalized conclusions to be drawn about some issues. For example, we know that the wage gap remains; sex-segregation is declining, but concentration of women is increasing in computing occupations; and we know that greater proportions of women than men work in lower skill computing jobs. Of the women working in high skill computing occupations, the largest proportions work in the lower-paying high skill computing occupations (programming, systems analysis). Even in the lower skill, female-dominated computer-related jobs, men still consistently earn higher average annual incomes than women.

One of the more interesting findings, and one that warrants further research, is the increase in women's enrollments in non-university CS technology education. Little is known of the extent to which private colleges and other institutes have taken over training the computer technology workforce. We do know from this research, however, that women are definitely moving into non-university computing education in larger numbers. The interviews suggest that women are more likely to take continuing education courses and other computer training than men. This finding is supported by Wright (1997) in the United States where she found that women are more likely to undertake ongoing studies relevant to their work.

Although the quantitative data do not provide the richness and depth of understanding found in the interviews, they show the trends over time in the education, work and incomes of Canadian women and men, and general conclusions about the situation can be made from the analysis of these data.

6.3. Suggestions for future research

The classification of factors affecting women in computing (Figure 3.1) is a starting point for continuing research into women's experiences in the male-dominated education and work of computing. The gaps in research that came to light through the classification require filling, and those studies of a preliminary or exploratory nature require larger, more comprehensive confirmatory studies for educators to understand where women are turning away from computing, what causes it, and what solutions may

help to minimize any loss of interest arising from unfair or discriminatory practices, lack of information, or other factors.

A second departure point for future research is the model of the social closure control process. Jacobs (1989) urges researchers to begin trying to flesh out the actual causes of women's "revolving door" experiences in male-dominated work. This model of social closure attempts to do just that. Not all links were assessed with the data in this study, nor is the model a static one. With the strong influence of historical and ideological factors found in the interviews, the controls that work against women entering and staying in computing would be expected to change over time as new events occur, affecting labour force needs and beliefs about computing work. Therefore, future research should assess the links not explored fully here, and should continue to identify and revise those controls that no longer appear to be having an influence on women's decisions over time.

This study attempted to identify computer-related occupations by skill level, rather than focusing solely on the high skill computing occupations. Various reasons make this a useful exercise. First, many women's choices about education and occupation are influenced by their desire to have children, and their understanding that in a patriarchal society, women will hold the primary responsibility for childcare (Wright, 1997). Therefore, comparing low and medium skill occupations where women are less of a minority allows us to consider the implications in terms of income and segregation associated with choices to take on less demanding work, take leaves to raise children, or work part-time, for example. In this study, clearly, those working at medium and lower

skill levels earned less than high skill computer workers, and the gender gap in income was greater at the lower levels than the higher levels.

The choice of which occupations to use in this study was based on the 1994 GSS and on HRDC occupational descriptions. Future research might look for a more systematic way of selecting high computer use occupations below the high skill level, perhaps based on a qualitative study of high technology workplaces.

6.4. Answering the question

At the beginning of the study, the question was posed: Why are women becoming a smaller proportion of those enrolling in CS programs, and graduating with degrees in CS, and what are the consequences for women in the computing workforce? The answer that arises from this research is related to historical factors such as the shortage of workers and the possibility of entry into computing work without having put oneself through the difficulties of a CS program. Closely linked to historical factors are the ideologies women hold concerning computer education and work, the stereotypes about super-technologists and about the competitiveness of entry into computing, and the sense that computing has moved in status from a scientific or clerical association to big business and power.

Patterns over time in women's education and work behaviour suggest that women are choosing to pursue non-university CS technology education as an alternative route to computing work, but a recent increase in women's proportional enrolments at universities suggests that there may be a reversal in the trend for CS. Women continue to

be substantially underrepresented in the engineering fields of study and occupations, but that is shifting slowly: women who may otherwise have gone into CS may be taking electrical and electronics engineering or computer engineering.

Finally, this study shows that there is no one answer at any given time to the question posed here. At various times over the life course, different explanations will be critical. The social control of women's behaviour is not brought about by a single causal factor, but controls of various kinds influence women in their educational and occupational choices.

Appendix 1: List of studies in the classification

1. Fisher *et al.*, 1997
2. Craig *et al.*, 1998
3. Reinen & Plomp, 1993
4. Lee, 1993
5. Barbieri & Light, 1992
6. Inkpen *et al.*, 1995
7. Huff, 1996
8. Chappell, 1996
9. Ring, 1991
10. Shashaani, 1994
11. Jones & Clarke, 1995
12. Levin & Gordon, 1989
13. Durndell, Glissov & Siann, 1995
14. Cooper & Stone, 1996
15. Lynam & Kamal, 1992
16. Teague & Clarke, 1993
17. Camp, 1997
18. Durndell & Lightbody, 1993
19. Colley *et al.*, 1995
20. Geenens & Rao, 1992
21. Teague, 1992
22. Busch, 1995
23. Busch, 1996
24. Pope-Davis & Twing, 1991
25. Pope-Davis & Vispoel, 1993
26. Corston & Colman, 1996
27. Stepulevage *et al.*, 1994
28. Taylor & Mounfield, 1994
29. Brown *et al.*, 1997
30. Bernstein, 1991
31. Rasmussen & Hapnes, 1991
32. Henwood, 1996
33. Sanders & Galpin, 1994
34. Bernstein, 1997
35. Durndell, 1991
36. Morgan *et al*, 1991
37. Lips & Temple, 1990
38. Teague & Clarke, 1991

Appendix 2: High Computer Use Occupations

High Computer Use (HCU) by sex and occupation (GSS 1994)

Occupation	HCU male	HCU female
Managers/Administrative & Rel. Occs	11.5	15.0
Management/Administration Related	15.7	19.9*
Life Sciences/Maths/Computers	23.1*	22.6*
Architects/Engineers/Related Occs	18.0*	20.3*
Social Science/Religion	9.9	11.0
Teaching Related	9.1	6.2
Medicine and Health	6.2	4.2
Artistic/Literary & Recreation	9.4	12.3
Stenographic/Typing	n/a	19.7*
Bookkeeping/Account-recording	17.3*	15.8*
EDP operators/Material Record	9.8	20.2*
Reception/Info./Mail/Message	7.8	17.3*
Library/File/Other Clerical	14.2	18.6*
Sales/Commodities	7.9	8.2
Sales/Services	9.8	16.9*
Protective Services	6.4	9.8
Food/Beverage/Accommodation services	3.5	1.6
Personal/Apparel/Furnishings	n/a	1.3
Other service occupations	1	1.2
Farm occupations	1.5	3.3
Primary occupations	2.2	n/a
Food/Bev./Processing etc.	3.4	1.1
Processing occupations (except food)	5.6	5.6
Machine/Related occupations	4.1	n/a
Electrical/Electronic related	10.2	9.4
Textiles/Fur/Leather	1.1	1.0
Wood products/Rubber/Plastics	4.1	3.7
Repairpersons (except electrical)	4.3	n/a
Excavating/Paving/Wire comm.	2.4	n/a
Other construction trades	1.0	n/a
Transport operating occupations	4.1	n/a
Material handling	2.0	7.7
Other crafts and equipment	7.5	15.3
TOTAL	7.1	10.8

n/a indicates that there were fewer than three individuals in that occupational category.

Appendix 3: High Technology Industries

COPS Industries where the percent of computer workers is at least 1.5 times the overall average for all industries (High Tech COPS) as of 1991 Census

Ind. No.	Industry name	% in Ind.
COPS 22	Refined Petroleum and Coal	2.292349
COPS 53	Finance, Insurance and Real Estate	2.724536
COPS 57	Federal Public Admin.	2.767435
COPS 58	Provincial and Territorial Public Admin.	2.955431
COPS 49	Gas Distribution	3.499505
COPS 55	Professional Services	3.767188
COPS 30	Aircraft and Parts	3.848887
COPS 7	Mining, Crude Petroleum and Natural Gas	4.940021
COPS 43	Pipelines	6.498389
COPS 48	Electric Power	7.999619
COPS 46	Telecommunication Carriers and Other	8.114344
COPS 34	Electrical and Electronic Products	9.837612
COPS 56	Other Business Services	14.45893

SIC major group industries where the percent of computer workers is at least 1.5 times the overall average for all industries (High tech SIC)

MG 36	Refined Petroleum and Coal Products Industries	2.364475
MG 74	Other Financial Intermediary Industries	2.391103
MG 72	Investment Intermediary Industries	2.662722
MG 81	Federal Government Service Industries	2.748191
MG 71	Consumer and Business Financing Inter. Inds	2.868447
MG 57	Machinery, Equipment and Supplies Inds, Whlsl	2.911915
MG 82	Provincial & Territorial Gov't Service Inds	2.920095
MG 70	Deposit Accepting Intermediary Industries	3.187752
MG 48	Communication Industries	4.127198
MG 73	Insurance Industries	4.675952
MG 07	Crude Petroleum and Natural Gas Industries	4.851951
MG 49	Other Utility Industries	6.104806
MG 46	Pipeline Transport Industries	6.426332
MG 77	Business Service Industries	8.286871
MG 33	Electrical and Electronic Products Industries	9.523997

Appendix 4: Data Files

GSS	1994 Use computers at work, average hours of computer use per week.
Emp9191	1991 employed labour force, 15 yrs and over by province, sex, 91 Standard Occupational Codes and 80 Standard Industrial Codes (3 digit) (1991 Census)
Fullpart	1996 Employed LF 15 yrs and over by sex, detailed 91 Standard Occupational Codes, full time/ part time and no hours worked (1996 Census data)
N29-005	1991, 1996 Census population 15 yrs and over with employment income by sex, work activity (FY/FT and Other) and detailed occupation (91 Standard Occupational Codes) showing no. and average employment income in constant 1995 dollars for Canada, provinces, territories and Census metropolitan areas (1996 Census data)
Occind	1984-1995 Employment by 1980 Standard Occupational Codes, COPS industry, with students or non-student, total (new COPS model data)
Scfearn2	1981-1996 average earnings by 80 Standard Occupational Codes (3 digit), age, sex, FY/FT only (Survey of consumer finance)
Usisgrds	1976 – 1996 University grads by province, level, sex, usis codes (fields of study) and year (Statistics Canada education and demographic data)
Univ/nonU	1990 to 1999 University and non-university enrolments, by sex and fields of study (Statistics Canada education data on universities, colleges and trade and vocational post-secondary schools)
Univ/non-univ	1991, 1996 Field of Study by sex, university/ non-university (1991, 1996 Census data)

Appendix 5: Letter of invitation and consent form for interviews

February 11, 1999

Dear _____ employee:

You are being asked to participate in a research project associated with McMaster University, and funded by the Social Sciences and Humanities Research Council, on recruitment into computer-related educational programs. As I'm sure you are aware, the need for people with computing expertise is growing, and a serious shortage of programmers and systems analysts is predicted over the next several years. In fact, the Ontario Government is so concerned about this shortage that it has budgeted 150 million dollars over three years to double entry-level enrolments in computer science and some engineering disciplines. Ensuring that there are people to meet the needs of companies such as yours means learning what factors are important to men and women in making decisions about post-secondary education.

As part of a larger research project into training for the computer-related labour force, _____ has agreed to a case study of computer-related employees in this company. Participation in the study is voluntary. One issue that we would like to explore is why so few women pursue careers in certain kinds of computing occupations. To understand this better, and to be able to recommend possible changes to the education system, we would like to interview men and women with a broad range of educational backgrounds working in computer-related occupations. This part of the study will explore the motivations of both men and women to enter computing work; why you chose the kind and level of education you did; what ambitions you have in the computing field; and what suggestions you might offer to make computing a more attractive option for young women going through the education system.

The interviews will be about twenty to thirty minutes in length. It is important for the study that we get as many participants as possible. If you would be willing to be interviewed, please complete the attached consent form and return it to the Human Resources department. You will be contacted to arrange a convenient time for the interview. I assure you that your responses will be kept completely confidential, and the findings will be reported in such a way as to protect your privacy. This project has received the approval of the Ethics Board at McMaster University. With your permission, the interviews will be taped and transcribed. You are free to withdraw from the study at any time and/or to refrain from answering whatever questions you prefer to omit.

The results of the study will be made available to the public. The findings will be submitted to academic journals and to the Applied Research Division of Human Resources Development Canada.

Sincerely yours,

Heather Dryburgh , BA, MA.
Doctoral candidate
McMaster University

Return this form to: Human Resources Department
c/o _____

Consent form for the Study on Recruitment into Computing

I have read the letter of information and agree to participate in the research project described. I understand that all information given by me in this interview will be kept completely confidential.

Signature_____

Date_____

Contact information:

Your name (please print) _____

Phone extension _____

Email address_____

Interviews will be scheduled a week in advance, when possible, and will usually take place on Thursdays. If you would prefer to have your interview scheduled in the morning or the afternoon, please indicate so below.

☐ Morning
☐ Afternoon
Other scheduling preferences_____

Thank you. If you have any questions please feel free to contact me:

Heather Dryburgh
Email: hpearso2@julian.uwo.ca
Phone: (519) 432-3516
Thursdays: Human Resources Department

Appendix 6: Questionnaire for women in computing study

First, I want you to think back to your educational experiences.
[The interviews will be semi-structured around the following questions.]

1. Education

a) First, could you just briefly tell me about your educational background?
   i) What kind of post-secondary education do you have?
   ii) What year did you graduate from high school? From university (college)?

b) What was your computer experience at elementary and high schools?

c) Did you find that you were encouraged in your computing interest at school?
   i) Did teachers encourage you?
   ii) Did you have plenty of access to computers in the school?
      a) Where were the computers located in the school?
      b) Was computing considered technology (linked to industrial arts), science (linked to more academic studies), or business (linked to data processing)?
   iii) If offered, were you encouraged to take computer science courses?
   iv) Were you encouraged to take prerequisite courses in math and science so that you could go on in computer science at university?

d) (If respondent has computing education)

   i) How were you recruited into computing education?
   ii) Why did you choose computing?
   iii) Why did you choose (university, private college, or public college) to prepare you for work in computing?
   iv) Did you find any obstacles to going on to higher education in computing?

e) (If respondent does not have computing education)

   i) Why did you choose to take this educational route into computing work?

2. Experience

a) Did your family encourage you in your computing interest?
   i) Did you, or your family, have a computer in your home?

ii) If so, did you have plenty of access to that computer?

b) Did you have any apprenticeship or work-related computing experiences prior to entering post-secondary education?
   i) How were you recruited into these apprenticeship or work experiences?

c) Did you face any obstacles to gaining experience in computing, other than those you have mentioned already?

3. Current work

a) What is your current job title?

b) What are the three activities you do most in your job?

c) What is the approximate ratio of men to women in your department?

d) How were you recruited into this kind of work?

e) At this point in your career, are you satisfied with your work, given your past experience and training? Why or why not?

f) Where do you see yourself working in the future?

4. Beliefs and values

a) What do you think it takes to be a successful computer scientist? At school? At work?

b) Do you think the status of your job has changed since you have been out in the workforce? (e.g., pay, prestige, education needed, authority, etc.)

c) Can you think of ways that attitudes or beliefs about women working in computing have changed over the years of your education and work in this field?

d) Why do you think more women do not take computer science?

e) Can you think of any way to make computer science a more attractive option for women than it is right now?

5. Demographics

a) Age

b) Sex

c) Number of years working in computing

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