Post-Secondary Paths in Science for
B. C. Young Women and Men

by

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ABSTRACT

The purpose of this thesis is to identify typical patterns of career destinations for young women and men in relation to their high school science preparedness. This is an empirical structural study that documents the way high school academic capital is turned (or not) into human capital for science and engineering professions. The study uses ten years of longitudinal data on educational and career paths of British Columbia high school graduates of the Class of '88. Correspondence analysis and other descriptive statistics provide a picture of students' participation in mathematics and science senior high school courses and post-secondary academic programs. School course choices, post-secondary educational attainment, specialization fields are correlated to respondents' high school science preparedness, parental education and gender. A major finding of this study is that high school science preparedness opens greater opportunity for students to attend and succeed along a broad range of post-secondary pathways. Still, thesis findings confirm the existence of a “leaking” phenomenon along the physical sciences and engineering post-secondary pipeline, especially for women as well as men with non-university educated parents. Equity in access and outcomes is discussed in relation to respondents' possession of cultural and academic capital, and in relation to gender inequality that persists within school and post-secondary institutions, the science community and society at large. Implications for further research emerge from the literature review and the interpretation of thesis findings. Longitudinal research needs to explore more directly the reasons why many young women and men who excelled in science at the high school level depart from the science pipeline sooner or later. A major conclusion is that the “critical mass” approach that directs attention toward creating a large supply pool to feed the science pipeline by encouraging more young women to enter the field of science is still a unilateral numerical strategy, and more has to be done to improve the retention and advancement of talented women interested in science. This thesis reinforces the need for an analysis of the culture of the science community and a revision of the leaking science pipeline concept that should be replaced by a more open non-linear model of science careers.
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DEDICATION

In memory of my parents, Zoe and Iosif, who stirred my passion for sciences and were my first role models of gender equity.
CHAPTER I

Introduction

1.1 Background to the Problem

Researchers have used the imagery of the "leaking science pipeline" to describe the training and filtering processes of scientists. It has been documented that a gender-related "leaking" phenomenon in science manifests itself starting at the subject-option level in high-school, continues through undergraduate and graduate studies, and finally leads to the widely discussed under-representation of women in academia, in industry and even in science education (Davis et al., 1996; Hanson, 1996). Seemingly, the leaking phenomenon is typical for the whole science field in general, but it appears to affect women particularly.

Although 58% of all Canadian University degrees were earned in 1998 by women, the proportion of women's degrees was as low as 31% within Mathematics and Physical Sciences, and only 21% in Engineering and Applied Sciences (Statistics Canada, 2001). It is true that women have taken the lead in education, humanities, health, arts, social sciences, as well as agriculture and biological sciences. Nevertheless, even in these areas, there is still a net disproportion regarding the type of university degrees earned by women. Thus, their overall achievement in earning university degrees in all disciplines decreases from 59% in undergraduate programs to 51% in master programs and, further on, to 33% at the Ph.D. level. The rates of enrolment in graduate programs, as well as the percentage of degrees earned are even lower in engineering and some science fields. For instance, in 1998, the percentage of Ph.D. degrees earned by women was about 16% in Mathematics & Physical Sciences and only 8% in Engineering & Applied Sciences.

While a visible diminution of female population appears in all academic disciplines exclusively at the Ph.D. level, the "leaking pipeline in science" is observed as early as at the high school level, thus leading to a more obvious academic funnelling (Byrne, 1993; Erwin & Maurutto, 1998). "Why are there so few women in science and engineering?" is the question raised by educational and governmental institutions, feminist organizations, specialized research and media. McGrayne (1998) examines a very select elite - the Nobel prize women in science. In her book, she presents the biographies of these 3% of Nobel Prize recipients, and describes the struggle to combine career and family as a major
challenge of these women's lives. Even in the case of the most talented and determined women in science, social barriers have proven to be the most resilient ones.

1.2 General Statement of the Problem

In relation to the professional field of science, gender issues are identified in the specialized literature through a variety of cognitive (Keller, 1985; Harding, 1986; Gross, 1992; Rosser, 1997), psychological (Keller, 1989; 1992), social (Bielby, 1991; Glover, 2000) and cultural politics (Harding, 1992; Byrne, 1993; Hess, 1995) perspectives. Although the general question "Why are women less likely to succeed in science?" requires a multidimensional investigation, the explicit framework of my research will be the socio-educational context in which science-related careers are shaped within the Canadian culture. This approach is appropriate for the analysis of available data on B.C. young women and men's educational and career pathways. It also constitutes a well-suited context for the examination of the way human capital (i.e., credentials and formal qualifications), cultural capital (i.e., specific attributes that influence one's advancement within a given profession), and social capital (i.e., social networks) contribute toward building a career in a competitive field like science (Glover, 2000). In terms of human resources policies, the science-career field is marked by a series of social inequities that affect women, as well as other disadvantaged groups (e.g., low socio-economic status people, minorities, immigrants). Gender discrepancies are reflected in the low representation of women, as well as in the social conditions in which women in science have to practice their profession.

Science-related Careers on the Labour Market.

A direct implication of the socio-educational circumstances in which science and engineering fields are promoted to women is observed in the low rate of their entrance, retention and advancement in science-related jobs. In the United States, the proportion of women in the science and engineering workforce was about 19.5% in 1997 (National Science Foundation, 2000). In 1996, the British science and engineering professional labour market had a female representation of only 14.5% (Glover, 2000, p. 43). The Canadian labour market data from the 1996 Census (Figure 1) show that women represent a majority in people-oriented occupations like health (79%), social sciences and education.
(60%), as well as art and culture (53%). Meanwhile, occupations that are mostly related to technology, like the ones in natural and applied sciences, and in trades and primary industry are male-dominated (82%, respectively 84%). Seemingly, the above professional distribution is the result of an accumulation of circumstances that start pushing women away from certain fields a long time before the moment they reach the workforce. The reality of the scientific world (i.e., resistance by men to women’s inclusion, women’s marginalization, low retention and advancement of women, professional patterns, workplace inequities) has a discouraging effect on girls, making them avoid some specific male-dominated fields (Glover, 2002, p. 30; Etzkowitz, Kemelgor & Uzzi, 2000, p. 47).

Even if the percentage of women full-time faculty in Canadian universities in the last two decades has shown its largest rate of growth in the fields of engineering, as well as in mathematics and physical sciences, these figures are still low. For instance, Figure 2 shows numerical evidence regarding the limited presence of women in academia - an institution that presumably plays a substantial role in shaping the image of various fields in society. Another regrettable aspect is that university women hold lower academic rank positions, a reason why women get only a small chance to having their views taken into account when it comes to running the science enterprise. For instance, in 1998, for all disciplines, the percentage of women in academia was lower than 14% at the rank of full professor, about 29% at the rank of associate professor, about 42% at the rank of assistant professor and approximately 50% at other ranks (Statistics Canada). The proportion of female faculty in engineering and physical sciences is typically even more limited.

The presence of women in science teaching positions is recognized as a stimulating factor in gearing girls’ career aspirations toward science. The British Columbia Teacher Federation has shown a continuous interest in the status of women in the B.C. education system. BCTF research reports show that even though the percentage of female secondary school teachers in mathematics in science has increased over the years, women are still under-represented in these subject areas. In 1991, 20.9% math teachers and 17.8% science teachers in secondary schools were women. In 1995, the headcount of educators by secondary school subjects showed 28.6% female teachers in mathematics and 26.7% in science (BCTF reports, 1991 & 1995) – increased figures, yet lower than the proportion of women with degrees in these fields.
Figure 1: Gender distribution across occupations - 1996 Canadian Census


Figure 2: Full Time Faculty in Canadian Universities by field

Source: Association of Universities and Colleges of Canada using data from Statistics Canada
The shortage of women in science and engineering fields has multiple causes, but it seems to be mainly determined by two major categories of factors, both social in nature, that include:

a) the uncertainty of career accomplishments at the end of hard, lengthy programs - an awareness that may not motivate women's persistence in completing the academic journey (Long, 2001, p. 63);

b) the unfriendly, discouraging or non-supportive environment, which is unwilling or just unprepared to address women's needs (Wasserman, 2000).

The social aspect that cannot be disregarded, overlapping the above categories, is the multiple roles women hold in society. In order to balance successfully their career and family life, professional women are forced to adopt more practical attitudes than their male colleagues. However, while in female-traditional occupations one can “take time for children” without great penalty, “a career in science and engineering, especially if one is interested in research, demands uninterrupted devotion” (Hornosty, 1998, p. 182). The author discusses the systemic discrimination against women in university and states that the roots of discrimination “lie in the social organization of the wider society” (p. 191).

The impact made by the socio-political context on women’s career and life course transitions is obvious in the case of post-1989 Eastern Europe nations. A recent study by Weymann, Sackmann and Wingens (1999) shows how the radical social changes that affected the East German labour market have had a larger effect on women than on men. The authors discuss the career development of professionals who graduated from vocational schools and universities in 1985 (i.e., a cohort that had schooling, their first job, and five years of employment under socialist conditions), 1990 (i.e., a cohort having schooling in the German Democratic Republic, but first job entry in post-1989 East Germany) and 1995 (i.e., a cohort that graduated under West German conditions).

Weymann and collaborators show that the labour market and the occupational structures being drastically reorganized in post-1989 East Germany, women had worse chances of transition from non-employment into job and experienced lower career mobility. The gender effect on job transition and career mobility was larger for women with pre-school age children, since social structures that existed in socialist East Germany (day care, social services, longer maternity leaves, guaranteed jobs) have probably become less affordable.
As a result, the post-socialist changes strongly influenced the pattern of early motherhood decisions in post-1989 East Germany. "While already at the age of 25 the percentage of mothers among women of the 1985 cohort was 52%, the respective percentage for the 1990 cohort was only 28% and for the 1995 cohort only 12%" (p. 105). These findings demonstrate the impact of social and political circumstances on the specific way women choose, or are forced to balance career and family life.

It should be a social justice concern not to have women's career options restricted due to family responsibilities. There is still an open discussion regarding the reasons why the issue of balancing career and family options has become so acute in science and engineering fields. A possible explanation is that the scientific community has stricter rules regarding the timing of various phases leading to career accomplishment and this fact would reduce the presence of women in upper level programs even more. Etzkowitz et al. (2000) identify "critical transitions in the graduate and post-graduate career path" (p. 69) such as the qualifying examination or finding a research advisor; especially when these academic transitions coincide with major life-course events, attrition rates are larger for women than for men.

Even considering the above aspect, it is not clear why one cannot at least match the participation of women in science-related careers with the overall rate of participation in Ph.D. programs by women. For instance, in 1995 in Canada, the proportion of Ph.D. degrees earned by women was about 17.3% in Mathematics & Physical Sciences and 9.4% in Engineering & Applied Sciences (Statistics Canada, 2001). Still, in 1997-1998 (i.e., allowing about two years of post-doctoral appointments before applying for a faculty position), the proportion of hired full-time faculty (Figure 2) was definitely lower in mathematics and physical sciences (10.2%), and still unbalanced in engineering (7.7%). Once again, this fact shows that gender equity issues are not resolved and the hiring process in university is not fair enough.

It is debatable whether female students become aware of the above situation and make decisions accordingly, as early as in high school and, thus, rationally restrain their career choices. However, the concern about being able to succeed in science-related work environments and about balancing scientific career and family appears to be part of the unwritten "folklore" that girls learn about from early stages of their school life. Actually,
trying to counteract this situation, there are groups whose focus is to encourage girls to go into science by presenting the few successful women in science as positive examples. This approach can possibly have a negative effect on girls who become aware, but also skeptical, of the family-versus-career issue related to one's success in the field of science. The above approach is still under researched and does not resolve existing social inequities or compensate for the lost talent in the larger group of women scientists (Adamuti-Trache & Andres, 2002).

The educational and career choices of young women and men cannot be isolated from the current trends in the science and engineering workforce. Young people choose career destinations that appear to guarantee both job and life satisfaction. The current situation of women's under-representation in the science and engineering labour market can be a major factor in negatively influencing young women's career decisions, so this concern cannot be ignored and should be included as a significant aspect of the general social context.

**Research Framework Reconstructed.**

Although there is a multitude of aspects that can shed light on topics related to women's participation in science, the issue will be stated within a structural and socio-educational approach in this thesis. Specifically, the current research will focus on the school-to-work dimension, following respondents from secondary school to post-secondary education and work. "What are the educational and career trajectories for women and men who excelled in science during their senior high school years?" This specific inquiry will be addressed in relation to main institutional and societal factors influencing men and women's attitudes, perceptions, motivations and, consequently, scientific career options. I have based my inquiry on the assumption that socio-educational factors play a major role in the career decision-making process experienced by young men and women and thus, these factors are accountable for gender differences in participation and achievement in science-related professions. I will specifically analyze the role played by parental background in the academic choices and educational decisions made by respondents during high school and post-secondary stages. The research will be developed within the framework of the theory of capital, looking at distinctive ways in which high school academic capital and cultural capital are turned into human capital in the fields of
science and engineering by B.C. young women and men.

It is certainly an anachronism to see science, a promoter of technological progress, as being resilient to social change. The answer to the gender and science question may not be straightforward, but scientists have been successful in solving even more complicated problems. In 1991, two women scientists, Sherriff and Svenne, recommended that, “one way of testing the question would be to use the scientific method itself: do the experiment, get more women into science, and then see how science changes” (p. 10). Seemingly, the scientific community is still at the level of reflecting on the need of this experiment or just of trying to anticipate the outcomes through theoretical models. Meanwhile, empirical and conceptual research in education, social sciences or philosophy of science aims at understanding the gender differences that may account for the occupational segregation in the science and engineering fields.

1.3 The Researcher's Stand

My own lengthy exposure to the scientific field within both school and university environments may help define my position as a researcher with respect to the topic under investigation. As a researcher working in the higher education area, I hold a double “outsider” identity, since I have a background in natural sciences and I was educated in an Eastern European culture (Romania). I am fully aware of the potential discipline-related and cultural-related bias that can influence my views. In this section, I will present my testimony as a woman in science, revealing first-hand observations on scientific communities located on two different continents in four countries in which I was employed (Romania, France, USA and Canada).

A Woman’s Scientific Path.

Being born in Romania, my schooling and career training in science were framed within an Eastern European culture. My educational growth portrays a gender-neutral ideal about education, according to which boys and girls are provided with equal opportunity and no societal stereotypes are manifested. The goal of Romanian education was to maximize the potential of individuals vis-à-vis the labour force by offering equal opportunities training regardless of sex, and according to students' interests, academic abilities and demonstrated achievements. In a previous paper, my entire journey in science
has been documented (Adamuti-Trache, Braendel, Long & Mitchell, 2001). My personal experience, influenced by my family and school, can be followed along a straightforward evolution of gradual growth of motivation that included the following:
a) having an early interest in mathematics and astronomy that was geared toward physics during the high school years;
b) receiving an appropriate school training in mathematics and physics stimulated through a competitive school contests atmosphere;
c) being enrolled in tough but well structured school and university institutions;
d) being strongly encouraged towards science by parents, school teachers and university instructors.

This form of liberal feminism was fostered within the Romanian society in the sixties and seventies and had complex socio-cultural and ideological causes that I will briefly mention.

As a twelve-year-old-child, my scientific choice was highly influenced by my parents, who valued the solidity of a scientific career and also believed that only the science field could stay ideology-free in the socialist Romanian society in the late sixties. Since the socialist ideology had an expressed goal of levelling class, ethnicity and gender differences (an authentic Marxist-Socialist feminist goal), gender issues were never identified as present in Romania. This fact did not necessarily imply that society was free of misogynist attitudes, sometimes manifested even within the family. Occasionally, these attitudes could occur in workplaces and in the university environment, especially in traditional male fields.

My experience as a woman in science was pretty smooth and linear in Romania, where a good university GPA would allow one to start a scientific career, as well as to continue part-time Ph.D. studies (the only form of doctoral degree accepted in a free-tuition educational system as the Romanian one was). I was twenty-seven years old when I competed and obtained a tenure appointment at the Faculty of Physics - an academic institution with more than 50% female students and about 30% female faculty. About 70% of the female graduates in Physics would choose high school teaching careers, while the other 30% would go into academia, research and industry.

Since many women had to hold multiple simultaneous roles as professionals, wives and mothers, in the Romanian society they were provided substantial maternity leaves and
daycare opportunities. However, male colleagues were not always supportive and some administrators would avoid hiring young mothers. Therefore, women in workplace, and especially in academia, were supposed to cover many job responsibilities, in order to prove their efficacy, avoid gender suspicion and gain a respected professional status. Even if my professional growth was not affected by gender discrimination at the University of Bucharest, that period of time was for me a continuous struggle to attain the highest level of professional fulfillment.

**Cross-Cultural Perspective.**

During the last decade, I have been exposed to sociopolitical changes (the collapse of a communist regime in Romania and the adjustment to a Western system), cultural transitions (living successively in the Romanian, French, American and Canadian societies), as well as career shifts. Therefore, I started to observe the role that, at a specific time, some institutions may play in "shaping" cultural mentalities, societal stereotypes, educational philosophy or workplace cultures. For instance, in Romania, the Marxist ideology and its economic policy have induced an improvement regarding gender equity, although having never been able to eliminate the patriarchal hierarchy. In France, I observed a more supportive attitude toward women’s rights, since both society and family have developed efficient and affordable ways of helping professional and working women to cope with their multiple roles.

My first contact with overt feminist issues occurred while living and working as a physicist in the United States, when I learned about affirmative action and I experienced the "chilly university climate". Even if I had excellent research collaborative experiences with most American male scientists, I never felt so socially excluded in a workplace. American women in science do get together in various professional and feminist associations. However, some female scientists still feel isolated within their departments, while others try to adjust themselves as to match the male-scientist image.

In Canada, I have never worked as a scientist in the field of physics. Early on, I discovered the presence of both sexism and ageism manifested in physics departments and I felt hesitant about starting a battle within an unfriendly environment. My having to cope with the condition of being a single mother and a recent immigrant certainly did influence my decision. Moreover, since my American experience had revealed some of the
unfriendly aspects of the science community, I decided to avoid a risky involvement with a professional field that would isolate me even more, thus hindering my integration in a new culture. The only chance offered to me by a Canadian physics department was a science communication job with no connection to my previous experience as a theoretical physicist and with no possibility for professional growth. However, this position that I held for more than three years has allowed me to observe the condition of women in science from a perspective that did not involve me competitively in the physics field. As a member of the Society of Canadian Women in Science and Technology (SCWIST), I also had the chance to meet Canadian female scientists in various fields and to hear stories about their career pathways. Since SCWIST is also developing programs to address issues of new Canadian women scientists, I did some research and learnt about how women immigrants strategize their integration in science and engineering fields (Fowler & Adamuti-Trache, 2002). In addition, my present involvement with both the field of education and the educational research has opened my eyes toward new facets of science education.

Etzkowitz and collaborators (2000) recognize that, even if the question “Why are there so few women in science?” is raised throughout the world, international differences exist among countries. In Eastern European socialist countries, the proportion of women in science grew close to parity (40%) after the Second World War, yet career advancement remained questionable for women (p. 218). In many developing and semi-industrialized countries (Turkey, Brazil, Mexico, Portugal, Greece) women in science come from upper-class families yet the rates of participation in scientific employment are no larger than 26 to 30% (Mexico). In highly industrialized European countries, women face the same dilemma of “the coincidence of child-bearing and child-raising years with the expected period of high research productivity” (p. 211). As a result, few women can survive in the field of science. In France, which has one of the best rate of participation of women in science, women CNRS scientists have reached 28% in chemistry, 19% in physics and mathematical sciences and 16% in engineering in 1997 (Glover, 2000, p. 81). In the USA, the percentage of women scientists and engineers employed in higher education was 13% in computer and mathematical sciences, 12% in physical sciences and 7% in engineering in 1995 (Glover, 2000, p. 71). Even if the rates of participation in science show some
variations depending on the political system, Etzkowitz concludes that “there was a common deficit of female scientists in the higher level of research organizations”. Ironically, when women achieved better positions in science, as in the former Yugoslavia, “this advance was associated with a decline in the position of science in society” (p. 219). This brief cross-national comparison shows that science is a social construct shaped by the socio-political and socio-cultural conditions of each country.

1.4 Purpose of Study

This thesis will use longitudinal data on educational and career paths of B.C. high school graduates of the Class of '88. The study will provide statistics of students' participation in science at various levels (high school, post-secondary instruction) and will identify typical patterns of educational and career pathways for young women and men. This is an empirical structural study that documents the way academic capital in secondary school is turned (or not) into educational attainment and occupational status in science and engineering professions. This transformation occurs during the passage from high school to university, as well as along various post-secondary stages. The research design is based on the hypothesis that high school preparedness is a likely indicator of students' abilities and interests in pursuing specific educational and career pathways. For the purpose of this research, senior high school academic orientation will be taken as an initial stage of respondents' trajectories. I hypothesise that female students' paths will be more erratic and more strongly influenced by a variety of personal, family and institutional factors. One purpose of this study is to identify specific academic programs or career destinations chosen by young women and men and how are these educational choices related to respondents' parental background and high school academic preparedness.

The available data can only bring evidence on the occurrence of gender patterns in science-related pathways, without attempting to address the question why such patterns occur. A tentative approach to addressing this question will be presented in the last chapter that will also consider ways of remedying this situation and of making educational policy recommendations.
1.5 Research Questions

This research study uses quantitative data on secondary, post-secondary education, and labour market phases, for a sample of B.C. high school graduates over a period of ten years (Andres, 1988-1998). The study will mainly focus on the undergraduate stage, but it will connect to the high school, as well as graduate and workplace stages, by addressing the following research questions:

a) What is the role of the high school academic capital in shaping a successful pathway toward a science-related career? Are course choices during the senior high school phase good predictors of participation and persistence in post-secondary education? How is the rate of completion in undergraduate studies influenced by the type of secondary science preparation (number and type of courses)?

b) Are there gender differences in the relationship between the secondary and post-secondary stages? Does gender influence high school course choices, post-secondary participation and educational attainment? Are there systematic gender differences in respondents' choices of academic specialization fields?

c) What is the role of cultural capital in respondents' secondary and post-secondary education choices, participation and attainment?

d) What is the relationship between academic capital, cultural capital, gender and human capital in science and engineering fields? Do existing inequities lead to a loss of human capital in these fields? Are women specialized in science and engineering fields happy with their career and work? Do they expect good opportunities for professional growth?

1.6 Research Methodology

The available longitudinal data have been collected from three follow-up surveys conducted by Lesley Andres (1989; 1993; 1998) on a B.C. sample of high school graduates of the Class of '88. School records also provide complete and extended information on Grade 11 and Grade 12 course choices and achievements of study participants. Specific data from all three waves of surveys, as well as the school records will be used. I will account for sample attrition through comparison with earlier stages in the study. Therefore, the existing database is adequate for a quantitative analysis of the research questions that
will be addressed through a variety of statistical methods.

The purpose of this thesis is to explore science-related career destinations, starting with specific high-school-student profiles and ending with post-secondary attainment, as known in 1998. The high school profiles are defined by student interest in science as reflected in the type and number of science courses taken for graduation. The type of degrees earned by students by 1998 describes their post-secondary educational attainment. The post-secondary academic programs describe respondents' professional orientations (or career destinations). The research will be conducted from a structural perspective that aims at revealing patterns of post-secondary educational choices and accomplishments, ten years after high school graduation. Descriptive and correspondence analyses are the main statistical tools for this structural study. Descriptive statistics will provide snapshots of students' science-related experience at different times, while correspondence analysis will be used to reveal relationships among various factors and to present them in a graphical suggestive form. Occasionally, multivariate analyses will be used for testing and confirming observed differences among groups. For the subset of university respondents a more thorough analysis on their post-secondary and workforce experiences will be provided. Since the study of science-related educational and career pathways will be accomplished through comparisons with other career destinations, this thesis will provide a broad picture of the available B.C. workforce in various areas by 1998.

1.7 Significance of the Study

Longitudinal studies are extremely important in observing correlational patterns over time and in developing causal models. The consistency of these patterns may offer a complex picture of the way various factors intertwine, as well as of the effects they produce. Since education is a long-term investment of time and money, the potential long-term effects revealed by longitudinal research become important in educational studies.

Most analyses in the gender and science area are dedicated to specific stages of educational or career growth. For instance, longitudinal research has been developed for studying the transition of students from high school to sophomore years (Hanson, 1996), the flow of students at the undergraduate stage (Katchadourian, 1985) and the patterns of advancement in scientific careers (Tang, 1997). Hanson, who developed a six-year study
on educational transitions, has noticed that

"longitudinal studies examining the pipeline from high school into careers are rare. A long-term approach, which does not stop with the end of education, is important given the evidence showing a considerable exiting from the sciences after college and graduate school and before young people enter occupations" (Hanson, 1996, p. 6).

Scarce longitudinal data and the small number of extended longitudinal studies in the specialized literature reinforce the significance of the current study.

Sometimes, longitudinal data are used to present just snapshots of students' science experience at a specific time, thus being confined to a static description of the problem. These analyses are not able to encompass the dynamics of student flow. Since science is a field with many exiting students, a systematic follow-up of a selected pool of students, over a longer period of time, would be more relevant. This study will have the advantage of using data with reference to over ten years of participants' lives, until they reach the stage of undergraduate and graduate degree completion. Consequently, the study will provide a dynamic description of the post-secondary educational paths of a selected pool of B.C. students.

Since this research is based on a cohort of high school graduates from 1988, a legitimate inquiry could be whether the study findings are still providing useful information on current aspects related to career choices of young women and men. The economic, social and educational contexts within which science education evolved in British Columbia in the late eighties and early nineties have certainly changed. The high-tech job market has expanded; information technology has penetrated a variety of fields, so that new science and engineering professions are being created. Therefore, the B.C. human potential has to be fully utilised and the workforce needs to be continuously upgraded. The last two decades have also been characterised by the expansion of feminist theories (Keller, 1985; Harding, 1986) into the science field, by the awareness of inclusiveness in classroom practices, and by the implementation of US affirmative action policies and of Canadian employment equity policies. In addition, the demographic context has also changed dramatically since immigration in British Columbia has led to an increase in the school
population by over 50% during the last ten years. The large number of immigrants coming from Eastern Europe and Asia has brought their own perspectives, interests, experiences and needs regarding equity issues in education and labour force.

Have any of the above facts been effective in changing the situation of women participation in science-related careers? Even if the percentage of women full-time faculty has continuously grown in all academic disciplines (Figure 2), the mathematical and physical sciences fields, as well as engineering and applied sciences departments still have less than 10% women in 1998. Even more discouraging is the fact that participation rates in B.C. Provincial Exams in science do not seem to have been significantly different over the last decade (B.C. Ministry of Education, 1992-1999). Consistently, participation of female students in mathematics provincial exams has been about 10% lower than for male students, and only about 10% of female students participate in physics provincial exams. These data show that the gender issues in science are still unresolved and the patterns in science participation have not changed over the last decade. Since the initial conditions at the moment of high school graduation are practically unchanged, there is no reason to assume that post-secondary educational patterns generated by them will be significantly different. Consequently, the findings of this longitudinal study will be still relevant for describing the current situation. However, this similarity should not necessarily imply that all factors causing women under-representation in science are still the same.

The Path on Life's Ways Project (Andres, 1988-1998) is the first longitudinal study examining post-secondary participation and completion over time in British Columbia. The merit of the current thesis lies in its being the first attempt at using longitudinal data focused specifically on analyzing the scientific paths of B.C. post-secondary students.
1.8 Overview of Chapters

Chapter 2 will present a literature review of the major themes related to the gender and family background versus science problem. Since the research is based on a longitudinal research design, various stages in a female scientist’s formation need to be explored. Elements of the theory of capital in social sciences will be discussed. Chapter 3 will describe the research method of this study, including the research design, data collection, and data analysis.

In Chapter 4, I will present the research findings for the whole research sample, starting with the high school stage and accumulation of academic capital and continuing with the post-secondary stage and the building of human capital in science and engineering. Chapter 5 contains research findings for the university graduates, namely specialization fields, educational aspirations and expectations, work or career satisfaction, future educational and career plans.

Chapter 6 will summarize and discuss the findings framed within the theory of capital. This final chapter also contains a discussion on possible implications and interventions, significance and limitations of the study, as well as recommendations for future research and policy. A Reference section and three Appendixes will end the paper.
CHAPTER II

Literature Review

2.1 Introduction

The topic of women in science is discussed in the specialized literature from various perspectives. First, feminist theories about science and feminist pedagogy models of science education bring a theoretical contribution to the topic of gender versus science. Second, there is a category of scholarly contributions aimed at collecting and interpreting data on gender issues in science at various levels of school, university and the workplace. These applied studies are based on both quantitative analysis (descriptive and inferential statistics) and qualitative research. The latter category also contains historiography and biographical studies, and memoirs by female scientists. There is also a third category of writing that develops practical guides for young women in science. For the purpose of this thesis, the specialized literature included in the second category is relevant. In the current chapter, the following themes will be addressed: a) girls and science, b) the undergraduate and graduate science pipeline, c) women and scientific careers, and d) human capital and gender issues in science.

Over the last twenty years, research has also been directed toward identifying factors that influence women's experience in science, as well as toward developing plausible models aimed at explaining gender differences in science at various stages. The specialised research does not provide well-established models on careers in science. The theoretical aspects are still in development, mostly backed up by studies on science pipeline issues that occur at various stages with little research on the relationship among these stages. Difficulties encountered in theory elaboration are due to the dynamic nature of the problem as well as to its complexity that involves a multitude of connected past, present and future factors. Longitudinal studies could generate reliable information on gender patterns illustrating scientific career paths. In a dynamic process, like the one under discussion, though different models are conceived for each stage, they also need to be connected in some specifically designed pattern. This literature review will support the delimitation of significant factors that can explain patterns along science-related educational and career destinations. The current study takes a structural approach in
explaining observed patterns of career choices but does not have enough information to
discuss the reasons of respondents’ choices. Therefore, some of the reviewed literature will
be often used to support the interpretation of thesis findings.

2.2 Girls and Science: Family and School Environment

In the last two decades, alongside the research on women and science, science
education research has also grown along four major directions, which include the
following:

a) classroom strategies meant to create an equitable learning environment for all students;
b) a gendered curriculum that segregates students’ participation in specific science areas;
c) societal stereotypes that influence students’ school subject choices and career options;
d) psychological issues, such as self-esteem and motivation.

These directions are explored using a variety of approaches including feminist
pedagogy, and liberal, radical and post-structuralist feminism (Cohee et al., 1998; Davis et
al., 1999). The feminine science model (sometimes called “girl-friendly science”) suggests
changes in the classroom atmosphere, toward a co-operative rather than a competitive
work style. Re-unifying cognitive and affective approaches to science, and eliminating
stereotypes in science materials, would lead to the acknowledgement of some aspects
supported by the “feminine” rehabilitation (Kelly, 1987). Proposed changes include
viewing science as a “philosophy of wisdom” rather than a “philosophy of knowledge”,
acknowledging subjectivity as part of science methodology, accepting women’s specific
perceptions of reality and logic, and abandoning the strict requirements of scientific
precision and reliability. The feminine science viewpoint suggests that "school science, and
not just girls, must change" (Kelly, 1987, p. 97).

Similarly, concrete issues of gender differentiation in schools are presented in
Toward Gender Equity in the Classroom (Streitmatter, 1994). For instance, the gender
equity notion is introduced through a discussion of two approaches - “equal” versus
“equitable” opportunities for women and men. Streitmatter also comments on the observed
segregation of sexes across various curriculum areas. Thus, boys, as a group, dominate
higher-level math and science classes, whereas girls prefer biology classes. It appears that
students feel more comfortable and empowered while working within a discipline that
features a gender-specific content with which they can socialize better, feel more closely related to or behave more naturally. One of the important issues under discussion is the influence of gender-role stereotypes in gradually shaping students’ perceptions of their own potential, dreams and roles in society. School exposure to gender-role differentiation confirms and deepens children’s earlier experiences regarding family and work gender-roles, thus shaping students’ preconceptions about gender and career. Although it starts as early as at the level of elementary school years, gender differences are more obviously manifested at the beginning of junior high school - a fact that supports the idea that gender-role stereotypes are a social construct.

The current situation in science and mathematics education is discussed extensively in the literature (Tolmie & Howe, 1993; Murphy, 1996; McArthur, 1997; Sanders et al., 1997), and evidence on science achievement, evaluation, pedagogy, curriculum and classroom interaction is analyzed within a feminist pedagogy framework. The literature reveals the important role that school and teachers could play in changing societal stereotypes and instilling in students appropriate attitudes regarding gender and science. Since it is unrealistic to believe that substantial change could occur as a result of individual practice, action on a global scale is recommended, including a specialized instruction on gender equity, offered to educators.

Debacker and Nelson (2000) identify gender differences in the motivation of students towards learning science (e.g., natural interests, goals, commitment, values, work habits). Students’ perceptions about science classes, science careers and scientists are usually dominated by stereotypical beliefs that also shape students’ career options. The role of societal stereotypes in influencing female students’ options for scientific careers, at all educational levels, is a major concern in feminist pedagogy.

There is also a large amount of psychological research addressing issues of students’ self esteem and motivation for learning science. In the speech given at the opening session of the First International Conference on Self-Esteem organized in Oslo in 1990, Nathaniel Branden defined the concept: “Self-esteem is the disposition to experience oneself as competent to cope with the challenges of life and as deserving of happiness” (Branden, 1992, p. 18). The author’s belief is that self-esteem is achieved and strengthened over time by the reinforcement of specific practices like the use of consciousness, self-
responsibility, self-assertiveness, purposefulness and integrity. Family and school are early factors that help individuals in shaping their self-esteem, which is believed to be strongly correlated with individuals' career goals.

*Student Self-Esteem: a Vital Element of School Success* (Walz & Bleuer, eds, 1992) is a collection of articles that address issues regarding academic performance and career development as related to elementary and high school students' self-esteem. Chiu discusses the issue of career development and self-esteem for boys and girls (Chiu, 1992, p. 181). Career choices are defined in connection with traditional versus non-traditional professions for men and women. Self-esteem measurements are based on students' self-reports and on teachers' ratings. Results show that adolescents with clearly defined career goals obtain better self-esteem scores. However, girls score lower than boys on their self-report tests, though they tend to receive a higher rating from their teachers. This fact suggests that girls are more critical of themselves than boys are, therefore greater encouragement from teachers would boost their confidence. Students' attitudes toward gender differentiated non-traditional careers show that young students adopt gender-based job stereotypes and even show negative attitudes toward people holding non-traditional occupations. In addition, boys are more conservative than girls in holding to gender stereotypes.

Haring and Tyler (1992, p. 185) demonstrate that boys are equally confident about performing well in both traditional and non-traditional careers, while girls manifest a lack of confidence regarding a future in an occupation seen as non-traditional for women. Another interesting result is that both boys and girls with high self-esteem are likely to prefer traditionally male careers.

Age is definitely an important factor influencing the level of students' self-esteem. Brutsaert (1992, p. 213) shows that, during early adolescence (junior high school), girls' self-esteem is highly dependent on parental support, while boys' self-esteem depends on their sense of mastery. However, at the middle adolescent stage (senior high school) boys and girls react similarly and their self-esteem becomes highly dependent on their academic achievements. This interdependence is stronger for girls, who show a higher level of confidence if they are enrolled in a more rigorous study curriculum. This fact suggests that girls adjust better to a more demanding school context, and may be more likely to benefit of a structured academic instruction.
Robison-Awana et al. (1992, p. 224) found that all seventh-grade students in their study ascribed higher self-esteem rates to boys than to girls. However, the "above-average" girls consider themselves higher achievers than boys - a finding speculated as a proof of masculinist traits present in the group of well-performing girls.

In the literature, family and school are identified as early factors in influencing students' attitudes about science. Family influence encompasses early orientation toward science, availability of resources, encouragement and recognition of achievements, and instillation of career aspirations. The mother's level of education, as well as her employment history, usually manifests a role-model effect on daughters, while the father's encouragement helps boost their self-confidence. Young women and men who planned science related careers reported higher levels of parental encouragement (Dick & Rallis, 1991).

Parents' occupation and social origin affect school subject choices of boys and girls. Dryler (1998) demonstrated that Swedish girls and boys made gender differentiated choices of upper secondary school courses. For instance, students who choose gender-atypical fields of study have parents working in the service class or parents with higher levels of education.

The first institutional impact within the school environment is likely to start defining students' inclinations, interests, as well as educational and career aspirations. Teachers, counsellors, peers, curricula, extra-curricular activities and types of school programs may either distance girls from science or attract them to it. This is certainly the stage when girls' self-confidence and attitudes are influenced by the above factors. While program content is essential in stimulating girls' interest in science, the science classroom environment is relevant in featuring the real-world science climate. As long as curriculum, school programs and class atmosphere will be male-dominated, there is a big chance that girls will be turned away from science (Kahle, 1996).

Moreover, family, school and society at large are responsible for girls' awareness regarding gender-role socialization. Typical gender stereotyping regarding career paths, the multiple-role reality of women's lives, the existence of other societal barriers for women's professional advancement and the characteristics of science-related pathways (e.g., rigidly-timing, highly specialized) promoted by the science community influence girls' attitude
toward pursuing specific scientific careers (Walz & Bleuer, 1992). This phenomenon is amplified during high school years, especially in Grade11 and Grade12, and it results in girls dropping out of “hard” science courses, like physics (Adamuti-Trache, 2002a). The high school leaking science pipeline has a significant effect in decreasing the number of talented female students intending to continue in science-related academic programs.

2.3 The Undergraduate and Graduate Science Pipeline

Seemingly, the undergraduate years are a major decision-making stage when female students are likely to choose whether or not to pursue science careers. It has been documented that female students who finally decide to enroll in undergraduate science courses are above-average achievers in science. Girls who succeed in coping with the school science environment start undergraduate studies with a variety of interests. University demography shows that a large number of female students choose biological and chemical sciences, fields that involve extensive experimental work (Statistics Canada, 2000). The working-in-a-lab goal, as well as the orientation toward applied areas, is also accomplished by their choosing some fields of experimental physics, astronomy or engineering. A small number of female students are willing to try theoretical physics, mathematics or computer sciences - definitely, fields requiring more abstract reasoning. There are also undecided female students, who, though having interest in science, still hesitate to make a clear choice, due to their lack of information on the field or due to little confidence in their own abilities. The above description would suggest the importance of several factors, such as effective teaching methods, stimulative learning environments, knowledgeable advising, effective role-models, as well as sustained career orientation events at the lower-level of undergraduate studies (Hyde & Newsome, 2000; Brainard & Carlin, 2001). Even so, a large number of female students decide to switch to other professional fields at some stage of their educational or career pathway.

Research aims at answering questions like “Why do most of high achieving female students complete majors in non-science academic programs? Why do most women with a Bachelor's in science continue graduate studies preferentially in fields like biological sciences, health, education and social sciences? Why do some women with graduate degrees in mathematical and physical sciences, and engineering decide to make career
shifts later in their life?” Themes that occur in the literature refer to students’ abilities, academic preparation and course choices; students’ socio-psychological characteristics; structural and cultural factors in undergraduate science environments.

The relationship between subject matter choice and gender represents a research direction in studies on both secondary and university education. In his book *Gender and Subject in Higher Education* (1990), Thomas provides accounts of university students regarding their options for science or humanities fields. Students’ gender-stereotyped options demonstrate that both science and humanities are social constructs in which gender roles are perceived to be clearly defined. However, the author notes the way gender identity creates a disadvantage for women, in both fields. For instance, women in science are identified as a minority group, while men in humanities identify themselves as special. Moreover, women in science appear to face a “dual identity” - one, as scientists (“as good as men”) and another one, as women (“being uncompetitive” according to the societal perception). Consequently, science and humanities do not even offer equivalent options for men or women, the two fields being actually open for men preferentially. Thomas concludes that “higher education does not actively discriminate against women; rather, through an acceptance of particular values and beliefs, it makes it difficult for women to succeed” (p. 179).

Students’ socio-psychological characteristics (self-esteem, math and science confidence) are carried through the early school years and deepened during college years, when students have to adjust to a specific disciplinary culture. In the science classes, most female students underestimate their abilities and thus perceive the field as less compatible with both their potential and their initial aspirations (Kubanek, 1996). These effects seem to be mediated especially by peers’ and instructors’ attitudes, by lack of mentors and role models, as well as by personal concerns about their future ability to balance career and family responsibilities. In addition, gender-patterns regarding learning and socialization are discussed in the literature, pointing toward a feminist approach regarding the transaction between objective and subjective experiences in knowledge building (Baxter Magolda, 1992). It is argued that female students need a more socially individualized context that would make them feel comfortable and stimulated toward learning. Since women value interpersonal reasoning, they tend to adopt a “building-towards-community-attitude”
The assumption that all women are motivated the same way can be interpreted as an essentialist argument in the feminist discourse.

Many studies discuss the effect of academic cultures and structures on the rate of attrition of female students from science programs, as well as on women's persistence in the scientific field. Since the culture of the scientific community is masculinist (e.g., teaching and research styles; aggressive, competitive or indifferent milieu; distancing from social concerns) the feelings of exclusion experienced by women are intensified (Erwin & Maurutto, 1998). Some authors express the hope that ensuring a "critical mass" of women in science would help establish a female identity in the field (Byrne, 1993) and thus, attract more young women toward science. This view is supported by the situation in areas like social sciences, education, arts or health, where there is a larger participation of women, a more supportive and open environment is established for both men and women. This friendly atmosphere has recently been created within the area of biological sciences, a reason why more and more girls feel encouraged to enter the field. New subfields related to biological sciences (e.g., biochemistry, artificial intelligence or bio-electrical area) also attract a large number of undergraduate female students. Etzkowitz, Kemelgor and Uzzi (2000) argue that this change is due to the rise of central networks developed by "women who are in positions of power" and it further contributes to having more young women directed toward their subfields. "There is a snowball effect: as the numbers increase in the biologically related areas in electrical engineering, chemistry and computer science, they then attract still more women" (p. 112). However, the authors still express a reservation toward the sufficiency of the critical mass strategy in resolving the issue of women under-representation, since "women faculty members may be unable or unwilling to play the designated role" in encouraging younger women toward science (p. 112).

For all students, the undergraduate stage represents a crucial time toward making their career decisions; the major influencing factors are related to institutional structures and to the culture of each scientific discipline (Clark, 2001). Research documenting patterns that describe students' options for courses and programs could be relevant for understanding the dynamics of this educational stage. If academic funneling occurs at the undergraduate stage, leading to the leaking out of the system of an additional group of above-average female students, the causes should be searched within university structures.
For a B.Sc. female student, the decision to embark on a graduate program within a male-dominated specialization requires perseverance, determination and courage. The most difficult part is the commitment to deal with an environment from which women can feel excluded (Betz, 1992). Most female students hardly have a voice in a group whose members are continuously striving for power and control. The often-mentioned aggressive, competitive and intolerant behaviour of male scientists is real and women have to train themselves to cope with it. Although some women are capable of copying masculinist attitudes, thus being able to deal with alienation aspects, this adjustment does not necessarily ensure their success in the field. Another important strategic aspect of graduate life is mentorship, even if it rarely leads to a real and continuous support of women along their career. Consequently, the effective inclusion of women within the scientific community during the graduate studies stage remains a real problem for most women.

An additional barrier to achieving success is the uncertainty of career opportunities that women experience during graduate studies (Etzkowitz et al., 2000). Current examples of women who have to leave science after long years of hard work are not likely to encourage graduate student persistence. Moreover, by starting a graduate program in “hard” science, women usually postpone marriage and childbearing for an indefinite period of time. The graduate stage is probably the beginning of a long journey characterized by the need of balancing time, energy, interests and desires. The typical path goes from Master’s to Ph.D. degrees, followed up by a series of post-doctoral phases that do not necessarily lead to academic careers.

Science undergraduate and graduate stages are supposed to follow immediately after high school graduation and to be accomplished in a rapid and continuous sequence. This requirement is mainly supported by tradition, rather than by strong research-based arguments, and it certainly creates a serious impediment for women’s educational and career growth, especially when maternity leaves occur. Both in theory and practice, there is little concern for the above aspects and for creating alternative scientific paths options. From a practice perspective, the concept of the science pipeline based on a one-way high-school-calculus-through-PhD track is challenged by the view of a “more open, nonlinear system”, displaying multiple entry and re-entry points in the academic flow (Hollensbead et al., 1996, p. 327). The factors influencing the funneling phenomenon at graduate stages
relate to the politics of academic departments and also show strong connections with the culture of each scientific discipline.

2.4 Women and Scientific Careers.

From early adolescence through graduate education to professional careers, journeys of women in science appear to be challenging experiences that could be disrupted at almost any stage. There are few female students who succeed in graduating with a Bachelor's in science and who still have optimistic dreams about pursuing science careers. An undergraduate degree in science is by itself worthy on the job market and many women would choose to use their degree in professional/technical workplaces, focusing in parallel on their personal and family lives. A small proportion of women may still be determined to pursue a scientific career and will enroll in graduate programs (Gadalla, 2001). In most cases, these women are highly confident in their ability in science, have had the chance to work with encouraging mentors and had continuous family support. The role of the last factor in favouring the persistence of women in sciences certainly raises social class issues. Since graduate studies in science do not offer many (if any) part-time options and financial incentives for women, their educational choices are even more restrained. The literature addresses various topics related to ways in which science-related careers are negotiated and pursued by women.

Some authors believe that men and women may have different career motivations. Based on the Study of Undergraduate Experience at Stanford initiated in 1977, Katchadourian and Boli (1985) distinguish between careerist attitudes of male students (i.e., view post-secondary experience as an opportunity to prepare for a vocation) and intellectualist attitudes of female students (i.e., view post-secondary experience as a modality to broaden academic interests and seek new challenges). The strong connection of science with social, cultural and political contexts, a connection that confers science a vanguard position in society, will certainly appeal to men more than to women; being socially constructed, the motivation for pursuing a scientific career is not only knowledge-driven. Therefore, if aspects related to the social position of science change over time, the interest in pursuing science-related careers may also vary, especially in the case of "careerist" students. This fact may explain why men leave those science fields that
offer less opportunity for professional and social growth. For instance, Glover (2001) shows that in the United Kingdom, there is “growing evidence that science is unpopular with both sexes” (p.75) and this situation is a major issue for the economic growth.

The most difficult problem that women face at this stage is the conflict between the strict regime of a scientific career (requiring more than full-time continuous commitment) and the duties that women hold in their newly-built families (especially maternal responsibilities). There is an extensive amount of research dedicated to women’s struggle with both academic career and family duties. Most research refers to issues like gender equity, hiring conditions and promotion, scientific productivity, workplace climate, “glass ceiling” barriers and family-work conflict (Davis et al., 1996; Caplan, 1993; Saunders et al., 1992; Zuckerman et al., 1991). On the other hand, research on female scientists’ working style, usually described as collaborative rather than competitive, has been given only superficial attention. The tendency of women toward collaboration could also be explained as a strategy to avoid isolation during periods of time when other duties overlap with career. Female scientists’ standpoints may provide a valuable insight into their “ways of knowing” and “surviving” in science - acquired knowledge that would be helpful for both epistemological feminism and academic practices.

Science-related career experiences, discussed in *Women’s Science* (Eisenhart & Finkel, 1998), are revealed by evidence gathered from four work sites. The case studies show that in most instances, women’s retention in science and technology fields, other than academia, is based on a redefinition of the job itself. Women seem to be successful in finding new meanings and satisfaction in their work, within the framework of public and personal relevance. The authors notice that most women’s careers in science are still marginal, even if most work places claim to support a “gender neutrality” policy that would give women and men equal opportunity for professional growth. Since policy is implemented by those who are in power, usually men, the authors are skeptical about the way policy is applied in practice.

The barriers manifested during the graduate stage are partially maintained during later phases, in workplaces and in academia. However, the list can be further lengthened with other factors, such as the gender inequity (e.g., differentiated salaries for women,
reduced career promotion) and the chilly climate in workplaces. Marriage and motherhood, as well as differentiated work commitment, are usually employers’ excuses for justifying gender-related employability.

Several models of scientific paths are discussed in the specialized literature. The *deficit model* (Sonnert, 1995) emphasises the fact that women are still treated differently in science. The “outer circle” positioning of women with respect to the scientific community (Zuckerman et al., 1991) is likely to maintain informal structural barriers to women scientists’ accomplishments. In this category, authors include factors like women’s exclusion from the power network, women’s limited access to strategic resources, as well as women’s limited job advancement opportunities.

The *difference model* relates women’s career achievements to two specific aspects: women’s innate traits and gender-role socialization values (Keller, 1985; Streitmatter, 1994). The former category includes genetic-related differences, extensively discussed in the literature of the seventies and early eighties. These factors are defined in the range of intellectual and behavioural characteristics that would differentiate men and women. Since science is viewed as a masculine profession, typical masculine characteristics, such as aggressiveness, ambition, resilience and competitiveness are reinforced as factors of success. The latter category includes differences generated by a gender-specific socialization, traditionally assigning each gender group to a specific type of work. All in all, the *difference model* factors are identified as “internal barriers” that prevent women from succeeding in science. According to Sonnert, (1995) these internal barriers should be studied in connection with structural barriers. Therefore, the *difference model* is connected to the *deficit model* since structural obstacles “that exist as a feature of the social system of science” (p. 6) favour the occurrence and manifestation of internal barriers.

A theory of *limited differences* was elaborated by Cole and Singer (1991) who propose an explanation for the “long established, but poorly understood, pattern of scientific productivity” (p. 277). The authors discuss differences regarding the initial conditions in which women and men start their scientific careers, notice dynamic patterns of increased differentiation over time and acknowledge the role of organizational contexts that influence scientific productivity.

Zuckerman (1991) describes a model based on the concept of “accumulation of
advantage and disadvantage” (p. 53) that could explain men’s and women’s disparity in scientific attainment. For instance, an advantage occurs when a professional group in science, on one hand, is offered more opportunities to access resources and, on the other hand, is properly rewarded for contributing to building knowledge. Traditionally, the opportunity to accumulate rewards and recognition ensures advantages to the male scientist group. The author also observes that self-selection, as well as women’s opting between family and career, will amplify and accentuate the gender disparities. Obviously, Zuckerman refers only to the professional career stage. However, this model of accumulation of advantages and disadvantages appears to be valid during all educational stages, leading to an even more increased difference in attainments between men and women. This model describes a scientific path as a dynamic process, which needs to be continuous and ascendant in order to be fulfilled. To be confirmed, this model has to be supported by longitudinal research data.

2.5 The Theory of Capital and Gender Issues in Science

Capital is defined by Bourdieu as “the set of actually usable resources and powers” (Andres, 1994) accumulated by an individual over the years and then, reproduced by active investment. The accumulation of capital depends not only on the individual action, but on societal context, since privileged groups in society may have a more favourable exposure to resources and more rewarding incentives for further investment than other groups. In science, some men have traditionally maintained a privileged position, by creating the set of rules and the forms of institutions that have favoured their own professional growth. *Pythagoras’ Trousers: God, Physics and the Gender Wars* (Wertheim, 1995) is a fascinating history of science analyzed from the perspective of gendered contribution to science and societal recognition of scientists’ contributions. For centuries, talented women contributed to the field as daughters, sisters and wives of remarkable scientists, without being accepted as part of the scientific community. Even though individual capital was accumulated (i.e., knowledge, skills), by not being recognized by society, it could not been further invested and reproduced. This situation has started to change during the last century, but under-representation by women in science-related fields is still a concern.
Over the years, physics has been the most reticent culture in accepting women’s participation and Wertheim argues that physics is the “Catholic church of science” (p.9). After demonstrating historically that modern physics has been intimately intertwined with Christianity, Wertheim concludes that “the problem women face trying to break into physics parallels the problem they face trying to break into the Roman Catholic clergy” (p.235). As bastions of male power, both communities have built rules that allow for the capital growth of selected members.

“What is human capital? It is what people know and are able to do. Human capital is knowledge, ability, skills, insights, dreams. It is the intellectual and, yes, moral vision that transforms dumb matter into goods and services” (Doyle, 1991). Schultz (1961) has discussed human capital from an economic perspective. He admitted that “our values and beliefs inhibit us from looking upon human beings as capital goods” (p. 2); yet, he has demonstrated that skills and knowledge are a form of capital and “investment in human beings yield a return over a long period” (p. 4). Investment in education falls into this category. Over the years, the societal investment as well as the “income forgone by students” has substantially increased, making any unwise use or deterioration of human capital a loss for society and individuals. In the science and engineering fields, the investment in human capital is quite expensive. Individuals need to embark on long, continuous and focused educational pathways, while society spends a considerable amount of money in expensive equipment and resources needed to train the scientists. Some authors argue that sex segregation and differences in career trajectories of women and men occur on the labour market because women “choose” to allocate more time to family and less to their job, thus being less productive (Becker, 1985). As shown by several authors (Colen, 1979), “the reward system in science is essentially meritocratic and not biased against women” (Bielby, 1991, p. 172). Since women make differential investments in human capital as compared to their male colleagues, they appear to be discriminated in science. Bielby argues that factors other than human capital, such as structural barriers and organizational dynamics as well as stereotypes and social-psychological barriers, should be also considered in explaining gender differences in career outcomes.

The growth of human capital is not only an individual matter, but it is determined by the societal context and by the culture of each discipline. There is increased evidence
suggesting that possession of equal amounts of human capital does not lead to similar effects for women and men in science. “Thus, human capital or “what you know” is the intellectual reservoir of ideas, methods, and factual knowledge that one accumulates, whereas social capital or “who you know” is the web of contacts and relationships that provide information, validation and encouragement” (Etzkowitz et al., 2000, p. 117). Social capital is built within each disciplinary community and therefore, the culture and traditions of the scientific community would control who is accepted and for what reasons. For the most traditional disciplines, like physics, the selection rules are so firmly determined by a masculine culture that establishing the chain of contacts (i.e., building the social capital that allows the individual get into the field) is even more challenging than accumulating human capital.

Social capital in science and engineering is often referred as to reputational capital. Citing the work of King (1994), Glover describes the reputational capital (2000) as “the social esteem which derives from putting discoveries into the public domain” (p.128). Even if other authors have argued that reputation enhancement is objectively assessed by merit, King’s view is “that the creation of reputational capital has a social aspect that is not done according to fair, objective criteria” (p. 129). Since who is involved in the process of judging one’s work or who promotes one’s work through citations and invitations to conferences depends on the social network available to each scientist, women have greater difficulty than men in establishing their scientific reputations. An important aspect in any academic and research career is collaboration with other scientists, a factor that may contribute to both science productivity and networking. An efficient and influential circle of collaborators can also consolidate a scientist’s “reputational capital” that would attract further networking. Since research objectives and domains of interest originate within scientific communities, research can be hardly done in isolation. Compared to men, it is more likely for women to miss the chance of establishing fruitful collaboration meant to grow in time from one’s being just mentored, to one’s becoming a co-worker and eventually mentoring someone else, in his/her own turn. Unfortunately, research on and beyond mentorship is not developed enough.

Human capital and social capital are concepts mainly related to career outcomes and/or later post-secondary education stages (graduate studies). At school and
undergraduate levels, the concepts of academic and cultural capital are more relevant. Academic capital in science disciplines is built continuously over years. Family and school play significant roles in stirring and maintaining a child’s interest and fascination for scientific disciplines. “No one becomes a scientist overnight. Rather, scientists are made in an arduous process of many years” (Sonnert, 1995, p. 164). The author cites a large-scale NASA study in which over 80% of the scientists and engineers report that they had decided on a science career before completing high school. Early inclination toward science and strong high school science preparedness are prerequisites for someone who intends to embark onto a scientific pathway. A child’s choice of a science career appears to be influenced by the “familial microenvironment of parental attitudes and behaviour”. Learning is assigned a high value in families that encourages children toward post-secondary education and science.

Information channels represent one form of social capital recognized in the literature. At the school level, information can be mainly provided by school and family. “Parents, and in particular mothers, acted as information brokers and environmental scanners, thereby establishing channels of information about the post-secondary system” (Andres, 1994). The author notices that the volume and quality of social capital provided “was contingent upon the level of cultural capital, in the form of educational qualifications, possessed by parents” (p. 124). However, the literature does not discuss whether school course choices and the production of school academic capital, as well as initial academic post-secondary choices made by children, reflect predominantly parental rather than students’ decisions. A study by De Broucker and Lavallee (1998) analyzed data from International Adult Literacy Survey for Canada conducted in 1994. The authors examined the role of inherited intellectual capital, represented by higher parental level of education and the socio-economic status of the father’s occupation, in the post-secondary educational attainment of respondents. Findings show that most respondents have as much or more education than their parents, but the probability of earning a diploma or degree is higher for young adults whose parents have a post-secondary education. In addition, fathers with higher socio-economic status were more likely to have children with high education. A similar result is obtained by Knighton (2002) who uses data from the Survey of Labour and Income Dynamics that followed a sample of Canadians aged 15 years and older from 1993
to 1998. In 1998, the findings based on a sample of 18 to 21 years old respondents, show that household income and parents’ education remain strong determinants of postsecondary participation and of the choice between college and university studies. As stated by Bourdieu’s theory, parental cultural capital is inherited by children and children’s cultural capital is converted into educational credentials – a major mechanism of social reproduction in advanced capitalist societies and a source of economic capital (Andres & Grayson, 2002).

2.6 Implications for Further Research

The specialized literature reveals that, even if fewer girls than boys seem to be interested in mathematics and science courses at the school level, a significant group of high achiever girls can be considered as candidates for post-secondary pathways in science (Walz & Bleuer, 1992). The roles of parental background, teacher encouragement or lack of it, school environment and course choices are presented in the literature as a multitude of factors that influence the educational pathways of students, especially girls. Yet, little research is done on the role of race and ethnicity in influencing students’ participation in science courses (Catsambis, 1995). Research further investigates various types of barriers that women encounter during undergraduate and graduate studies, or in workplaces (Erwin & Maurutto, 1998; Byrne, 1993; Etzkowitz et al., 2000). Structural and institutional factors, the culture of scientific community, and social barriers influence the persistence of women in science-related professions and their perception about how friendly these fields are. Some longitudinal studies (Katchadourian & Boli, 1985; Hanson, 1996; Tang, 1997; Brainard & Carlin, 2001) offer data describing the flow of young women (and men) along educational and/or career pathways.

Glover and Fielding (1999) distinguish between two schools of thought, “which differ according to where the ‘blame’ is located: with women and girls themselves or with science” (p. 59). The first category focuses on women’s capability to adjust to the field of science based on their cognitive abilities, interests, motivations, feelings and coping strategies. Some authors present women as victims of the leaking science pipeline, others see women as rejecting the scientific and technical pathways. The second research perspective “directs our attention towards the ‘male agenda’ of science” (p. 60) and
dissects its definition, content and methodology. Both research perspectives are relevant for addressing the multitude of issues raised by the topic, and both have had a great impact on alerting the community on the issue of women's under-representation in science and engineering. Yet, none of them has resolved the problem. A more pragmatic approach, developed from a policy perspective, should deal with the structures and culture of the scientific community (Glover, 2001), as well as with the social aspects that can create conditions to balance work and family duties for both young women and men.

The literature review has revealed a complexity of research themes and perspectives. The purpose and achievability of the current research is restricted to addressing the specific question: "What are the educational and career trajectories for women and men who excelled in science during the senior high school years?" This thesis will portray gender differences in educational and career patterns and will discuss them from structural and socio-educational perspectives. In this thesis, parental background, gender, and high school academic capital are main factors considered determinant for respondents' post-school status, academic program choices, educational attainment and career destinations. Further research needs to be conducted to address thoroughly the issue of institutional and societal causes that perpetuate gender differences in science.

As emphasized in the literature, each moment along a scientific career may influence the professional outcomes, while each moment may also be determined by a multitude of factors. Moreover, especially in "hard" sciences and engineering, there are critical points along a career path that may change it dramatically - an effect that appears to be more evident in the case of women than in that of men. More longitudinal research is needed for revealing the way various professional stages are connected and for developing realistic career path models. The general question generating this research: "Why are women less likely to succeed in science?" cannot be properly addressed by analysing achievements at isolated times. Moreover, at each particular stage, there is a need to analyse a complexity of multiple life aspects like education, work, family and society, in general (Hanson, 1996). Therefore, multidimensional longitudinal models would appropriately display women's experiences from both dynamic and causal perspectives.
CHAPTER III

Research Method

3.1 Research Purpose and Hypotheses

The research design is based on the assumption that high school preparedness (defined by the type and number of science courses taken for graduation) is a likely indicator of the abilities and interests of students in pursuing specific educational and career science-related pathways. Therefore, senior high school academic orientation will be taken as an initial point on respondents' career trajectories. The thesis analyses the extent to which students' post-secondary choices are consistent with their high school preparedness, and reflect career goals made during the high school stage and followed over the years. Science-related educational and career pathways are the focus of this study, but these pathways will be discussed in comparison with other career options chosen by respondents. Since science-related careers normally require university instruction, the study will often emphasize the university-based route.

The current empirical-based research study aims at identifying patterns of scientific career paths and relating these patterns to factors like gender and parental education. This is a secondary analysis research that uses existing survey data (Andres, 1988-1998). The database is complex, providing a large amount of information on several stages related to the educational and professional paths of survey participants.

Hypotheses

H1: The undergraduate paths in science-related programs present gender-dependent patterns specific to each high school profile (defined by school science preparedness).

H2: The persistence rate in science academic programs is different for male and female students.

H3: The academic specialization of young women and men show different patterns, even if respondents' high school profiles were similar.

H4: Women and men manifest different aspirations, expectations and satisfaction regarding their educational and work achievements. These patterns depend on their initial high school profile and academic specialization.
H5: Parental education plays a role in the academic orientation and educational attainment of both young women and men at the secondary and post-secondary educational stages.

3.2 Data Collection

The surveys have been developed as part of the *Path on Life’s Ways Project* (Andres, 1989-1998) - a project intending to offer a picture of educational, job and life accomplishments of the *Class of ’88* B. C: high school graduates. A first set of data provides information regarding the participation and achievement of students during the last two years of high school (Grade 11 and Grade 12). This data set, originally in a nested format, has already been converted by the author into a convenient SPSS format and it has been prepared for quantitative analysis.

A second set of data is provided by the first follow-up survey in 1989. The aim of the survey was to obtain information about the life paths of Grade 12 graduates one year after finishing high school. The purpose of this survey was to gather information regarding graduates’ transition period to post-secondary education or work, such as students’ attitudes and expectations regarding post-secondary education, factors influencing participants’ decision to continue their education, high-school evaluation and future plans. Students’ demographic and financial situation information is also provided by this survey.

A third set of data was obtained from a five-year-later follow-up survey conducted by Andres, in 1993. This survey provides longitudinal data regarding educational and/or work history, as well as participants’ attitudes, motivation factors and perceptions regarding post-secondary education and career attainment. Updated demographic information, including data about newly-formed families and household responsibilities is provided.

A fourth set of data was obtained from another follow-up survey conducted by Andres, in 1998. This survey contains detailed information on the updated post-secondary experience, on the work experience, as well as on participants’ plans concerning further formal or informal education. In addition, extensive data on family background and household, as well as on personal well-being and general life satisfaction are provided. For the purpose of this study, selected information extracted from these four data sets will be organized for statistical analysis in a unique SPSS file.
Sampling procedures

The 1988 data set describes a selective random sample of about 10,000 students, representing over 40% of the B. C. high school graduate population at that time. The sample was drawn from all 75 school districts in B.C. and is gender-balanced (51.7% female and 48.3% male). A probability sampling procedure based on randomization ensured the sample representativeness for the population.

The follow-up surveys were conducted by self-administered questionnaires mailed to the respondents of each previous survey. The mail-out questionnaire contained explanations regarding the purpose of the research, asking respondents for the permission to be included in further studies. The rates of response were good for all surveys (a detailed description will be provided during the statistical analysis stage). For instance, the 1989 survey had a response rate of about 53%, representing about 23% of the entire cohort of 1988 high school graduates in B. C. (Andres, 2001). As a result, the 1989 sample has 5,344 subjects, of which 56.6% are female and 43.4% are male.

In 1993, the mail-out questionnaire was sent to all respondents to the 1989 study and 2,233 (42%) replied. This number still represented about 9% of the population when reported to the entire cohort of 1988 B. C. graduates. The gender representation in the 1993 sample is 59.2% female and 40.8% male. By sending the 1998 mail-out questionnaire to the 1993 study respondents, a sample of 1,055 subjects was ensured (59.4% female and 40.6% male). The 1998 sample, which represents about 5% of the Class of '88 population, is representative.

Research Data

For the purpose of this thesis, respondents who have participated in all follow-up surveys were selected. This ensured the selection of a pool of students that have completed or are going to complete at least an undergraduate degree. The 1998 survey offers data regarding the educational and career pathways for a total of 1,055 respondents. Thus, the study used a systematic random sample affected by attrition.

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*In 1988, there were 75 school districts in British Columbia. After reorganization in 1998, this number was reduced to 60.*
3.3 Research Design

Variable sets

Variables correspond to survey questions that are relevant to the research topic and can be used to address the research questions. They are selected from all follow-up surveys and organized by the following themes:

a) **Demographic information** includes respondent's gender and parental education.

b) **Secondary education information** includes respondent's high-school academic orientation described by the type of secondary science preparation (number and type of courses, school and provincial exam grades).

c) **Post-secondary education information** includes type of program, degree of study, educational history, educational attainment, and aspirations and expectations for education assessed at various stages.

d) **Professional (career) orientation data** describes respondents' field of specialization educational and work satisfaction, planning for further education.

Reliability

Two aspects of reliability can be discussed: the reliability of the survey instrument and the internal consistency of respondent answers. Based on the discussion with the primary investigator, the author ensured follow-up surveys have been checked for complete and clear wording, as well as for consistent meaning, before finalising the questionnaire and mailing it out. Therefore, we can expect a desired reliability of the survey instrument.

Survey questions will be used independently, not as measures of construct scales. The selection of survey questions is based on the use of similar variables in the literature and on conceptual analysis. The internal consistency of various set of survey questions is beyond the scope and needs of this paper.

Validity

Good survey questions also need to be valid, as to measure exactly the concept for which they have been designed. For the follow-up surveys, most themes are addressed through a large number of questions that explore respondent attitudes or opinions, from
different perspectives. This type of questioning increases the content validity of the set of questions that would measure all important aspects of each concept. Since the purpose of this study is mainly descriptive and survey questions are used individually, content validity is applied to individual questions rather than to sets of questions.

Construct validity should be checked with precaution, since there is no firm theoretical agreement regarding the researched concepts. For instance, if a theory indicates the way a concept should relate to other measures, this information can serve as a criterion for checking the construct validity. However, if the theory is in making, the relationships among concepts are also under discussion and cannot be used for checking the validity of any of them. It is premature to discuss the issue of construct validity for this research study which is in its empirical stage.

Overview of analyses

The research design section includes a brief presentation of the analyses used to reach the goals of this study. Since current research objectives are mainly devoted to identify patterns that reflect differences in educational and career choices by gender, high school preparedness and socio-economic status, a research design incorporating descriptive and comparative analyses was utilized.

The descriptive analysis of the study aims at describing the distribution of the sample with respect to various categorical groups. Frequency or crosstabulation tables provide information about the distribution of students across undergraduate academic programs, the relation between high school profiles and gender or parental background, the effect of gender and high school profile on post-secondary choices, etc. Moreover, the descriptive approach also aids the author to gain further insight into the phenomenon, meant to help refining the research objectives.

Correspondence Analysis is a multivariate technique that summarizes the information in a two-way contingency table and provides a visual informative representation of data distribution. Several variables can be analysed simultaneously by combining sets of crosstabulations tables into a two-way table. Correspondence analysis is a useful correlational tool for analysing categorical data. It produces an intuitive picture of the two-way tables by creating sets of profile points displayed in a low-dimensional space.
Categories described by sets of points that are closely in space are similar, while points corresponding to dissimilar categories will be situated far apart. This method underlies relationships among variables and can serve as a basis for designing causal models (Greenacre & Blasius, 1994).

The method relies on geometry and mechanics concepts. The basic idea consists in creating row and column profiles as percentages that show the distribution of responses. Each profile is then assigned a weight (mass) proportional to the number of respondents in the corresponding row (or column). A chi-square distance based on the cell profiles (and weighed to assure that even less frequent responses contribute) measures the separation of two categories on the map. Since chi-square distances are calculated separately for row and columns profiles, only the relative position of points belonging to the same set of profiles can be compared. Average (marginal) profiles corresponding to each set lie in the common origin of the axes. If points that belong to different sets of profiles are closer, the corresponding cells in the two-way contingency table include more observations than expected on the basis of average profiles.

The chi-square distance between a row profile and the average profile multiplied with the profile mass will give its contribution to inertia – “a measure of the dispersion of the profiles in multidimensional space. The higher the inertia, the more spread out they are” (Greenacre & Blasius, 1994, p. 12). The two-dimensional map shows how similar various groups are and how they are distributed with respect to the two axes. The amount of the total inertia explained by each axis is obtained. Only eigenvalues that account for at least 5% of the total inertia are retained. Each axis (dimension) can be interpreted by identifying the points (profiles) aligned along that dimension. Correspondence analysis is also described as a technique for decomposing the total inertia (Clausen, 1998, p. 15).

The comparative analysis component of the study aims at identifying similarities and differences among groups by gender, family background, high school profile or academic specialization.
3.4 Research Objectives

In this section, I will present the plan for the data analysis. Objectives, data, variables, measures and statistical methods are described below.

Objective 1:

a) To obtain high school profile groups (non-science; mathematics; life sciences; physical sciences) based on the number and type of math and science courses taken in senior high school years
b) To obtain a measure of respondents' parental background based on parents' education.
c) To obtain a measure of post-secondary educational attainment, as well as a professional orientation (specialization academic field) classification based on current classification of undergraduate and graduate academic fields (Statistics Canada, 2001).

Methodology:
- Use conceptual analysis of measures and criteria for groups' classification.

Objective 2:

a) To obtain tables, charts and CA maps describing high school course choices by gender and student background
b) To obtain tables, charts and CA maps describing the distribution of respondents during undergraduate studies by gender, parental background, high school profile
c) To obtain tables, charts and CA maps relating respondents’ high school preparedness with their educational attainment and specific professional orientation ten years after high school graduation.

Methodology:
- Use descriptive statistics (Frequency, Crosstabs, Graphs)
- Use correspondence analysis.

Objective 3:

a) To perform group comparisons regarding achievements, educational aspirations and expectations, educational and work satisfaction, using gender, high school
preparedness, family background, academic specialization field as factors.

Methodology:
- Use inferential statistics (Parametric and Non-parametric tests).

3.5 Limitations and Delimitation of the Research Design

The limitations of the study are imposed by the nature of data sets. Since surveys were not designed specifically to study women's under-representation in science, some data will be used in an implicit manner in order to reach the research objectives. Therefore, survey responses will be re-organized for being used only in a relevant and reliable context.

Existing data are appropriate for identifying patterns along the educational and career pathways and for relating these patterns to factors like high school science preparedness, gender and family background. The existing dataset is used to explain the patterns observed along respondents' educational and career pathways, but there are no data that allow exploring the reasons of respondents' educational choices. In addition, the causes that may discourage women from entering and/or persisting in this field cannot be explored with existing data. Therefore, some questions will remain open for further research.

Since there are no available data at the elementary and early secondary levels, the study is also limited to the analysis of senior secondary and post-secondary education stages. It has also been acknowledged that the topic under discussion should be addressed through a multi-dimensional approach that requires a complex research design. Consequently, an empirical research can investigate only some aspects of the topic. Another limitation of the study may be related to the researcher’s cultural and discipline bias.

A delimitation of the study consists in emphasising only gender and parental background as differential factors in scientific practice. Parental background will be described by parental education only, even if data on parents' occupation is also available. This delimitation is based on preliminary results that showed the dominance of parental
education in determining educational outcomes for children (Adamuti-Trache, 2002b), as well as on specialized literature that uses similar indicators (Andres & Krahn, 1999).

I am aware that ethnicity and race could be other significant factors inducing a differential participation in the field of science, and that there is little research emphasizing these factors. Even if existing survey data contains information on ethnicity, this variable is not used in the current analysis because the majority of students identified themselves as Canadians.

The datasets contain detailed information regarding respondents' school preparedness. Since the topic of this study is related to choice and success in the fields of science and engineering, the sample was organized by criteria that emphasize a science-oriented academic capital built at the high school level. I selected high school mathematics and science courses that I consider relevant for an educational and career pathway in biological sciences, mathematical and physical sciences, and engineering. I am aware that the definitions of science vary by country or over time, but for the purpose of this thesis I mainly focus on disciplines traditionally related to life and natural sciences.

Even if the focus of the study is on career destinations based on mathematics and science background, respondents' post-secondary participation is followed in all academic fields. Since the science pipeline has many leakage points, it is relevant to find what alternative pathways are chosen by students who turn away from science-orientated destinations. Even when other groups will be used in the study for comparison, the analysis will remain focused on the group of respondents who are prepared for or enrolled in science and engineering educational pathways, and specific analysis will be provided for this group only.
CHAPTER IV

Findings: Patterns along the Science Pipeline

4.1 High School Participation and Achievement in Science

The current practice of the science community describes career pathways in science and engineering as focused, rigidly-timed and continuous (Zuckerman et al., 1991). Students tend to go straight from high school into undergraduate studies. Those who enter teaching or industry careers need to earn additional professional credentials. Those who plan a career in research or academia have to commit themselves to a long journey through graduate and postdoctoral phases. Since these typical paths through the science pipeline require university degrees, well-rounded high school preparedness with a strong emphasis on mathematics and science disciplines is recommended to support these career destinations, usually called the “high-school-calculus-through-PhD tracks”.

Grade 11 & Grade 12 Participation in Science

This section will analyze gender differences regarding the participation in Grade 11 and Grade 12 mathematics and science courses for the 1998 sample (N=1,055). Science courses include biology, chemistry and physics. Geology was a provincial examinable subject, not included in this study because it was taken by small number of students (~2%). In 1988, the only provincial examinable mathematics course was algebra. Table 1 accounts for gender differences in Grade 11 and Grade 12 math and science enrollments and for the non-continuance rates of math and science courses.

The same participation rate (89%) for female and male students is observed in Math 11, while enrollment in Chemistry 11 is slightly different by gender (61% of all girls vs. 72% of all boys). Meanwhile, there is a clear orientation of girls toward biology (Biology 11: 80% of all girls vs. 55% of all boys) and of boys toward physics (Physics 11: 42% of all girls vs. 69% of all boys), a fact that shows students’ gendered early on preference for specific science courses. Since overall the average number of science courses is 1.82 for girls and 1.96 for boys (only slightly higher), there is no apparent reason for concern regarding gender differences in participation at the Grade 11 level. However, the girls’ preference for biology
courses and boys’ preference for physics confirm other researchers’ findings.

The last two columns in Table 1 show the non-continuance rates of the four courses at the Grade 12 level. Rates of persistence in math and science courses show large gender differences. For instance, the non-continuance rate for Biology 12 courses is higher for boys (43%) than for girls (27%), while the non-continuance rate for Chemistry 12 courses is higher for girls (42%) than for boys (27%). This situation cannot be explained by students’ Grade 11 achievements, since average grades in these courses do not present almost any differences (Biology 11: average grade is 76% for girls vs. 75% for boys; Chemistry 11: average grade is 76% for both girls and boys). The reason for differentiated non-continuance rates should be sought in students’ academic preferences rather than students’ achievements.

### Table 1: Non-continuance Rate in Senior High School Math and Science Courses
(N = 1,055; Female = 622; Male = 433)

<table>
<thead>
<tr>
<th>Course</th>
<th>Grade 11 #studs (%)</th>
<th>Grade 12 #studs (%)</th>
<th>G11 school mark</th>
<th>Non-continuance (#students)</th>
<th>Non-continuance rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>551 (89%)</td>
<td>383 (89%)</td>
<td>73</td>
<td>171</td>
<td>31%</td>
</tr>
<tr>
<td>Biology</td>
<td>495 (80%)</td>
<td>238 (55%)</td>
<td>76</td>
<td>134</td>
<td>27%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>379 (61%)</td>
<td>311 (72%)</td>
<td>76</td>
<td>160</td>
<td>42%</td>
</tr>
<tr>
<td>Physics</td>
<td>261 (42%)</td>
<td>298 (69%)</td>
<td>75</td>
<td>197</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>379 (61%)</td>
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<td>76</td>
<td>160</td>
<td>42%</td>
</tr>
<tr>
<td>Chemistry</td>
<td>261 (42%)</td>
<td>298 (69%)</td>
<td>75</td>
<td>197</td>
<td>75%</td>
</tr>
<tr>
<td>Physics</td>
<td>559 (53%)</td>
<td>249 (24%)</td>
<td>75</td>
<td>310</td>
<td>55%</td>
</tr>
</tbody>
</table>

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A different situation occurs for the mathematics and physics courses. Although boys and girls have comparable performances in Math 11 (73% for girls vs. 75% for boys), 31% of girls did not continue to Math 12, as compared to only 18% of boys. Physics courses present an even more interesting case. Although girls and boys have same achievement in Physics 11 (75%), the non-continuance rate for girls is spectacular: 75% of girls who took Physics 11 did not continue with Physics 12, while 38% boys drop out of Physics in Grade 12. In addition, it is certainly relevant to notice that physics courses present the highest non-continuance rates of all courses for both boys and girls. For the research sample, enrollment rates in Grade 12 courses reflect also the participation in provincial exams (Table 1, second column). While male students participate quite evenly in all three sciences exams (31-53%), female students prefer to choose biology in a proportion of up to 58% to the detriment of physics, which receives about 10% participation. Since physics is the most mathematical of all sciences, girls’ avoidance of physics courses seems to be associated with their higher tendency to drop out of Mathematics 12. Even if this relationship is often mentioned in the literature, it cannot be accepted without a thorough analysis.

A comparative table showing participation and continuance in Grade 11 and Grade 12 mathematics and science courses is obtained for the large survey sample (N=9,998) that represents 40% of the B.C. Class of ’88. This table is presented in the Appendix A and it was discussed in other papers (Adamuti-Trache, 2002a). All participation and continuance rates are significantly lower for the large sample. By analysing the research sample (N=1,055), which includes the best high school science achievers, the findings obtained will correspond to the best scenario showing the participation and achievement along science-related educational pathways of the British Columbia Class of ’88.

High School Profiles and the Research Sample

For the purpose of this study, respondents are grouped by their participation in high school science and mathematics courses, as reflected in the type and number of courses taken for graduation. Based on upper secondary school courses, namely Grade 12 biology, chemistry, mathematics and physics, four high school profiles were developed. The rationale for this classification is that students take Grade 12 courses that reflect their future post-secondary plans (institution and program admission requirements), their interests and abilities
(grade requirements for high school graduation and post-secondary admission). The four high school profiles are: non-science, mathematics, life sciences and physical sciences. This classification was used by the author in several papers and presentations (Adamuti-Trache, 2001, 2002a, 2002b; Adamuti-Trache & Andres, 2002; Andres et al., 2002).

Students in the non-science profile (NS) group did not complete any Grade 12 mathematics and science courses, or in a few cases (1.3%), they completed one physics or chemistry course. Since these few respondents did not complete Grade 12 mathematics to ensure a solid foundation for the physical sciences, they were still included in the NS group. The mathematics profile (MA) group contains students who took mathematics but no science courses for graduation. The life sciences profile (LS) group contains students who took biology (with or without mathematics or chemistry), but no physics courses. Those in the physical sciences profile (PS) group have completed courses that include mathematics in combination with at least one of the chemistry or physics courses. Although the purpose of this study is to focus on the last two groups (LS and PS), comparisons with the NS and MA groups will be made at various stages. In addition, the analysis will include comparisons by gender and parental education within each group and for the whole sample.

Analyzing separately the life sciences and physical sciences groups is crucial for revealing the actual situation of under-representation of women in sciences. Since women's participation in life sciences disciplines has improved recently, measuring women's representation in all sciences gives the false impression that the issue under discussion is on its way to resolution. In reality, even if women started to be better represented in biological sciences and medicine, there is still a large numerical gender discrepancy in their representation in mathematical and physical sciences, as well as in engineering. This discrepancy, visible at the high school level when a large proportion of female students drop out of mathematics and hard sciences courses (Table 1), is deepened along the science pipeline.

Table 2 shows the distribution of students in the research sample (N=1,055) by their high school academic orientation (i.e., described by the four high school profiles) and their academic performance (i.e., assessed by the average final Grade 12 marks). The sample size is fairly large for most subgroups, except the Mathematics high school profile; for this subgroup findings will be interpreted with caution. The research sample contains a large
proportion of students with high school science preparedness. The physical sciences group, which includes students with the broadest science-oriented preparation, has the highest Grade 12 average final mark across all courses. About 38% of students in this group have final grades over 80% and 7% of students have final grades over 90%.

| Table 2: Description of Research Sample by Gender and High School Profile |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                | Academic Orientation | Academic Performance |
|                                | Nr of students (% in brackets) | Grade 12 average final mark |
|                                | Female | Male | Total | Female | Male | Total |
| Non-Science                    | 135    | 90   | 225   | 67     | 66   | 67    |
|                                | (22)   | (21) | (24)  |        |      |       |
| Mathematics                    | 62     | 28   | 90    | 72     | 68   | 71    |
|                                | (10)   | (7)  | (8)   |        |      |       |
| Life Sciences                  | 323    | 92   | 415   | 72     | 72   | 72    |
|                                | (52)   | (21) | (39)  |        |      |       |
| Physical Sciences              | 102    | 223  | 325   | 77     | 76   | 76    |
|                                | (16)   | (51) | (29)  |        |      |       |
| All                            | 622    | 433  | 1055  | 72     | 73   | 72    |

While Table 2 describes characteristics of the longitudinal research sample (N=1,055), Table 3 describes the initial random sample (N=9,998). The research sample preserves the main characteristics of the initial random sample, while higher achievers and more high-school-science-oriented respondents are included in the research sample.

| Table 3: Description of 1988 Sample by Gender and High School Profile |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                | Academic Orientation | Academic Performance |
|                                | Nr of students (% in brackets) | Grade 12 final average mark |
|                                | Female | Male | Total | Female | Male | Total |
| Non-Science                    | 1794   | 1571 | 3365  | 65     | 62   | 64    |
|                                | (35)   | (33) | (34)  |        |      |       |
| Mathematics                    | 429    | 462  | 891   | 70     | 65   | 67    |
|                                | (8)    | (10) | (9)   |        |      |       |
| Life Sciences                  | 2302   | 1185 | 3487  | 69     | 68   | 69    |
|                                | (45)   | (25) | (35)  |        |      |       |
| Physical Sciences              | 643    | 1612 | 2255  | 74     | 73   | 73    |
|                                | (12)   | (33) | (23)  |        |      |       |
| All                            | 5168   | 4830 | 9998  | 68     | 67   | 68    |

One can notice that a larger proportion of female and male respondents from the non-science group, as well as male from the life sciences group dropped out of study.
Relatively, the proportion of respondents in the physical sciences group (especially men) has increased. Overall, the research sample contains a large pool of high achievers and students with high-school-science-preparation, which would increase the credibility of study findings for the topic under discussion.

**High School Profiles and Family Background**

One of the assumptions of this study is that parental background is a factor that influences students’ high school course selection. There is documented evidence that parents’ education is a strong determinant of children’s post-secondary participation and of their orientation toward college or university education (Knighton, 2002). A British study also shows that cultural capital is passed from parents to children through language, cultural knowledge and participation in cultural activities, thus enabling students to succeed better in school (Sullivan, 2001). It is also documented that first-year medical students in Canada were more likely to have high socio-economic status and were less likely to come from rural areas (Dhalla et al., 2002). The authors have tested “the hypothesis that medical students often come from privileged socio-economic backgrounds” (p. 1029). The aim of this subsection is to explore whether parental background plays a role in respondents’ senior high school course choices.

In the literature, parental background construct is operationalized by various measures:

a) parents’ education and family income (Knighton, 2002)
b) parents’ education and occupation (De Broucker & Lavallee, 1998)
c) parental educational attainment (Andres & Krahn, 1999).

The survey contains variables describing the highest levels of education for both parents (i.e., secondary education or less, less than university and university). Based on these data, a two-category parental education variable that describes whether at least one parent has a university degree was created. Parents’ occupation can be used as a second measure of parental background. The survey contains data on the mother and father’s current occupations. Occupational categories are aggregated into three categories of low (unskilled workers), medium (skilled workers and administrative occupations) and high
(professional and managerial occupations) occupational prestige (Blishen & McRoberts, 1976). It was demonstrated in the literature that father occupation has a stronger influence on educational qualifications of children (De Broucker & Lavallee, 1998).

Initially in this study, I constructed the parental background variable based on a measure of father's occupation status combined with a measure of parental education. Since preliminary analyses (Adamuti-Trache, 2002b) showed that father’s occupation is less influential on respondents’ educational outcomes, in this thesis I used only the parental education variable. Other studies also expect “parents’ education, in the form of cultural capital to play a direct role in determining their children’s educational choices” (Andres & Krahn, 1999, p. 59) and use only parental educational attainment to describe students’ family background. To perform correspondence analysis maps, I combined respondents’ parental education and gender, or parental education, gender and high school profiles to define group characteristics corresponding to factors expected to influence respondents’ educational outcomes.

Table 4: Sample Distribution by Gender and Parental Education

<table>
<thead>
<tr>
<th>a. Gender and parental education categories</th>
<th>b. High school profile, gender and parental education categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fem_nonuniv 395 40%</td>
<td>NS_fem_nonuniv 94 10%</td>
</tr>
<tr>
<td>Fem_univ 185 19%</td>
<td>NS_fem_univ 28 3%</td>
</tr>
<tr>
<td>Male_nonuniv 267 27%</td>
<td>NS_male_nonuniv 65 7%</td>
</tr>
<tr>
<td>Male_univ 141 14%</td>
<td>NS_male_univ 17 2%</td>
</tr>
<tr>
<td></td>
<td>MA_fem_nonuniv 43 4%</td>
</tr>
<tr>
<td>TOTAL 988 100%</td>
<td>MA_fem_univ 17 2%</td>
</tr>
<tr>
<td></td>
<td>MA_male_nonuniv 19 2%</td>
</tr>
<tr>
<td></td>
<td>MA_male_univ 9 1%</td>
</tr>
<tr>
<td></td>
<td>LS_fem_nonuniv 197 20%</td>
</tr>
<tr>
<td></td>
<td>LS_fem_univ 103 10%</td>
</tr>
<tr>
<td></td>
<td>LS_male_nonuniv 51 5%</td>
</tr>
<tr>
<td></td>
<td>LS_male_univ 30 3%</td>
</tr>
<tr>
<td></td>
<td>PS_fem_nonuniv 61 6%</td>
</tr>
<tr>
<td></td>
<td>PS_fem_univ 37 4%</td>
</tr>
<tr>
<td></td>
<td>PS_male_nonuniv 132 13%</td>
</tr>
<tr>
<td></td>
<td>PS_male_univ 85 9%</td>
</tr>
<tr>
<td>TOTAL 988 100%</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 shows the distribution of respondents (counts and valid percentages) in each group. Table notations will be used in all correspondence analysis maps that deal with
parental background (more details on abbreviations are given in the Appendix B). The available sample size is slightly reduced (N=988) since not all respondents gave information regarding the education of their parents. The smallest group sizes are male in the Mathematics high school profile group with university educated parents. There is no restriction in the use of Correspondence Analysis method by group size, but findings should be interpreted with some caution for small groups.

To answer the question “Is there any relationship between parental education and students’ course choices in senior high school year?” I ran correspondence analysis (CA) tests and obtained the map shown in Figure 3. The CA test is based on the use of crosstabulation tables obtained for the four high school profiles across the four-category groups describing respondents’ background (i.e., gender and parental education) (Table 4a). Basically, two maps of the four high school profiles and the four background profiles are created and next overlapped showing how various groups associate. The closer two points of same type, either high school profiles or background profiles, the more similar corresponding groups are with respect to their relation with profiles in the other set of points. For instance, the group of boys with parents having university degrees appears to be highly associated to the physical sciences (PS) profile point, being more similar in this respect to the group of boys with parents without university degrees than to the group of girls with educated parents.

The distribution of points around the centroid (origin of axes) will produce an average total inertia. The larger the inertia, the more spread the points are in the two dimensional space. Correspondence analysis tests produce two main eigenvalues of the inertia matrix associated to the horizontal and the vertical axes on the map and the amount of variance of the total inertia explained by the distribution of points. Each dimension is interpreted by studying the distribution of points along that dimension.

The correspondence analysis map shown in Figure 3 can be interpreted as follows:

a) Science high school profiles (PS and LS) are highly associated with groups of respondents with university-educated parents, while MA and NS high school profiles to
respondents from families where neither parent attended university. Parental educational attainment has an impact on the number of science courses students take for graduation, suggesting that there is a clear orientation of university-educated parents toward increasing the science preparation of their children. While boys are more attracted toward Physical Sciences, girls are attracted toward Life Sciences high school profiles.

b) The Non-Science preparedness is mostly related to male and female students from families where neither parent attended university. Mathematics preparation (i.e., typical route toward business and commerce) is relatively high related to the groups of female students, especially from families with no university education.

c) The correspondence analysis map used to model the above profiles is described in a two dimensional space. The first larger eigenvalue $\lambda_1 = 0.172679$ corresponds to the horizontal axis that can be identified as a gender dimension, since gender categories are perfectly separated horizontally. The proportion of average total inertia (profiles distribution) that is explained by gender is very high, 91.61%, which shows the students' gender play the most significant role in explaining the pattern of points.

d) The vertical axis on the map can be identified as a parental education dimension, but the separation of categories is more dispersed (eigenvalue $\lambda_2 = 0.014005$) and this dimension can explain only 8.28% of the total inertia. Along the vertical axis one can also notice a separation of the science-oriented high school profiles on the bottom of the map.

In summary, there is a relationship among high school profiles (course selection), gender and parental education. University-educated parents tend to guide their children toward high school science preparation. Overall, female students are more oriented toward life sciences, while male students toward physical sciences.

4.2 One Year after High School Graduation

Postsecondary Participation

The 1998 survey contains valuable information regarding the year by year institutions and academic programs chosen by all students enrolled in post-secondary institutions between 1988 and 1998. Students’ participation in post-secondary education follows a large variety of patterns that depend on their high school preparedness, gender and parental background.
Figure 4: Post-secondary participation by high school profile
One year after high school graduation

Non-science high school profile

Life sciences high school profile

Mathematics high school profile

Physical sciences high school profile
One year after high school graduation, post-secondary enrollment manifests strong differences by high school profiles and shows some gender differences for the NS and MA groups only (Figure 4). Thus, a net university orientation is manifested by the PS group (55-58%) without significant gender differences. The LS group went to university immediately after high school in a proportion of 33-35%, while the NS group only in a proportion of about 14%. In the case of the MA group, there is a large difference in the enrollment rate for women (~53%) vs. men (~32%). While a large proportion of the PS students went directly to university, the MA and LS students tended to go to community colleges or university colleges, perhaps before attending university (except the MA female students enrolled in university programs preferentially). In the case of the NS group, the non-university participation is gender differentiated, about 56% of women and 35% of men being enrolled in non-university programs. Meanwhile, many NS male (58%) and female (35%) students did not participate in any post-secondary education in the first year after high school graduation. The non-participation rates were only 20% for the LS and MA groups and 15% for the PS group.

High school curricular differentiation appears to be strongly related to students’ decisions to continue post-secondary education. A large proportion of high school students who went on to post-secondary instruction immediately after school graduation were selected from the category of students who took science and mathematics courses in the senior years. The stronger the math and science preparation (as in the case of physical sciences group), the greater was the participation in post-secondary education, especially at the university level.

Correspondence analysis methodology is used to study the combined effect of high school preparedness, gender and parental education on the post-school status of respondents one year after high school graduation. The post-school status is described by the following three profiles: no postsecondary attendance (non-attendant), enrollment in institutions other than university (non-university participant) and university enrollment (university participant). The correspondence analysis map in Figure 5 plots the above three categories and the sixteen different groups that describe respondents’ background and high school profile (Table 4b).
Figure 5: Respondents' post-school status regarding Post-secondary participation
One year after high school graduation

Post School Status by HS profile, Gender and Parental Education

\[ \lambda_1 = 0.174947 \ (81.96\%) \]
\[ \lambda_2 = 0.036938 \ (18.04\%) \]
Is there any relationship between respondents’ post-school status and gender combined with parental background? The following findings are the most significant:

a) The profile of university participants is highly associated to groups of respondents with high school science preparedness. All profiles corresponding to physical sciences groups, independent of gender and parental education, are closely to the University profile. Similarly, some life sciences and mathematics groups that correspond to respondents with university-educated parents tend to be oriented toward the University profile.

b) The non-university participants’ profile is highly associated to all life sciences groups, independent of gender and parental education, and some non-science and mathematics groups. A relatively high association to the non-university participants profile is shown by the group of female within non-science high school profiles and from families with no university education.

c) The non-participants profile is highly associated to the groups of male respondents in the non-science high school profile.

d) The correspondence analysis map that models the above profiles is described in a two dimensional space. The first largest eigenvalue $\lambda_1 = 0.174947$ corresponds to the horizontal axis which could be described as a high school science preparedness dimension, with the more science oriented groups on the right of the map. Most groups of respondents from highly educated families are also situated on the right side of the map. The proportion of total inertia (profiles distribution) that is explained by the horizontal dimension is 81.96%.

e) The vertical axis on the map can be identified as a gender dimension, with female groups at the top of the map and male groups at the bottom of the map. The vertical dimension explains 18.04% of the total inertia (eigenvalue $\lambda_2 = 0.036938$). Some profiles do not fit well the direction of the vertical axis: female groups with university-educated parents and mathematics or physical sciences preparation are more similar to most male groups, while male groups from the life sciences or mathematics high school profiles are more similar to most female respondents groups.

In summary, there is a relationship among respondents’ post school status one year after graduation, and gender, parental education and high school profile. Female and male respondents with high school science preparedness, especially those with university-educated parents, tend to go directly to university.
Academic Program Choices

One year after high school graduation, about 80% of women and 78% of men were enrolled in post-secondary institutions. In order to assess whether there is consistency in choices between secondary and post-secondary educational levels, for respondents enrolled in post-secondary institutions, academic orientation was correlated to their high school preparedness. Had students planned beforehand, post-secondary educational choices would be more consistent with high school academic orientation (Adamuti-Trache, 2002a).

Respondents indicated a variety of academic programs, taken at various post-secondary institutions, that can be grouped into eleven categories, based on the classification of university and community college academic fields used in the report *Education in Canada, 2000* (Statistics Canada, 2001), namely: Agriculture and Biological Sciences; Education; Engineering and Applied Science; Health; Humanities; Mathematics and Physical Sciences; Business, Management, Commerce and Law; Social Sciences; General Studies; General Science; Vocational. Some students make specific choices for science disciplines from the first year of post-secondary education, but a large number of students take general science courses only. The General Science classification was introduced specifically for this study to include this general science orientation.

Tables 5a and 5b show the distribution of choices across academic programs by high school profiles for young women and men. The relationship between first year academic program choices and the high school profiles is mostly due to specific distributions of high school groups over post-secondary academic fields, without reflecting a consistent association of the program type at the two educational levels. Actually, a large proportion of students (40% of all respondents enrolled in post-secondary institutions) start with General academic programs, and about 66% of these programs are taken outside university. The large enrollment in General Studies and General Sciences courses demonstrates that more than one third of post-secondary participants did not have clear academic orientation plans at high school graduation, or needed to upgrade their marks.

Tables 5a and 5b also show that high-school-profile and gender differences are combined to produce specific patterns of academic program choices. The NS group shows a large preference (over 10%) for Business, General Studies and Humanities (female) and for General Studies and Humanities (male). The MA group shows a large preference (over 10%)

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for Humanities, General Studies and Business (female and male). Very few respondents enrolled in Mathematics and Physical Sciences programs. Meanwhile, both women and men within the LS group show a large preference (over 10%) for Humanities, Business, General Studies and General Science. The female PS group manifests a similar pattern, while the male PS group shows a large preference (over 10%) for Engineering, Mathematics and Physical Sciences, Business, General Studies and General Science. Overall, both women and men preferred (over 10% participation rate) academic programs like Humanities, Business and General Studies. Less than 2% of women choose Engineering, as well as Mathematical and Physical Sciences, while less than 2% of men go into Health and Education academic programs.

**Table 5a: 1988-1989 Academic Program Choices for Post-secondary Female Participants**

<table>
<thead>
<tr>
<th>Academic Fields</th>
<th>Non-science</th>
<th>Mathematics</th>
<th>Life Sciences</th>
<th>Phys Sciences</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture &amp; Biological Sciences</td>
<td>11 (3%)</td>
<td>6 (6%)</td>
<td>6 (3%)</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Education</td>
<td>3 (2%)</td>
<td>3 (5%)</td>
<td>15 (5%)</td>
<td>5 (5%)</td>
<td>26</td>
</tr>
<tr>
<td>Engineering &amp; Applied Sciences</td>
<td>4 (4%)</td>
<td>4 (1%)</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Health</td>
<td>19 (6%)</td>
<td>3 (3%)</td>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Humanities</td>
<td>23 (17%)</td>
<td>15 (24%)</td>
<td>50 (16%)</td>
<td>15 (15%)</td>
<td>103</td>
</tr>
<tr>
<td>Mathematics &amp; Physical Sciences</td>
<td>2 (2%)</td>
<td>1 (2%)</td>
<td>3 (1%)</td>
<td>5 (5%)</td>
<td>11</td>
</tr>
<tr>
<td>Business &amp; Law &amp; Commerce</td>
<td>28 (21%)</td>
<td>10 (16%)</td>
<td>35 (11%)</td>
<td>11 (11%)</td>
<td>84</td>
</tr>
<tr>
<td>Behavioural &amp; Social Sciences</td>
<td>6 (4%)</td>
<td>7 (11%)</td>
<td>16 (5%)</td>
<td>4 (4%)</td>
<td>33</td>
</tr>
<tr>
<td>General Studies</td>
<td>18 (13%)</td>
<td>14 (23%)</td>
<td>81 (25%)</td>
<td>22 (22%)</td>
<td>135</td>
</tr>
<tr>
<td>General Science</td>
<td>2 (2%)</td>
<td>29 (9%)</td>
<td>15 (15%)</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Vocational</td>
<td>3 (2%)</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>85</strong></td>
<td><strong>50</strong></td>
<td><strong>259</strong></td>
<td><strong>90</strong></td>
<td><strong>484</strong></td>
</tr>
</tbody>
</table>
Table 5b: 1988-1989 Academic Program Choices for Post-secondary Male Participants

<table>
<thead>
<tr>
<th>Academic Fields</th>
<th>High school profiles</th>
<th>Non-science</th>
<th>Mathematics</th>
<th>Life Sciences</th>
<th>Phys Sciences</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural &amp; Biological Sciences</td>
<td></td>
<td>1 (1%)</td>
<td>5 (5%)</td>
<td>6 (3%)</td>
<td>12 (3%)</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td>2 (2%)</td>
<td>3 (1%)</td>
<td>5 (1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering &amp; Applied Sciences</td>
<td></td>
<td>1 (4%)</td>
<td>2 (2%)</td>
<td>31 (14%)</td>
<td>34 (8%)</td>
<td></td>
</tr>
<tr>
<td>Health</td>
<td></td>
<td>2 (1%)</td>
<td>2 (1%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humanities</td>
<td></td>
<td>9 (10%)</td>
<td>5 (18%)</td>
<td>11 (12%)</td>
<td>21 (9%)</td>
<td>46 (11%)</td>
</tr>
<tr>
<td>Mathematics &amp; Physical Sciences</td>
<td></td>
<td>2 (2%)</td>
<td>2 (7%)</td>
<td>6 (7%)</td>
<td>25 (11%)</td>
<td>35 (8%)</td>
</tr>
<tr>
<td>Business &amp; Law &amp; Commerce</td>
<td></td>
<td>4 (4%)</td>
<td>3 (11%)</td>
<td>11 (12%)</td>
<td>23 (10%)</td>
<td>41 (10%)</td>
</tr>
<tr>
<td>Behavioural &amp; Social Sciences</td>
<td></td>
<td>1 (1%)</td>
<td>1 (4%)</td>
<td>2 (2%)</td>
<td>6 (3%)</td>
<td>10 (2%)</td>
</tr>
<tr>
<td>General Studies</td>
<td></td>
<td>12 (13%)</td>
<td>6 (21%)</td>
<td>16 (17%)</td>
<td>24 (11%)</td>
<td>58 (13%)</td>
</tr>
<tr>
<td>General Science</td>
<td></td>
<td>1 (4%)</td>
<td>15 (16%)</td>
<td>49 (22%)</td>
<td>65 (15%)</td>
<td></td>
</tr>
<tr>
<td>Vocational</td>
<td></td>
<td>7 (8%)</td>
<td>1 (4%)</td>
<td>3 (3%)</td>
<td>4 (2%)</td>
<td>15 (4%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>36</td>
<td>20</td>
<td>73</td>
<td>194</td>
<td>323</td>
</tr>
</tbody>
</table>

Even in the case of LS and PS groups, enrollments are low in science-oriented programs like Agriculture and Biological Sciences, and Mathematics and Physical Sciences immediately after high school graduation. Perhaps some students initially enrolled in General Studies or General Science programs will turn toward these scientific fields later, but at the beginning of post-secondary studies the scientific pathways are either not available for or not preferred by a large number of students. Even so, male students appear to be better oriented toward science: about 5% of LS male students and only 3% of LS female students choose Agriculture and Biological Sciences (although it is the case that another 6% of LS female students choose to start with a Health academic program). In the case of the PS group, 11% of male and only 5% of female students chose Mathematics and
Physical Sciences in the first year of post-secondary education. Even General Science programs are more preferred by the male than the female students with high school science preparedness. About 16% male compared to 9% female students from the LS group and 22% male compared to 15% female students from the PS group choose General Science programs.

The above findings show that even high school students with strong mathematics and science backgrounds do not necessarily go into science-related academic programs after school graduation. However, students in these categories have a broader range of post-secondary choices, both in terms of institutions and in terms of programs (e.g., the physical sciences group covers the broader choice of academic programs), than students without mathematics and science backgrounds. The above findings suggest that school course selection is mainly dictated by general post-secondary institutional requirements, combined with the strategy of “keeping open” students’ academic choices – a strategy promoted by parents and school counsellors, and adopted by students. During the first year of post-secondary instruction at least, the choices of specific academic programs do not appear to continue a career planning process started in high school. The findings of this study support other research data showing low persistence rates of undergraduate women in physical sciences (Astin & Sax, 1996).

**Parental Background Influence**

In a previous section, it was shown that parents play a significant role in students’ high school course choices in Grade 12. Parents with higher education would perhaps advise and support their children to take more science courses in order to keep more choices open. One can hypothesize that this conservative attitude would extend at least during the first year after high school graduation when students may not yet be decided about what educational path to choose and may still be financially and emotionally dependent on their parents.

To find out if there is any relationship between academic program choices and respondents’ gender and parental background, I use the correspondence analysis methodology. The academic programs are aggregated into a small number of wide domains:

a) humanities include all arts, languages, history, philosophy, psychology, education,
sociology programs
b) general academics include general studies, university transfer, arts and science programs
c) general science includes science programs with no specified field
d) science & engineering programs for which the field is specified (e.g., physics, biology, chemical engineering, etc)
e) other includes various business, health, technical and vocational programs (e.g., business administration, commerce, accounting, nursing, medical lab technology, etc).

The correspondence analysis map in Figure 6 shows how the above five profiles and the four groups defined by gender and parental background are relatively distributed. The relationship between the academic programs profiles and the gender and parental background categories is described by the following:
a) There is a clear separation of the General Science and Science & Engineering programs on the right side of the map, and male groups are relatively highly associated to these programs.
b) The non-science academic programs (i.e., Humanities, General Studies and Other) are situated on the left side of the map and female groups are relatively highly associated to these programs.
c) The correspondence analysis map used to model the above profiles is described in a two dimensional space. The first largest eigenvalue $\lambda_1 = 0.125392$ corresponds to the horizontal axis that can be identified as a gender dimension. The proportion of total inertia (profiles distribution) that is explained by gender is 82.51%. There is also a net separation along the horizontal dimension of non-science and science oriented academic programs.
d) The vertical axis on the map can be identified as a parental education dimension that explains 16.12% of the total inertia (eigenvalue $\lambda_2 = 0.024086$). Female respondents with highly educated parents are more likely to go into Humanities, while female respondents from families where no parent attended university are more likely to go into General Studies and Other academic programs. The group of male respondents with university-educated parents tends to be oriented towards science-related programs, while the orientation of men from less educated families is somehow ambiguous.
Figure 6: Academic programs chosen by Post-secondary participants
One year after high school graduation

Post Secondary Programs by Gender and Parental Education

\[ \lambda_1 = 0.125392 \text{ (82.51\%)} \]
\[ \lambda_2 = 0.024086 \text{ (16.12\%)} \]
4.3 Ten Years after High School Graduation

Educational Attainment by Gender and High School Preparedness

Post-secondary educational attainment describes whether respondents in the study ever enrolled in, attended and completed various forms of post-secondary instruction. Respondents are classified into four profiles: students who never enrolled in post-secondary instruction up to and including 1998; students who enrolled in various post-secondary institutions (university or non-university) but did not earn any credential; students who attended colleges, university colleges and institutes, and earned non-university credentials; students who attended and completed university programs, earning university degrees (Adamuti-Trache, 2002a). Some respondents in the latter group have also completed non-university credentials.

Table 6 presents educational attainment ten years after high school graduation for all respondents. Only 6% of all respondents never attended post-secondary institutions. Another 12% of all respondents attended, but did not complete a post-secondary credential, and the proportion of men in this category is higher than the proportion of women. About 28% of all respondents have completed only non-university studies (i.e., at colleges, university colleges and institutes), with a larger proportion of women than men in this category. Finally, about 54% of all respondents in the study have completed university instruction, with a slightly larger proportion of women in this category.

<table>
<thead>
<tr>
<th>Educational status</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No attendance of post-secondary institutions</td>
<td>37 (6%)</td>
<td>29 (7%)</td>
<td>66 (6%)</td>
</tr>
<tr>
<td>Post-secondary attendance &amp; no completed studies</td>
<td>62 (10%)</td>
<td>64 (15%)</td>
<td>126 (12%)</td>
</tr>
<tr>
<td>Completed only non-university studies &amp; obtained Credentials</td>
<td>191 (31%)</td>
<td>107 (25%)</td>
<td>297 (28%)</td>
</tr>
<tr>
<td>Completed university studies &amp; obtained university degrees</td>
<td>332 (53%)</td>
<td>233 (54%)</td>
<td>565 (54%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>622 (100%)</td>
<td>433 (100%)</td>
<td>1055 (100%)</td>
</tr>
</tbody>
</table>

Even if educational attainment patterns are quite similar for young men and women, different patterns are observed for the four high school profiles that differentiate respondents

65
by their high school preparedness (Figure 7). Both men and women in the NS group obtained the largest proportion of non-university credentials (43% for women and 34% for men) and the lowest proportion of university degrees (30% for women and 27% for men). By 1998, 27% of women and 39% of men in the NS group did not attend or did not complete their post-secondary studies.

The MA group’s educational attainment is less homogeneous by gender. A large proportion of women (about 73%) obtained university degrees, while only 36% of men completed university studies. In compensation, a larger proportion of men (39%) than women (15%) obtained only non-university credentials. Less than 7% of men and 5% of women never attended post-secondary institutions, while 18% of men and 8% of women did not yet complete their post-secondary studies.

For the LS group, a lower proportion of women (54%) compared to men (62%) obtained university degrees, and comparable proportions of women and men did not attend any post-secondary institution (4% of women and 2% of men). A larger proportion of women (33%) compared to men (22%) obtained only non-university degrees, and about 8% of women and 14% of men did not finish their post-secondary studies before 1998.

Ten years after graduation, the PS group obtained a high level of educational attainment for both men and women. Over 64% of men and 70% of women obtained university degrees, while less than 3% never attended post-secondary institutions. About 20% of men and 16% of women obtained only non-university degrees, while 12% of women and 13% of men did not complete their post-secondary credentials.

Overall, about 84% of all women and 78% of all men in the study obtained university or non-university credentials by 1998. Ten years after high school graduation, respondents’ educational attainment shows a large orientation toward university instruction for both men and women who opted for math and science courses during senior high school years. For all three math-and-science groups (MA, LS and PS), university attainment rates are higher than non-university attainment rates, and also higher than the rates of non-participation or non-completion. By contrast, both women and men in the NS group obtained their highest rates of educational attainment in non-university credentials; men in the NS group have also completed the lowest proportion of university degrees by 1998.
Figure 7: Educational attainment of respondents by high school profile and gender
Ten years after high school graduation
Role of Parental Background

Educational attainment of respondents is analysed with correspondence analysis methodology to assess the combined role of gender, family background and high school preparedness. Postsecondary educational attainment is described by the four profiles used in the previous section (more details about map abbreviations are given in Appendix B). The correspondence analysis map in Figure 8 shows the distribution of the above profiles and the sixteen groups defined by high school preparedness, gender and parental background.

Is there any relationship between respondents’ post-secondary completion status and school preparedness combined with gender and parental education? The following findings are the most significant:

a) The groups associated to the university graduates profile proceed mostly from respondents who completed science courses in high schools, especially physical sciences, and/or respondents with university-educated parents, for both men and women.

b) The holders of non-university credentials are mainly female or male respondents from families where no parent attended university.

c) The profile of respondents who did not attend any postsecondary institution is highly associated to male respondents from the non-science high school profile and with parents who did not attend university.

d) The non-completers profile is highly associated to groups of respondents, especially men, with parents having less than university education.

e) The correspondence analysis map that models the above profiles is described in a two dimensional space. The first largest eigenvalue $\lambda_1 = 0.168781$ corresponds to the horizontal axis that can be identified as a parental education dimension, with the university education mainly on the left on the map. Groups of respondents with science-oriented high school preparedness tend to be oriented toward same direction. The proportion of total inertia (profiles distribution) that is explained by the horizontal dimension is 83.98%.

f) The vertical axis on the map can be identified as a gender dimension and explains 10.69% of the total inertia (eigenvalue $\lambda_2 = 0.025868$).
Figure 8: Educational attainment by gender and parental education
Ten years after high school graduation

Educational Attainment

$\lambda_1 = 0.168781 (83.98\%)$

$\lambda_2 = 0.025868 (10.69\%)$
4.4 Chapter Summary

In summary, there is a relationship among high school profiles (course selection), gender and parental education. Overall, female students are more oriented toward life sciences, while male students toward physical sciences. Students with university-educated parents tend to take more science courses in high school.

One year after school graduation, respondents' post school status is strongly related to gender, parental education and high school profile. Female and male respondents with high school science preparedness and/or university-educated parents, tend to go directly to the university. Overall, male post-secondary participants show a preference for enrolling in science-oriented academic programs, while female post-secondary participants enroll preferentially in non-science academic programs.

In addition, high school preparedness, gender and parental education still play a significant role in the educational attainment of respondents ten years after high school graduation. Apparently, the influence of parents with university education, started at the high school level, is also extended over the post-secondary years.
CHAPTER V
Findings: University Graduates Outcomes

5.1 Ten Years after High School Graduation

Since science-related careers in academia, industry and education require university degrees, this study had to emphasize the university route specifically. This chapter presents findings describing only educational and career pathways of university graduates, looking at their specialization fields and the way earned credentials could turn into occupations in science, engineering and science education. In most cases, these career paths require more than undergraduate education, so the human potential expected to go into these fields need to follow a variety of post-secondary phases and to acquire a combination of professional and graduate credentials. These career pathways are built with substantial personal and societal investment, so it is desirable that, at the end of the journey, individuals are happy with their choices, while professional areas succeed to recruit and retain the most talented available human capital.

Specialization Fields of University Graduates

A total of 565 respondents in the study (54% of the research sample, N=1,055) completed at least one university program between 1988 and 1998, and obtained a university degree at the Bachelor’s level. Many respondents also completed graduate studies (mostly after 1993), as well as university professional degrees (e.g., teaching or language certificates) or various non-university credentials. In 1998, about 23% of university graduates were still enrolled in post-secondary studies for completing additional degrees.

Due to the complex educational pathways of respondents, determining the specialization field of university graduates was not an easy task. Students reported the first and second academic programs in which they participated year by year. Their choices combine arts and science, business and engineering, science and health, as well as academic and vocational destinations. Data do not permit to assess the reasons why students make this amalgam of choices. It is definitely possible that, in many cases, the complex post-secondary academic pathways would reflect the variety of educational options offered by Canadian post-secondary institutions (i.e., double majors, degree and non-degree programs, co-op programs). In addition, more and more Canadian post-secondary institutions offer programs
that allow learners to combine school with work, and thus, students have good opportunity to explore a broad range of career destinations.

The fields of specialization were assessed based on the dominant academic programs attended by students over the years and the type of the degree acquired. For instance:

- the Sciences group (Agricultural & Biological Sciences and Mathematical & Physical Sciences) includes graduates holding Bachelor’s degrees in Science with or without further graduate degrees
- the Education group includes graduates holding Bachelor’s degrees in Education, or a combination of teaching certificates with Bachelor’s degrees in Arts or Science
- the Engineering group includes graduates holding Bachelor’s degrees in Engineering or Applied Sciences
- the Health group includes graduates with Bachelor’s degrees in Nursing or other medical degrees based on undergraduate science degrees
- the Humanities group includes graduates holding Bachelor’s degrees in Arts
- the Business group includes graduates with degrees in Law, Commerce or Business
- the Behavioural & Social Sciences groups includes graduates with Bachelor’s degrees in Arts or Science in appropriate fields (e.g., Psychology, Social Work, Sociology, Anthropology).

In Figure 9, the distribution of university graduates over the above professional destinations is presented by gender and high school profiles. Since data are accumulated from the 1993 and 1998 surveys, and many respondents completed more than one university degree, the most recent or the highest degree (e.g., graduate degree) received up to and including 1998 was considered. In some cases, university degrees in a specific field were continued with professional degrees (e.g., teaching certificates) that suggest the area in which respondents would intend to use their credentials.

In terms of academic specializations, the NS and MA high school profile groups present some similarity, respondents holding university degrees in the field of Humanities, Other academic areas and in Education. For these profiles, degrees in Science, Health or
Figure 9: Fields of study of university graduates by gender and high school profile

Ten years after high school graduation

Non-Science high school profile

Life Sciences high school profile

Mathematics high school profile

Physical Sciences high school profile
Engineering fields are minimal. In contrast, the LS and PS groups cover a broad range of fields. In fact, the PS group is represented in all areas, and the PS female students group is the most uniformly distribution over fields.

Overall, female university graduates populate the fields of Education (25%), Humanities (18%), Business (18%), Health (17%), Social Sciences (10%) and Biological Sciences (8%). Small proportions (2%) of the total number of women in this research sample went into the Engineering and Physical Science fields. Meanwhile, male university graduates went into fields like Business (24%), Engineering (18%), Humanities (14%), Physical Sciences (13%), Health (12%), Education (8%), Biological Sciences (6%) and Social Sciences (5%).

Male university graduates are concentrated in larger proportions in fields related to their high school orientation. Thus, the LS group feeds preferentially (about one third) the Biological Sciences and Health fields; about 44% of the PS group goes into Engineering and Physical Sciences. The NS and MA groups are oriented toward Business and Humanities. The LS and PS groups feed Education and Social Sciences fields. In the case of female university graduates, the relationship between high school orientation and university specialization is less obvious.

Women cover in large and uniform proportions the Education, Business and Social Sciences fields, independent of their high school orientation. Differentiations are more distinct in the case of Biological Sciences and Health fields, preferred by the LS and PS groups, and Humanities, preferred by the NS and MA groups. The above discussion suggests that men are more likely than women to keep their initial professional orientation and to persist in fields in which they have accumulated knowledge and skills.

The above figures give the proportions of respondents that hold at least one Bachelor’s degree in a certain field, by 1998. The field corresponding to the most recent acquired bachelor degree or a graduate degree was assigned to each university graduate. The above proportions for the Class of ’88 research sample are compared (Table 7) with data regarding the Bachelor's degrees acquired by the entire B.C. population in 1998 (Statistics Canada, 2001).

The sample is quite similar with the B.C. population in the field of Biological Sciences and Humanities (including Fine Arts) for both men and women. In the fields of
Business and Social Sciences, the sample is depleted (a total of about 28% vs. 38% in B.C.), while it is over-populated in Health (12% of men and 17% of women, as compared to 5% men and 9% women in B.C.). However, there is a larger proportion of women than men in Education (8% of men and 25% of women, as compared to 11% of men and 19% of women in B.C.); there is a larger proportion of men in Engineering (18% of men and 2% of women, as compared to 14% of men and 3% of women in B.C.), and Mathematics and Physical Sciences (13% of men and 2% of women, as compared to 10% of men and 3% of women in B.C.). This comparison shows that the sample follows the general patterns for B.C.-wide participation of women and men in various specialization fields. The variations can be explained by the fact that the entire educational history over ten years is used for assessing respondents' field of specialization, not only the degrees acquired in a specific year.

<table>
<thead>
<tr>
<th>Table 7: Specialization Fields for University Graduates – BC Comparison</th>
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</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Agriculture &amp; Biological Sciences</td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td>Engineering &amp; Applied Sciences</td>
</tr>
<tr>
<td>Health</td>
</tr>
<tr>
<td>Humanities</td>
</tr>
<tr>
<td>Mathematics &amp; Physical Sciences</td>
</tr>
<tr>
<td>Business &amp; Commerce &amp; Law &amp; Social Sciences</td>
</tr>
</tbody>
</table>

**Gender and Parental Background Influence**

So far, it was demonstrated that parental background had a strong influence on school course selection of children, but it was less clearly related to the post-secondary academic programs chosen by respondents one year after high school graduation. In this section, I will discuss the relationship between gender, parental educational attainment and
the specialization fields chosen by university graduates by using the correspondence analysis method. The sample distribution (counts and valid percents) is shown in Table 8.

### Table 8: Sample Distribution by Gender and Parental Background for University Graduates

<table>
<thead>
<tr>
<th>Parents' education, father occupation and gender categories</th>
<th>Fem_nonuniv</th>
<th>Fem_univ</th>
<th>Male_nonuniv</th>
<th>Male_univ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>174</td>
<td>139</td>
<td>124</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>33%</td>
<td>26%</td>
<td>23%</td>
<td>18%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>534</strong></td>
<td></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

The correspondence analysis map in Figure 10 shows the distribution of the four groups defined by gender and parental education around the specialization fields that are aggregated into six main areas: Education, Engineering, Health, Humanities, Science, Others (Adamuti-Trache & Andres, 2002). The relationship between gender, parental education and specialization field is described by the following most significant findings:

a) There is a clear separation of the Science and Engineering profiles on the left side of the map. The group of male with highly educated parents appears to be associated with the Engineering profile. The group of male from less educated families is comparatively associated to Science, Humanities, Health and Other specialization profiles. The group of female respondents with highly educated parents is also in the proximity of Science profile, which includes both Biological and Physical Sciences.

b) The group of women with highly educated parents is associated to the Humanities profile, while the group of women from less educated families is associated to the Education profile.

c) Health and Other specialization fields correspond to points on the map that are less polarized by gender and parental educational attainment.

d) The correspondence analysis map used to model the above patterns is described in a two dimensional space. The first largest eigenvalue \( \lambda_1 = 0.149531 \) corresponds to the horizontal axis that can be identified as a gender dimension with men on the left and women on the right of the map. The proportion of total inertia (profiles distribution) that is explained by
Figure 10: Specialization fields of university graduates by gender and parental education

Academic Specialization by Gender and Parental Education

\( \lambda_1 = 0.149531 \) (91.75%)
\( \lambda_2 = 0.012697 \) (7.80%)
gender is 91.75%. Profiles associated to specialization fields are also separated along this dimension with science-oriented fields on the left side of the map.

e) The second largest eigenvalue \( \lambda_2 = 0.012697 \) corresponds to the vertical axis. This dimension accounts for 7.80% of the total inertia, but it cannot be identified in this model.

A clear role of parental education was identified in the correspondence analysis maps that describe respondents' high school profiles (Figure 3) and to some extent, in the map describing the choice of academic programs by post-secondary participants (Figure 6) in the first year after school graduation. However, the specialization fields of university graduates, ten years after high school graduation are even less determined by parental education. High school academic preparedness, gender and parental background can account for respondents' post-secondary participation and attainment, but cannot account entirely for the specific post-secondary choices, first-year academic programs, specialization fields and career pathways.

5.2 Human Capital in Science and Engineering Fields

The previous sections have addressed the question, "What is the nature and extent to which young women and men limit their educational and career options through early or late academic course selection?" The findings demonstrate that post-secondary participation is strongly related to high school profiles, and only slightly influenced by gender. However, the specific academic specializations of university graduates depend on both gender and high school preparation. High school students who take more science courses (physical sciences, life sciences) are more likely to have their professional orientations evenly distributed across all academic fields and thus, they have access to a broader range of career options. Post-secondary academic choices do not naturally emerge from the high school course selection, a fact suggesting that high school course selection does not necessarily reflect consistent planning for future educational destinations. However, men make more narrow academic choices at the post-secondary levels and they seem to persist in fields related to their original high school orientation. Meanwhile, women have a greater tendency to cover a broader range of professional fields,
independent of their high school preparedness. There is one noticeable exception: even women who have excelled in high school math and science courses choose science and engineering fields in low proportions. A more detailed analysis of this issue will be offered in this section.

From the total of 1,055 respondents in the sample, a large proportion of high school graduates had good preparedness in both math and science courses (LS and PS groups with a total of N=740 respondents) and could pursue careers in life and physical sciences. A total of 565 respondents (54% of the original research sample, N=1,055) held university degrees ten years after high school graduation. About 79% of the university graduates (445 respondents) belong to the LS and PS groups, namely 246 women and 199 men. This science-oriented sub-sample of university graduates (N=445) with high school preparedness in math and science is large enough to assess the scientific career choices of B. C. young women and men, and it will be used for analysis in this section.

Students in the science-oriented sub-sample were also the higher achievers at the school level, as reflected by their average grades in all examinable school subjects. Thus, students in the LS group received average grades of 75% for both girls and boys, while students in the PS group obtained average grades of 78% (girls) and 80% (boys). Students’ performance in G12 math and science courses was 73% (girls) vs. 74% (boys) for the LS group, and 76% (girls) vs. 81% (boys) for the PS group. The above figures show that, on average, male respondents performed at the high school level slightly better than female respondents.

What are the educational and career trajectories for women and men who excelled in math and science during their senior high school years? Findings presented in Figure 9 show that the LS and PS students’ degrees cover almost all specialization fields. This is a positive fact that demonstrates that a scientific background would support a broad range of career destinations. On the other hand, one can ask whether this wide distribution of human capital does not disadvantage the science and engineering fields that lose potential candidates for science-related career pathways. Since the science and engineering professions require long, continuous and advanced training, these fields need to maximize even more the use of individuals’ knowledge and skills. The large individual and societal investments in science training would justify a better use of the available human potential to feed the science
professions.

Do high school course selection and students' preparedness match their post-secondary educational specialization areas ten years after high school graduation? I will use the data on university graduates' specialization fields to assess the extent to which school preparedness is related to the most probable career orientation. Matching the orientation at the two levels is based on the assumption that the life sciences preparedness (based on high school biology) is a "perfect" start for a career in Agricultural and Biological Sciences or Health, while the physical sciences preparedness (based on mathematics and physics or chemistry) is a "perfect" start for a career in Engineering or Mathematics and Physical Sciences. A perfect match of the two educational levels would allow students to focus their energy toward developing and enriching their initial interests and skills along same direction. Careers in Education, Engineering, Mathematical and Physical Sciences or Behavioral and Social Sciences are a "medium" match for the LS group, while careers in Education, Agricultural and Biological Sciences or Health would be a "medium" match for the PS group. In this case, there is only a partial use of the initial school preparedness and additional competencies are required. A "low" match would connect the LS and the PS groups to careers in Humanities, Business and Law and Commerce or, for the PS group, to Behavioral and Social Sciences too.

Figure 11 presents the proportion of university graduates who fit at a perfect, medium or low level their school and university academic orientation ten years after high school graduation. For each high-school profile the proportions are compared by gender. The LS group shows a homogeneous distribution of university graduates over the three career-matching categories, with the largest proportion of university graduates (38% for women and 37% for men) changing their initial educational orientation toward neighbour fields. About 31% of female LS respondents and 28% of male LS respondents succeed in keeping a stable career orientation over the years and may end up working in fields for which they started to prepare in high school. About 31% of women and 35% of men end up in a field that is not related to their initial high school preparedness. For the LS group, there is no significant gender difference associated to the proportion of respondents matching high school and post-secondary academic choices (contingency coefficient C= 0.036, p>0.05).
Figure 11: Matching high school and post-secondary academic choice

Life sciences high school profile

Physical sciences high school profile
The PS group appears to split less evenly over the three academic-matching categories. In the case of the male PS group, 44% of respondents remain consistent with their initial high school career orientation, 21% of men having a medium connection to their initial orientation and about 35% of men adopting a different career orientation.

By contrast, the female PS group presents the most uneven distribution over the academic fields, since only 13% of women continue in a field directly related to their initial high school career orientation. A large proportion of PS female students (48%) switched to biology-related and education careers, while 39% obtained their university degrees in areas unrelated to their initial high school preparedness. For the PS group, there is a significant association between gender and the extent to which respondents match their high school and post-secondary academic choices (contingency coefficient C= 0.328, p<001).

The above findings show that, independent of gender or high school science profile, more than one third of the students who succeeded in university have chosen educational and career orientations unrelated to their high school academic preparedness. Differences by high school profile and gender occur in comparing the first and second academic matching categories. In general, men are more likely than women to keep their initial professional orientation and persist in fields in which they consistently accumulate knowledge, skills and reputation – a tendency that is the most obvious for the male PS group. Meanwhile, Figure 11 suggests that a large proportion of women in the PS group move from fields that are largely related to their high school academic preparation to fields that are less related. Obviously, a large proportion of the female PS group was either pushed away or decided to leave the physical sciences pipeline, a phenomenon that leads to the much discussed under-representation of women in mathematical and physical sciences, and engineering fields.

On the other hand, women appear to be more flexible than men in changing their career orientation and in accumulating new knowledge and skills within different professional fields. Unfortunately, this ability to change and adjust career plans does not help in a competitive field like science that requires long-time persistence in accumulating knowledge, building skills and creating a network of collaborators. The findings of this section are consistent with the specialized literature that emphasizes that only a small proportion of women scientists succeed to “stay on” and “get on” with a scientific profession in physical sciences and engineering (Glover, 2000, p. 4).
5.3 Human Capital in Mathematics and Science Education

Based on the number and type of credentials acquired by the respondents during the first ten years after high school graduation, I will analyse how the human capital in Education is created, with emphasis on science education. Teaching in the B.C. school system requires a University degree at the Bachelor’s level at minimum combined with a teaching certificate granted by certain post-secondary institutions. The teaching certification is sometimes included in a Bachelor of Education Degree that may offer a combination of specializations at the Primary and Elementary level. For teaching mathematics or science at the high school level, especially for senior courses, a Bachelor in Science is mandatory.

What are the profiles of teachers-to-be, as reflected in the type of credentials earned by the university graduates in the sample used in this study? As mentioned in the previous section, 565 out of 1,055 respondents earned at least one university degree by 1998. Based on the type of degree, respondents are classified in five groups:

1) the largest group contains university graduates with degrees that cannot be directly used toward a science teaching career or clearly suggest a different professional orientation, such as degrees in Health, Engineering, Business, Commerce, Law, Humanities, Behavioural Sciences.
2) the second group contains university graduates who possess a Bachelor in Education degree, sometimes combined with a teaching certificate.
3) the third group contains university graduates possessing a degree in Education combined with a Bachelor in Arts or other non-scientific fields.
4) the fourth group contains university graduates who possess Bachelor’s in Science continued or not with graduate degrees in science, but no education or teaching credential.
5) the fifth group is represented by university graduates possessing a Bachelor’s in Science and a degree in Education (or a teaching certificate).

Which of these combinations of credentials can support a teaching career in school subjects like mathematics and science? I would argue that only the last two groups based on Science degrees are likely to produce future science and mathematics teachers. For the first group, even if some degrees are based on science and mathematics (e.g., Engineering or
Health), they require a long and expensive education and it is unlikely that graduates possessing such degrees would turn toward a teaching career instead. Other degrees in this group (e.g., Humanities, Law, Behavioural Sciences) are less or not at all based on science preparation and it is unlikely that graduates possessing such degrees could easily accumulate the knowledge required for a science teaching career. Similar arguments stand for the second and the third group. University graduates in the second group are unlikely to get into a science-preparation pathway after losing the connection with science for ten years, while graduates in the third group already made the choice of a non-science teaching or education-related career. It is possible that some Bachelor’s in Education have science orientation, but it is likely that this would allow the recipient to teach at the elementary or junior high school level. Teaching at the senior high school level requires a Bachelor’s in Science, so the only candidates remain respondents in the fourth and fifth group.

The distribution of university degrees by gender is presented in Table 9, which shows that about 14% of the university graduates can go into teaching mathematics and science. Only 2% already possess all the necessary credentials in 1998. Twelve percent of the graduates (16% of men and 9% of women) possess science degrees and, if they will acquire teaching certificates, may turn toward teaching later in life.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Female N=332</th>
<th>Male N=233</th>
<th>Total N=565</th>
</tr>
</thead>
<tbody>
<tr>
<td>Others (B Eng, B.A.Sc, B. of Law, B. of Commerce, B. Nursing, B. Pharmacy, etc)</td>
<td>211 (64%)</td>
<td>176 (76%)</td>
<td>387 (68%)</td>
</tr>
<tr>
<td>Education (B. Ed)</td>
<td>47 (14%)</td>
<td>7 (3%)</td>
<td>54 (10%)</td>
</tr>
<tr>
<td>Education and other fields (B.A &amp; B. Ed/teaching certificate)</td>
<td>36 (11%)</td>
<td>8 (3%)</td>
<td>44 (8%)</td>
</tr>
<tr>
<td>Science (B. Sc)</td>
<td>31 (9%)</td>
<td>38 (16%)</td>
<td>69 (12%)</td>
</tr>
<tr>
<td>Education and Science (B. Sc &amp; B. Ed/teaching certificate)</td>
<td>7 (2%)</td>
<td>4 (3%)</td>
<td>11 (2%)</td>
</tr>
</tbody>
</table>

In the case of women, there is also a large difference between the proportion of graduates with degrees in education and non-science fields (11%) as compared to education and science fields (2%). Women interested in teaching are clearly more oriented toward non-
science fields. In the case of men, same proportions of graduates (3%) have education degrees and science or non-science degrees. The gender representation in the group of university graduates possessing only Education degrees is very disproportionate: 14% of women compared to 3% of men are apparently oriented toward teaching at the primary and elementary levels. Gender is definitely a factor that controls the profiles of teachers-to-be.

The graphs in Figure 12 show the patterns of education-related careers by gender for each of the four high school profiles used in this study. For all high school profiles, the proportion of men going into career pathways that are unlikely to lead to school teaching is higher: about 60-65% of women and 70-90% of men from each profile obtained degrees leading to other professional fields. The lowest male proportion in Other fields is represented by men in the LS group. For both men and women, the LS and PS profiles lead to more diverse patterns of career choice covering all combination of science and/or education degrees.

Observing now only the Education and/or Science career orientation, some gender and high school science preparedness differences can be noticed:

a) In the case of the NS high school profile, men are minimally represented in Education, mainly in combination with Bachelor’s in Arts degrees. As expected, the NS profile members do not earn science-related degrees.

b) In the case of the MA high school profile, men earn only science-related degrees and there is no Education degree earned by men, while women earn degrees in Education or combined with other fields. The sample of graduates coming from the MA profile is quite small (45 women and 10 men) so the above findings may not be generalized.

c) In the case of the LS high school profile, one can notice the distribution over all combinations of Education degrees with a higher proportion of men obtaining science only degrees and of women obtaining education only degrees.

d) Respondents from the PS high school profile show the largest proportion with Science only degrees (about 19%) for both women and men. A larger proportion of women with a B.Sc. (8%) have already chosen a teaching career ten years after high school graduation. The above patterns show that women and men with same qualification have the tendency to prepare differently for the use of their credentials.
Figure 12: Distribution of university degrees by high school profiles and gender
5.4 Education and Work Satisfaction of University Graduates

Following the pace of rapidly changing economies and dynamic labour markets, current jobs become more and more complex requiring individuals with a well-rounded education complemented by flexible adjustable specialization. Researchers claim that the average Canadian changes occupations every five years (Donaldson et al., 1998). Since the labour market is governed by high competition, education is becoming a mandatory prerequisite of success. While the rate of unemployment is up to 11% for individuals with high school education only, it drops to 5% for university graduates. Individuals should recognize educational and career opportunities that fit their background in order to take chances of new job pathways.

The educational pathways of the sample used in this study confirm that young Canadians understand the trends of the labour market. Ten years after high school graduation, 6% of the 1,055 respondents possess only a high school diploma and have not attended post-secondary instruction, 12% of graduates attended but did not complete post-secondary education, 28% possess non-university credentials and 54% posses at least one university degree (Table 6). This is a diverse population that shows a high tendency toward continuing education after high school, especially at the university level. One can speculate that, besides offering appropriate skills and knowledge, university instruction is expected to contribute to the formation of individuals with a high capacity to adjust their competencies to the challenge of a demanding economy. The high costs of university education, from both societal and individual part, have to be paid back when graduates enter the job market. From the society perspective, university graduates pay back their education through higher taxes. The individual investment in education should be also paid back by rewarding jobs, satisfaction with work, good perspectives for professional growth.

I hypothesized that the education and work satisfaction of university graduates depends on gender and specialization field. The specialization fields are aggregated into six professional areas based on the type of undergraduate degrees acquired: Education (B. Ed.), Humanities (B.A.), Science (B.Sc.), Health (B. Nursing, medical degrees), Engineering (B.Eng. and B.A.Sc.) and Others (B. of Law, B. of Commerce, B. Adm., etc). Figure 13 shows the distribution of university graduates in the six areas by their high school preparedness, for women and men. Most university graduates have science-oriented
Figure 13: Number of university graduates in each professional category by HS profile and gender (Female: N=332; Male: N=233)
high school preparedness. In the case of women, the largest number was recruited from the life sciences (LS) profile and in the case of men from the physical sciences (PS) high school profile. Respondents from the PS high school profile feed all professional domains both for women and men, and this is also valid for the LS profile (except the absence of women in Engineering). Female respondents from the non-science (NS) and mathematics (MA) high school profiles populate the Education, Humanities and Other professional domains. In the case of men, the NS high school profile populates the Humanities and Other fields, and the MA high school profile populates the Other professional domains.

**Educational Aspirations and Expectations over the Years**

Has the passing of time changed the educational aspirations and expectations of the longitudinal sample? Survey participants indicated a) the highest level of education they would like to attain and b) the highest level of education they would expect to attain.

Respondents’ educational aspirations are compared at two moments of time, in 1989 (i.e., effect of high school) and 1998 (i.e., effect of post-secondary education and/or work). To test whether gender and high school preparedness determine respondents’ aspirations, crosstabulation tables are obtained for each high school profile and gender group. The percentages of respondents aspiring to Bachelor’s, professional and graduate degrees are presented in Table 10.

In 1989, 57% of women and 63% of men aspired toward graduate degrees. Overall, a larger proportion of women (29%) compared to men (14%) aspired to earn professional degrees and 8% of women, respectively 22% of men aspired toward undergraduate degrees. In 1998, men decreased their aspirations toward graduate degrees to 57% while women as a whole increased their aspirations to 69%. Meanwhile, women lost interest in professional degrees (10%) and tended to acknowledge that bachelor’s degree represented the highest level of education they wanted to achieve (21%). Women in the LS and PS groups showed the largest increase in their aspirations toward bachelor’s degrees.

In the case of men as a group, there was a tendency to decrease the interest in graduate degrees, maintain constant interest in professional degrees and increase the interest in bachelor’s degrees, but these variations were less pronounced. Different patterns are shown by the male NS group - not very reliable since the sample size is small (N=16).
Table 10: Percentage of University Graduates Aspiring Toward Various Post-Secondary Degrees

<table>
<thead>
<tr>
<th>Gender &amp; HS profiles</th>
<th>Bachelor's degrees</th>
<th>Professional degrees</th>
<th>Graduate degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female (N=287)</td>
<td>8%</td>
<td>21%</td>
<td>29%</td>
</tr>
<tr>
<td>NS (N=38)</td>
<td>13%</td>
<td>11%</td>
<td>16%</td>
</tr>
<tr>
<td>MA (N=41)</td>
<td>5%</td>
<td>7%</td>
<td>27%</td>
</tr>
<tr>
<td>LS (N=147)</td>
<td>8%</td>
<td>23%</td>
<td>35%</td>
</tr>
<tr>
<td>PS (N=61)</td>
<td>7%</td>
<td>23%</td>
<td>26%</td>
</tr>
<tr>
<td>Male (N=199)</td>
<td>22%</td>
<td>28%</td>
<td>14%</td>
</tr>
<tr>
<td>NS (N=16)</td>
<td>25%</td>
<td>25%</td>
<td>44%</td>
</tr>
<tr>
<td>MA (N=8)</td>
<td>0%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>LS (N=49)</td>
<td>14%</td>
<td>22%</td>
<td>20%</td>
</tr>
<tr>
<td>PS (N=126)</td>
<td>14%</td>
<td>11%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Respondents’ educational expectations in 1989 and 1998 are described by the set of findings in Table 11. For all respondents, the expectations toward earning graduate degrees are largely increased over time. Overall, women decreased their expectations toward earning undergraduate and professional credentials. Overall, men manifested more stable expectations regarding earning professional credentials, and expected to earn more graduate instead of undergraduate degrees in 1998. Over time, there occurred a tendency among respondents to increase their expectations.

Table 11: Percentage of University Graduates Expecting Various Post-Secondary Degrees

<table>
<thead>
<tr>
<th>Gender &amp; HS profiles</th>
<th>Bachelor's degrees</th>
<th>Professional degrees</th>
<th>Graduate degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female (N=298)</td>
<td>39%</td>
<td>30%</td>
<td>34%</td>
</tr>
<tr>
<td>NS (N=37)</td>
<td>43%</td>
<td>32%</td>
<td>19%</td>
</tr>
<tr>
<td>MA (N=41)</td>
<td>54%</td>
<td>32%</td>
<td>24%</td>
</tr>
<tr>
<td>LS (N=156)</td>
<td>36%</td>
<td>30%</td>
<td>36%</td>
</tr>
<tr>
<td>PS (N=64)</td>
<td>36%</td>
<td>28%</td>
<td>42%</td>
</tr>
<tr>
<td>Male (N=217)</td>
<td>40%</td>
<td>22%</td>
<td>31%</td>
</tr>
<tr>
<td>NS (N=22)</td>
<td>41%</td>
<td>46%</td>
<td>27%</td>
</tr>
<tr>
<td>MA (N=10)</td>
<td>30%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>LS (N=54)</td>
<td>39%</td>
<td>32%</td>
<td>26%</td>
</tr>
<tr>
<td>PS (N=131)</td>
<td>41%</td>
<td>14%</td>
<td>34%</td>
</tr>
</tbody>
</table>
Satisfaction with Education and Career or Work

The high level of satisfaction with their current level of educational attainment expressed by a large majority of respondents also supports the tendency manifested by respondents to increase their aspirations and expectations toward higher levels of education. One of the survey questions refers to respondents' satisfaction with "the way things have turned out in the following areas" (Appendix C):

a) educational attainment in 1998
b) work or career situation in 1998.

University graduates expressed their degree of satisfaction measured on a 5-point Likert scale. The extent of agreement is measured on a 5-point Likert scale varying from 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree to 5 = strongly agree. The mean values of the above variables are presented by gender combined with either high school profiles or specialization fields in Figure 14. In addition, MANOVA tests are performed to confirm whether observed differences by groups are statistically significant.

The first graph in Figure 14 shows that respondents acknowledge an above average degree of satisfaction with their educational attainment for all high school profiles, for both women and men. There is a significant difference by gender (F=5.295, p<0.05) and by high school profile (F=7.607, p<0.001) as shown in a MANOVA test, and no interaction is observed between the two factors.

The second graph in Figure 14 (bottom left) shows quite similar level of satisfaction with career or work for all groups defined by gender and high school profile. MANOVA statistical tests confirm that the above differences are small, and high school preparedness has a diminished effect on work-related variables ten years after high school graduation, for both women and men.

Satisfaction with current educational attainment and satisfaction with work is also analyzed from the perspective of respondents' professional fields. The third graph in Figure 14 displays university graduates' satisfaction with educational attainment. Patterns are quite similar by gender, presenting some differences by specialization field. The non-parametric Kruskal Wallis test (H= 20.535, p<0.001) shows that there is significant statistical difference by specialization field and groups that manifest the highest level of satisfaction with their educational attainment are Education, Health and Engineering.
Figure 14: Respondents' satisfaction with educational attainment and career in 1998
The fourth graph in Figure 14 (bottom right) displays university graduates' satisfaction with work or career. Using MANOVA tests, significant differences by specialization fields (F=3.237, p<0.01) and no differences by gender are obtained. All groups show an above average level of satisfaction with current work or career. The groups showing higher level of satisfaction with work or career are Health and Education. Female Engineering group actually scored very high, but the result cannot be generalized because of the small sample. The less satisfied with their work or career are men in Humanities and Other fields, and women in Science and Other fields.

**Future Educational Plans in 1998**

Table 12 presents respondents' answers regarding the highest degrees wanted and expected in 1998 by gender and specialization field. Since all respondents possess at least a Bachelor's degree in 1998, these responses describe educational plans for upgrading or changing professional pathways.

<table>
<thead>
<tr>
<th>Gender &amp; Specialization Fields</th>
<th>Bachelor's degrees</th>
<th>Professional degrees</th>
<th>Graduate degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wanted</td>
<td>Expected</td>
<td>Wanted</td>
</tr>
<tr>
<td>Female Education</td>
<td>20%</td>
<td>31%</td>
<td>10%</td>
</tr>
<tr>
<td>Humanities</td>
<td>23%</td>
<td>27%</td>
<td>5%</td>
</tr>
<tr>
<td>Science</td>
<td>20%</td>
<td>41%</td>
<td>4%</td>
</tr>
<tr>
<td>Health</td>
<td>28%</td>
<td>35%</td>
<td>3%</td>
</tr>
<tr>
<td>Engineering</td>
<td>20%</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>Others</td>
<td>13%</td>
<td>27%</td>
<td>19%</td>
</tr>
</tbody>
</table>

Women as a group show low interest in earning professional degrees, with high consistency between aspirations (10%) and expectations (11%). Their expectations for
Bachelor’s degrees (31%) exceed the aspirations (20%), while expectations for graduate degrees (57%) are below aspirations (70%). Men follow similar patterns, but their interest in professional degrees is much higher (wanted 27%; expected 28%), while the interest in Bachelor’s degrees (wanted 15%; expected 21%) and graduate degrees (wanted 58%; expected 50%) is lower than in the case of women.

**Satisfaction with Current Work**

Some measures of respondents’ satisfaction with their work are represented in Figure 15, where the level of agreement with various statements is shown for each professional and gender group. The extent of agreement is measured on a 5-point Likert scale varying from 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree to 5 = strongly agree.

For the first three statements (i.e., “chances of promotion are good”, “feeling of job accomplishment” and “job is directly related to education”), there is no significant difference by gender or specialization field as shown by the corresponding graphs. Yet, some patterns can be observed. On average, respondents are neutral about the issue of promotion at work. Men in Engineering, Science and Education, as well as women in Other fields are more inclined to agree that chances of promotion are good. Most respondents agree that their job gives them a feeling of accomplishment and some peaks occur for the female and male groups in Education and Health. The same groups acknowledge that their current jobs are related to education and training. Males in Humanities and females in Engineering sense less work accomplishment. Groups that express a neutral opinion about how much their education was related to work are men in Humanities, and women in Humanities, Science and Engineering.

There is also a visible gender difference regarding the issue of difficulties encountered by women in succeeding in the work force. Men manifest a neutral opinion, while women agree that it is still difficult for women to succeed in the workforce. Women in Humanities, Science and Engineering express this fact the most firmly.

Testing the differences by the use of parametric statistics is problematic since most normality and equal variances tests fail. Non-parametric tests (Kruskal Wallis tests) show statistically significant gender differences, women as a group agreeing more that their job
Figure 15: Respondents' satisfaction with their work by professional category and gender
gives them a feeling a fulfillment (H=4.775, p<0.05) and that it is more difficult for women to succeed in work force (H=17.561, p<0.001).

For each gender group, non-parametric tests by specialization field are performed. For male respondents, the only significant Kruskal Wallis test occurs for the question about the relation between job and education, with the largest rank differences between Health and Education groups on the highest side and Humanities group on the lowest side (H= 34.074, p<0.001).

For women, more statistically significant differences are obtained:

a) relation between job and education is ranked high by the Education and Health groups and low by Science and Engineering (H=56.504, p<0.001)

b) feeling of accomplishment at work is ranked high by the Education and Health groups and low by Engineering and Science (H=22.401, p<0.001)

c) difficulty of women to succeed in workforce is ranked high by Engineering group, followed by Humanities, Science, Others, Health and Education groups (H=19.596, p=0.001).

Overall, gender and specialization field differences are manifested in the respondents' opinions regarding education and work satisfaction. However, all groups show above average satisfaction with their educational attainment and career or work.

Career Choice Satisfaction and Future Career Plans

When asked whether they would still choose the same line of work, 77% of women and 83% of men answer affirmatively. Differences by specialization fields are presented in Table 13, with women in Engineering (43%) and men in Humanities (76%) scoring the last in their gender groups. Men in Science, Education and Engineering confirm their intention to keep same line of work in proportions above the average male group score. The most pronounced gender differences appear in Engineering, Education, Science and Other fields.

Table 13: If you had the choice to make again, would you choose the same line of work you do now?

<table>
<thead>
<tr>
<th>Gender</th>
<th>Percentage of affirmative responses by field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Education</td>
</tr>
<tr>
<td>Female</td>
<td>77%</td>
</tr>
<tr>
<td>Male</td>
<td>90%</td>
</tr>
</tbody>
</table>
Women and men with science-related specialization fields show different perception of their work situation. Eighty percent of women in the Science field answered they would choose again the same line of work. However, this group includes both life and physical sciences-related careers. Considering Science and Engineering fields together, 73% of women would continue with current line of work, as compared to 88% of men with same post-secondary preparation.

Respondents were also asked whether they are currently looking for another job. Forty five percent of female scientists and 43% of female engineers are looking for another job, a large proportion compared to the average for the whole female group (36%), the average for male group (29%) and the average for the men in science and engineering group (26%). This fact suggests that women with science and engineering degrees are either underemployed or unhappy with their current job situation. Women looking for new jobs mention the following reasons: low income, lack of specialized training, need for security and stability, and intention to do further education. Men who are looking for new jobs also refer to a bad workplace, over-qualification, need for more work responsibility, and running their own company. None of the women looking for a new job mention the issue of balancing family and work as a problem – a typical excuse embraced by the scientific community to legitimize the under-representation of women in these fields.

5.5 Chapter Summary

Ten years after school graduation, respondents who received science-oriented preparedness at the high school level cover a broad spectrum of post-secondary specialization fields. Men who had a scientific orientation in high school are more likely than women to continue along science-related educational pathways. Especially in the case of women in the physical sciences high school profile, a leaking phenomenon is obvious. Ten years after high school graduation, very small proportions of respondents are oriented toward science education for both women and men.

Educational aspirations and expectations of university graduates are high in 1998 and slightly different compared to 1989. Gender and high school profile differences are observed. Large proportions of graduates manifest high level of satisfaction with their educational attainment and work or career.
CHAPTER VI
Discussion and Conclusions

In short, this thesis has addressed the following research questions:

a) What is the role of the high school academic capital in shaping a successful pathway toward a science-related career?

b) Are there gender differences in the relationship between the secondary and post-secondary stages?

c) What is the role of cultural capital in respondents' secondary and post-secondary education choices, participation and attainment?

d) What is the relationship between academic capital, cultural capital, gender and human capital in science and engineering fields? Are women and men specialized in science and engineering fields happy with their education, and work or career?

6.1 Summary

A diagrammatic presentation of topics and findings of this study is shown in Figure 16. The study findings, obtained for a representative research sample (5%) of the Class of '88 high school graduates, are summarized below, arranged by the order they have been obtained in the study that also corresponds to a longitudinal development of the research topic.

During the senior high school stage, girls and boys show different participation in science courses. Boys participate quite evenly in biology, chemistry and physics courses, with a larger preference for chemistry. Girls choose biology and chemistry, and show very low participation rates in physics courses. Physics courses are actually avoided by both girls and boys, as it is reflected in the high non-continuance rates into Physics 12, and the low participation rates in physics provincial exams. During senior high school stage, female students are more oriented toward life sciences and male students toward physical sciences preparation. Parental education plays a determinant role in senior high school course choices made by respondents. There is a noticeable academic orientation of students with university-educated parents toward science high school preparedness. Meanwhile, respondents from families where no parent attended university select non-science high school preparedness.
Study Topics and Major Findings

<table>
<thead>
<tr>
<th>Class of '88 Longitudinal Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
</tr>
<tr>
<td>Senior High School Years &amp; Graduation</td>
</tr>
<tr>
<td>Science preparedness &amp; Gender differences</td>
</tr>
<tr>
<td>Science preparedness &amp; Parental background</td>
</tr>
<tr>
<td>Post-school choices &amp; HS preparedness</td>
</tr>
<tr>
<td>1989</td>
</tr>
<tr>
<td>One year after Graduation</td>
</tr>
<tr>
<td>Post-school choices vs. Gender &amp; Parental Background</td>
</tr>
<tr>
<td>HS Science preparedness &amp; Broad PS academic program choices</td>
</tr>
<tr>
<td>Senior high school course selection vs. Career planning</td>
</tr>
<tr>
<td>1993</td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td>Educational attainment vs. Gender &amp; HS science preparedness</td>
</tr>
<tr>
<td>Educational attainment vs. Gender &amp; Parental background</td>
</tr>
<tr>
<td>Post-secondary Academic programs vs. Gender &amp; Parental background</td>
</tr>
<tr>
<td>1998</td>
</tr>
<tr>
<td>Career &amp; Work</td>
</tr>
<tr>
<td>Matching career orientation &amp; HS preparedness: Gender differences</td>
</tr>
<tr>
<td>Science background &amp; Broad career choices</td>
</tr>
<tr>
<td>Work satisfaction vs. Gender &amp; Specialization field</td>
</tr>
<tr>
<td>Future Educational &amp; Career Plans</td>
</tr>
<tr>
<td>Satisfaction with educational level vs. Gender &amp; Academic capital</td>
</tr>
<tr>
<td>Future educational plans are high for university graduates</td>
</tr>
<tr>
<td>Gender differences re work situation in Sc &amp; Eng group</td>
</tr>
</tbody>
</table>

The differential ways in which Academic and Cultural Capital are turned into Human and Social Capital in the field of Science and Engineering for B.C. young women and men still represent sources of inequity.
High school graduates make post-school choices related to their senior high school course selection. Students with stronger math and science high school orientation (e.g., physical sciences group) are more likely to go directly from school to university. The non-science high school profile students are more likely to not attend any post-secondary institution in the first year after school graduation. The life sciences and mathematics high school profiles show a large orientation toward non-university post-secondary participation. Parental education influences the post-school status of respondents, one year after high school graduation. University participants proceed mainly from the categories of respondents with university-educated parents, for both men and women. Non-university participants are mainly female and male respondents with parents possessing less than university education. Non-participants are mainly male respondents. One year after school graduation, parents’ education determines the post-school status of respondents, as it has determined students’ course choices during the senior high school stage.

High school course selection does not necessarily reflect students’ long-term career decisions. In the first year of post-secondary education, students’ academic program choices shift toward non-science fields. Even a large proportion of students with math and science high school preparedness make non-science academic choices. Overall, female students manifest a greater interest for General Studies, Humanities, Business, General Science and Behavioural & Social Sciences, while male students prefer General Science, General Studies, Humanities, Business, Engineering and Mathematics & Physical Sciences fields. Parental education is still an influencing factor of respondents’ academic program choices.

High school preparedness, gender and parental education play a significant role in the educational attainment of respondents ten years after high school graduation. Eighty four percent of all women and 79% of all men in the study obtained post-secondary credentials by 1998. About 54% of respondents received university degrees. The highest proportion of university degrees (66%) was obtained by the physical sciences high-school profile group for both women and men. The life sciences and mathematics groups obtained lower proportions of university degrees (56% respectively 61%), while getting 31%, respectively 22% non-university credentials. The non-science high school profile obtained the highest proportion of
non-university credentials (40%), while getting 29% university degrees. The highest proportion of non-completers (13%) is found in the physical sciences group, while the largest proportion of post-secondary non-participants (16%) is found in the non-science group. University graduates proceed mainly from the groups of respondents with university-educated parents, for both men and women. The holders of non-university credentials, the non-completers and those who did not attend any postsecondary institution are mainly respondents from families where neither parent had attended university.

Both gender and high school preparedness are related to the academic orientation of university graduates. High school students who took more science courses (i.e., physical sciences and life sciences groups) have their academic orientations distributed more evenly across all academic fields and thus, have access to a broader range of career options. Post-secondary academic choices do not naturally emerge from the high school course selection, which suggests that the senior high school course selection does not necessarily reflect a career-planning phase. Ten years after high school graduation, parental education has a less significant role regarding the choice of specialization fields for university graduates. High school preparedness was also found to be less related to graduates’ specialization fields; therefore, the only strong determinant of these choices is gender.

Male students are more likely than female students to continue their university studies in fields related to their high school academic orientation. Female students diversify their academic choices at the post-secondary level. As a result, the proportion of women in science and engineering fields at university is even lower than the proportion of female students in high school math and science courses. Still, a scientific background upholds a broader range of educational choices and career opportunity. On the other hand, the fact that many potential candidates for science-related careers are going into unrelated fields leads to a loss of human potential for science and engineering professions. This situation is more critical for women than for men, since the proportion of women is constantly reduced along various educational and career stages. Men who excelled in math and science high school courses are more likely than women who excelled in science to continue in careers that match their initial high school preparedness. Some respondents with mathematics and science preparedness at the high
school level are likely to become school teachers. Ten years after high school graduation, respondents who possess credentials that allow them to teach high school science are coming from the life sciences (more men) and physical sciences (more women) high school profiles.

In 1998, university graduates are highly satisfied with their current educational attainment and career or work. Compared by their high school academic capital, respondents with science preparation are happier than non-science ones regarding current educational attainment. More pronounced differences can be observed when respondents are compared by their post-secondary field of specialization. Men in Engineering and women in Health fields show the highest degree of satisfaction with their current educational attainment. Women and men in the fields of Health and Education show the highest satisfaction with their career. Among the less satisfied with their current career or work are women in the Science and Other fields and men in the Humanities field. In 1998, large proportions of respondents manifest high educational aspirations and expectations, with differences by gender and specialization field. Men in the Health and Engineering fields largely oriented toward earning professional degrees in the future, while most men in Education want and expect in large proportion to earn graduate degrees. Women in various specialization fields are more homogenously oriented toward all types of degrees, with the largest interest in graduate degrees.

Overall, gender and specialization field differences are manifested in respondents' opinions regarding various aspects of work satisfaction, but all groups express an above average level of satisfaction with chances for promotion, feelings of job accomplishment and the relation between work and education. Women in all fields believe that job success is still more difficult for women. The large majority of women and men would still choose the same line of work. However, women and men in science-related fields have very different perceptions regarding their work situations. A much larger proportion of men than women possessing degrees in the Science and Engineering fields would still choose the same line of work, and more women than men in these fields are looking for a new job. Women in the Science and Engineering fields constitute actually the largest proportion of university graduates looking for a new job.
6.2 Discussion and Interpretation of Findings

This section contains a discussion of study findings organized by several themes. Findings are discussed and interpreted in relation to specialized literature, as well as in relation to my lengthy experience as a woman in physics.

The Making of a Scientist

Currently, career pathways in science and engineering are described as focused, rigidly timed and continuous (Zuckerman et al., 1991). Students tend to go straight from high school into undergraduate studies. Those who enter teaching or industry careers need to earn additional professional credentials. Those who plan careers in research or academia have to commit themselves to a long journey through graduate and postdoctoral phases. Since these typical paths through the science pipeline require university degrees, well-rounded high school preparedness with a strong emphasis on mathematics and science disciplines is necessary to support these career destinations.

The study findings support the above image of science-related educational and career pathways. Students with strong high school science instruction (primarily those from the physical sciences high school profile) are high achievers who, in large proportion, go straight to university after school graduation. High school graduates with life sciences and physical sciences are the main feeders of science-based programs. Still, many university students do not opt for specific science academic programs at the beginning, and go into General Science or other programs to explore perhaps their interests or to fill gaps of information or instruction. When compared to male students, the proportion of female students who get on pathways toward science and engineering fields is significantly small: the science pipeline leaks more young women than men at the high school and undergraduate stages. Gender, high school preparedness and parental education produce differences that are visible during the senior high school years and the transition to post-secondary education.

What contributes to growing interest, enhancing skills and developing the confidence required to survive along these educational pathways? The following scenario is based on literature findings, my own experience and my interpretation of current situations in the B.C. education system.
Early exposure to science, usually offered by parents through extracurricular activities (Kahle, 1996), can stir the interest of young children towards fun science-oriented activities. An enthusiastic and knowledgeable elementary and/or junior high school teacher, who develops a sense of scientific inquiry in his/her students, can motivate young people to read more science books, to do hands-on science and to understand "how things work," at least at the basic level. However, this is just an opening toward a science-related career. Science cannot be learned and practised through stories and excitement only. At some point, and better sooner than later, the school student has to reach a level of understanding that requires more abstract thought, as well as an ability to master the mathematical apparatus. In many cases, students lose their interest in science when the transition to a mathematical foundation of scientific knowledge is required. In the B.C. school system, this phase usually occurs at the senior secondary level, when students start to study thoroughly specialized science courses, thus realizing "how scientific reasoning works." To make this qualitative leap, students need the support of knowledgeable and open-minded teachers capable of creating a classroom environment in which various learning styles and assessment practices will be encouraged (Murphy, 1996). The low continuance in physics, the most mathematical of all sciences, at the Grade 11 and Grade 12 levels, supports the interpretation that large proportions of students have difficulties in intertwining abstract concepts with the real world phenomena.

Therefore, parents and teachers have a substantial role in getting the student on the educational pathway leading to a science-related career. They should also play a decisive role in stimulating student’s individual confidence in their own abilities and potential success, in developing his or her learning and work habits, and in guiding the student to plan for a career (Walz & Bleuer, 1992). The findings in this study show the strong relation between parental education and students’ high school course choices or post-school status. When parents and the school fail to offer students the type and guidance needed for further advancement at the right time, individuals accumulate disadvantages that lead to large inequities in access to post-secondary education and labour market.

The educational stages of a scientist’s formation are recognized in the literature as being governed by the masculinist culture (Caplan, 1993). The community of science teachers, university professors and scientists, mostly represented by men, creates the social
context of learning. Consequently, it is the masculinist culture that practically models the image held by science in society (e.g., school and post-secondary curriculum, topics and research style, institutional structures, relation with non-science fields, use of science in technology, human resources). One of the institutions that play a substantial role in creating and maintaining the image of various fields in society, academia, is a setting where the presence of women is still limited, especially in the sciences and engineering fields. The findings in this thesis show the low proportion of female students persisting along science-related pathways and confirm that a "leaking phenomenon" is manifested along the science pipeline. Likewise, the number of female teachers in high school subjects, such as mathematics, physics and chemistry, is still low which makes the entire educational pathway leading to science-related careers a result of a male dominated culture. Findings of this study are not conclusive regarding female participation in mathematics and science education, since the overall proportion of respondents oriented toward teaching is still low ten years after high school graduation. It is possible that many recipients of science degrees will turn toward teaching careers later in life.

The phases of the "making of a scientist" pathway are complex, interconnected and governed by masculinist rules. Not being exposed appropriately to the school and post-secondary stages would diminish an individual’s chance of following a science-related pathway. Since not only young women, but many young men in this study, especially those coming from families with less education, do not choose science-oriented preparedness in high school or go away from science pathways during post-secondary years suggests that non-participation in science fields is related to existing barriers (i.e., knowledge barriers, gender barriers, social barriers) hindering the access of certain groups to these fields. This observation raises the issue whether equal opportunity for all potential candidates for science careers really exists. The making of a scientist is an example of existing inequities in access and outcomes to rewarding careers, inequities determined by gender, academic preparedness and parental education.
High School Academic Capital

The role of high school academic capital in succeeding along post-secondary pathways was continuously reinforced along this study. Apparently, a broader science preparation was able to support diverse and accomplished educational pathways. This empirical observation cannot be transformed in a golden rule to determine the ideal type of education that should be offered at the school level. For instance, learning foreign languages is an excellent cognitive exercise, but foreign languages are not considered as important as mathematics in the Canadian and American systems of education. Contextual factors, such as B.C. graduation requirements and post-secondary admission rules, the system of testing, the technological culture we live in could influence students toward a scientific preparedness.

It is not my intention to diminish the importance of a broad scientific preparedness, in which I firmly believe and consistently promote. Definitely, science literacy based on a strong mathematical foundation is equally important in the formation and development of intellectual abilities, views and values, as are literature and arts. It is my purpose to search for possible interpretations of one finding of this study: why do a large proportion of students engaged in science-oriented programs in high school leave this route as early as the first year of post-secondary education?

One explanation is that students do not know which educational pathway to take, so they follow the current advice circulated by school counsellors: “keep all options open”. This implies that it is the post-secondary stage when the majority of students will probably make career decisions. Still, it is not clear why “keeping all options open” does not apply to non-science pathways also and why the best achievers are oriented toward science courses in high school.

Another possible explanation is that parents are still in control of children’s academic choices. It was demonstrated in the study that parental education is strongly related to students’ course choices, and the more educated parents somehow push the children toward more intensive science preparedness. This attitude may relate to parents’ understanding and interpretation of current trends on the workforce that reflect mentalities of a technological culture in which scientific and technical careers are valued and rewarded by society. Consequently, parents may acknowledge the need for a mathematical and scientific formation.
A simplistic but very possible explanation of the non-concordance between students' high school academic choices and their educational and career pathways is that students' high school choices are controlled by the most convenient way of obtaining good marks required for admission to post-secondary institutions. Testing in mathematics and sciences is based on more exact rules and looks less controversial than in humanities. Since the entire school system is dominated by multiple-choice testing (i.e., a guessing exercise in the minds of most students and use of marking answer keys in teachers' practice), it is easier for students to prepare provincial exams on exact subjects with little writing, as it is easier for teachers to mark them.

This suggests that course selection in senior high school may not necessarily reflect students' career decisions, but a strategy to fulfil school graduation, to cover a broader range of post secondary admission requirements and to meet parental demands. As shown in this study, not all students who take and excel at several science courses have the intention to pursue a career in science-based fields. Yet, large proportions of students who perform well in a specific Grade 11 science discipline do not necessarily continue it, and the existing data do not permit to explain why this happens.

Science high school preparedness still remains a pre-requisite for specialization in science and engineering fields. The role of high school years and early orientation toward science is emphasized in the literature (Sonnert, 1995, p.165), so a natural question arises: Would it be more beneficial for students with expressed academic interest in science to receive a more discipline-oriented instruction? Apparently, some career destinations can benefit from a longer and deeper acquaintance with academic disciplines that build the foundation of those particular careers. I would argue that mathematics and some sciences, like physics and chemistry, fall into this category and this is one reason why the science community has such strict rules about timing, continuity and specialization. For instance, mathematical skills are developed and consolidated through practice; mastering these skills eases further understanding by following steps in logical connection with previous ones. The B.C. high school system encourages students to diversify their course selection by trying a large variety of subjects, a practice that supports a broad education approach. However, it may limit the time that science-oriented students can use to excel in science disciplines and
may be a reason why only the best achievers feel encouraged to persevere.

One has to acknowledge that "making early career decisions" that would place the student on the desired trajectory becomes a requirement for those who intend to pursue science-related careers. For instance, as shown in this study, students within the physical sciences high school profile who feed the science and engineering groups enrol in university studies immediately after school graduation. The role of science teachers becomes salutary in informing all students, independent of gender, on the pros and cons of science-related careers and the educational pathways to follow. Since girls and boys with highly educated parents benefit of guidance and have access to resources, they can make informed decisions and avoid delays that cannot be easily recuperated.

Cultural Capital

Parental background contributes in creating values embodied in the individual (Andres, 1994) and facilitating the accumulation of children's academic capital along various stages of education. In Bourdieu's theory, cultural capital is discussed in relation to family and does not comprise the distribution of academic credentials, which is an attribute of the school system. He argues that schools are only places where the cultural capital of the middle and upper classes is reified and rewarded. Therefore, the educational system contributes in reproducing the social structure.

Findings in this study show the consistent role exerted by parents in building up children's academic capital. Parental education plays a role in respondents' senior high school course choices, it is related to their post-secondary participation one year after school graduation and still exerts an influence on their educational attainment ten years later. However, it was found that the effect of parental background on the specific post-secondary academic programs and specialization fields selected by respondents is less evident.

Overall, cultural capital that respondents have inherited exerts influence on their educational outcomes even if it becomes more diffused over the years. This relationship can be interpreted as a transfer of values, traditions and beliefs to children, and reinforces the need to address the question of equity for students coming from families with less education and the enhanced role of school that should compensate for cultural capital differences. These
students are definitely disadvantaged in planning for post-secondary education, and this situation is even more aggravated for science-based pathways that demand early orientation, guidance and educational support. In terms of policy, it is not sufficient to expect individual initiatives by principals or teachers to compensate for the missing cultural capital in order to make the educational system equitable. I would argue that this issue has to be treated at the provincial and national level and I will support this view by the following example.

In the sixties and seventies, in Romania, a former Eastern European country, I witnessed an equitable educational system with policies promoted and regulated at the national level. The system was based on a structured and diverse school education with an enhanced role played by teachers in guiding all students' learning and career planning, followed by a free tuition post-secondary system controlled by entrance exams. Teaching careers were valued by society and were well remunerated, and teachers in general showed remarkable professional ethics and career dedication. In the early eighties, the economic realities combined with the corruption of the ideological system led to a deterioration of education too. The secondary system did not offer the same quality of teaching and guidance, because teachers were overloaded, underpaid, and political criteria started to play a more significant role in career advancement. Meanwhile, entrance exams became barriers to the post-secondary system where mainly students who could afford extra-school preparation would get in. The entire educational system became inequitable and the most affected by the system were students from families with a lower socio-economic status. The fact that a number of teachers still wanted to do their job with dedication did not make much difference, since the general direction of the educational system was imposed from higher administrative and political levels. This example is extreme, but still suggests the enhanced role played by socio-political structures and societal trends in determining the characteristics of educational systems.

Cultural capital overlaps with some elements of social capital. Resources provided by social relations developed within families are both a source of social capital (i.e., network, relationships) and cultural capital (i.e., values, goods, knowledge) for individuals. School is the first major arena where young women and men start accumulating social capital, by capitalizing the cultural capital inherited from their families, acquiring
competences and credentials and developing a social network. This study has demonstrated the role of cultural capital in supporting respondents' education at various stages. It was hypothesized that tradition, values, guidance, information, financial support, all embedded in parents' education are essential in facilitating children's road through the educational system and towards professions.

In my view, both the education and occupational prestige of parents may also contribute toward creating and enlarging the social network that children start to accumulate especially during the post-secondary education stage when their career orientations are better defined. This social aspect is crucial in the field of science, mainly due to its male traditional environment that favours fraternity ideals. Especially for women, it is well documented that daughters and wives of scientists have a better chance to succeed along educational and career pathways. This is usually explained by the effect of father's encouragement on increasing the self-confidence of his daughter and/or by the understanding of the demands of a science career manifested by a husband scientist (Wasserman, 2000). Without denying the importance of the above aspects, I would argue that the enlargement of the professional network and the access to informational and material resources provided by the male representative in the family, who can better relate and negotiate with the community of male scientists, are even more significant. Therefore, family is a resource of actual and potential social capital.

**Human Capital: Who Invests along the Science Pipeline?**

In this study, the concept of human capital was used in relation to credentials and type of education acquired by respondents over the years. Human capital represents the sum of individual skills, competences and all other attributes that can be relevant to the labour market. This study is focused on the formation of human capital for sciences and engineering fields, as well as in mathematics and science education. It was shown that human capital in these fields could not be built without possessing and developing academic capital in the areas of mathematics and sciences. This process starts during school years and it is formally completed during long and diverse post-secondary stages. It never stops, as long as the individual has the chance to use his or her scientific abilities in the appropriate domain.
A finding of this study is that men who received science high school preparedness are more likely than women to keep their initial professional orientation and to continue in fields in which they have accumulated knowledge and skills. The science career model based on the concept of “accumulation of advantage and disadvantage” (Zuckerman, 1991, p. 53) suggests that persistence in a field becomes an advantage for those individuals who can consistently accumulate and develop academic and professional capital. Even more important is that by persisting in a field, individuals have enhanced chances to grow their reputational capital, a concept that relates to academic sciences and seeks to explain “why equally qualified women and men advance at different speeds in academic scientific careers” (King, 1994, cited by Glover, 2000, p.128). Being less visible in the scientific community, women have less of a chance to enlarge their network, to make their research known and to gain an “authoritative voice”. Staying for a long time in a field gives one specific knowledge, confidence and authority, making him/her known within scientific community.

The findings in this study that present the matching of secondary and post-secondary academic choices showed a clear gender difference for the physical sciences group, with only 13% of women continuing in physical sciences-related fields as compared to 44% of men. Meanwhile, women and men with life sciences high school preparedness showed similar patterns in matching high school and post-secondary academic choices (Figure 11). The available survey data cannot offer an explanation of the observed patterns. As shown in the study, female students with physical sciences preparedness shifted toward biological sciences, health and education fields and also made non-science academic choices in large proportions. My interpretation is that there is a combination of external conditions that make even the most determined women abandon their initial interest in physical sciences-related fields and try new career avenues where they can anticipate professional growth and do not feel marginalized. The idealist view that science is a rewarding activity by itself is outdated and no male scientist is doing science without professional benefit. Science is a social activity in which the individual needs to be integrated and to have his or her contribution recognized – a simple rule that has to be applied for both women and men.
The study has also addressed the issue of human capital in science education. Surprisingly, ten years after high school graduation the available human potential for this domain was proportionally lower in science than in humanities. A larger number of respondents with a Bachelor's in Arts have also earned teaching certificates ten years after high school graduation. Maybe decisions for science teaching are taken later in life? It can be speculated that individuals with scientific preparation try to use their credentials in other fields and turn later to teaching for various reasons. In this study, a larger proportion of respondents with both science and education credentials, which are more clearly oriented toward teaching, were women. Another tendency observed in the study was that men in science and engineering are more tempted than women to obtain a variety of professional credentials. Since existing data on the B.C. science teacher population indicate a male predominance, it is possible that men with science credentials try initially careers in industry or post-secondary education (better paid, more power involved) and turn toward secondary teaching later in life. The above patterns show that women and men with same qualification have different orientation for using of their credentials.

Who invests along a science-oriented pathway? I would argue that the individual investment is extremely large: it requires a focus on disciplines that are demanding, time consuming, contain very specific type of knowledge and are dominated by a continuous filtering process. Can the individual transfer and use this knowledge in different fields if by necessity he or she has to shift the educational or career pathway? Based on the findings of this study, a large number of respondents with science preparedness in high school and post-secondary education did succeed along different educational pathways. There is a net personal and societal benefit of transferring and using scientific skills in other fields of activity, as long as the decision to make the educational shift belongs to the individual and is not imposed by external circumstances. Available data used in this study cannot explain why the science pipeline is leaking mostly women and whether this situation is the result of continuous emotional pressure exerted on female students during school years and post-secondary stage as emphasized in other studies (Etzkowitz et al., 2000, p. 93).

The study's findings confirm that the filtering process along the science pipeline affects women in larger proportion than men, so that women would less efficiently turn
their academic capital into human capital. This is not only an individual issue, since society also invests in science-oriented pathways: the cost of equipment for a science lab is definitely larger than the cost for an English class. Certainly, most of this investment is retrieved in an increase in science literacy and in the fact that individuals who received some training in science can transfer elements of the methodology of science in other fields. Still, this is not an optimal capitalization of the resources invested by individuals and society in science-related educational and career pathways. Overall, at the level of society the diminution of a diverse human capital on the labour market is a loss, especially for fields of activity where it is recognized that a diverse and well-qualified labour force would be beneficial (Brzustowski, 2002).

Some areas are affected especially. According to some authors (e.g., Fuller, 2000), science education is experiencing a moment of crisis. A gender mixed audience portrays science as unapproachable, unrelated to one’s life and, thus, dehumanizing. Scientific rigour is perceived as rigid; science complexity seems overwhelming and scientific reasoning is seen as inefficient by a large number of people. Fuller claims that, due to the current situation of low science literacy, science has failed to "liberate people". In order to improve the image of science and to bring this human activity closer to the understanding of the large public, all members of the scientific community should be overtly allowed to contribute their views toward improving science communication. Science education requires both capability to understand natural phenomena and talent to communicate your knowledge, by engaging people in a friendly endeavour of discovery. I would argue that women with scientific backgrounds can bring a huge contribution in making science a friendly discipline, in the name of that acknowledged “calling” they might have toward “people-oriented fields”. Findings in this study show that a very small proportion of science qualified respondents turned toward high school science teaching ten years after high school graduation. In addition, the proportion of women with science degrees being still small, there is little chance to increase women participation in science education. This is one of the biggest losses since it is through science education that people can change their mentalities and views about science, in general, and specifically about the role that it plays in society.
Retention and Advancement in the Field of Science

Time is a significant enemy of professional women, especially when career and family duties are combined. Since time has a different “lapse” for adult men and women and since the science-related fields are shaped by the masculinist style, women feel more pressured about keeping in step with their colleagues. It is emphasized in the literature that, in the case of science-related professions, a longer career-search process and/or a long time to establish in the field becomes critical. Since successful pathways in science are traditionally linear, continuous, and started at the “right time”, there is a possibility that the hesitant or uninformed student or professional will not be able to persist and succeed in the field. This is not related to one’s ability, it is just a mismatch of rhythm, which is usually aggravated during graduate years and throughout their career.

Moreover, most university science departments are still rigid about offering alternative ways for "getting in" and "staying on" academic programs that can lead to a successful science-related career when the traditional “high-school-calculus-through-PhD” track is skipped for various reasons. Interrupting a science-oriented pathway for personal or professional reasons makes the return to the track almost impossible, especially if a career in academia is envisaged. This situation affects women more than men since women have a different life cycle and, following this rigid traditional track, they have by necessity to delay the moment to start a new family and have children. British Royal Societies (Glover, 2000), have suggested that the concept of “academic age” should be introduced to avoid penalization of those “who have not had a traditional linear research career” (p. 26).

To support women participation in science and engineering, the National Science and Engineering Research Council of Canada (NSERC) launched in 1998 a program called University Faculty Awards that is open exclusively to universities wishing to appoint women scientists and engineers in academic positions. This initiative followed the establishment in April 1997 of the five NSERC Chairs designed to encourage the participation of women in science and engineering by “developing strategies to encourage female students in elementary and secondary schools to consider careers in science or engineering, as well as sensitizing faculties on how to improve and promote the integration of women students and professionals” (NSERC Website). In a recent paper on challenges faced by research funding in Canada, Tom Brzustowski (2002), NSERC President,
recognized that women participation in science and engineering is essential for individual fairness reasons and for societal reasons “at a time when we face a looming shortage of HQP” (p.3).

The leaking science pipeline is certainly a low retention system along all educational and career phases. Feminist literature emphasizes that “staying on” in the field of science and engineering is harder for women than for men, and this fact is not related to ability, or educational level, or even marriage and motherhood (Fox, 1996, p.283). Women experience less stability and continuity in the labour market. The findings in this study show that women with science credentials are less satisfied with their career and work, would not choose the same line of work in the same proportion as men and are looking for a new job. There are definitely labour market factors that hinder women’s work satisfaction: the “chilly climate” mentioned so often is not a figure of speech. Women’s chances to “get on” the ladder in academic scientific employment or in managerial positions in industry are also reduced and women held the most insecure and poorly paid positions (Glover, 2000, p.54). This situation creates frustration and may contribute to a decrease of work productivity. In this study, women who earn credentials in science and engineering are satisfied with their education, but are less happy than men with their career and find that their education is not strongly related to work. Since the data used in this study cover only ten years after school graduation, most respondents with science-related credentials are perhaps employed in industry, some are continuing the long graduate education track, and few are in secondary education teaching or are employed in other sectors, so issues of retention and advancement are less pronounced. Still, women and men in these fields manifest different levels of satisfaction with their professional growth.

Even if all stages of the “leaking science pipeline” are under scrutiny, there is still a tacit agreement that encouraging more young women to enter the fields of science remains our first priority through creating a large supply pool to feed the science pipeline. Efforts are directed toward reaching a sufficient "critical mass" of female students and professionals who, at least theoretically, will actively change the climate of academic departments and workplaces. It follows that as more women penetrate science fields, the result will be a greater number of successful female scientists at the other end of the science pipeline. Etzkowitz et al. (2000) discuss the "paradox of the critical mass for
women in science" and argue that the issue of women participation in science cannot be solved by simply increasing a specific minority group numerically and it is also important to have women represented at different points in the hierarchy of the professional field as men are.

In a recent paper (Adamuti-Trache & Andres, 2002) we also expressed a concern regarding the efficacy of the "critical mass" strategy that directs the attention toward the group of successful women in science, by searching for an increased quota, striving to learn how they survived in science and expecting to discover miraculous "tips" leading to other women's success. This mentor-oriented approach, while useful for those young women who are already on their way into scientific or engineering fields, is yet a unilateral "numerical" strategy. Focusing on successful stories will produce only a limited view on reasons that prevent many other women from embracing and/or persisting in scientific careers. On the contrary, following the paths of women who abandon science at various stages can bring a more realistic insight into existing barriers and gender inequities. The above argument leads to the conclusion that research needs to be done from a broader perspective that would include data on all female students who are potential candidates for scientific and technological careers. This argument supports the design of this research, which is developed from the perspective of all young women and men who could have a chance to go into science and engineering fields based on their high school academic capital.

6.3 Recommendations

Reinforcing the Importance of Studying Math and Science in High School

Mathematics and science background at the high school level can be beneficial even for students who intend to follow non-scientific educational pathways. This preparation would keep more options open in students' future educational and career pursuits. Even those students who do not go on to science careers will find their skills useful in a wide range of fields. I would argue that basic math and science knowledge is an important part of the formation of a well-rounded personality for non-scientists, in the same way that basic preparation in humanities contributes to forming well-rounded scientists.
More Specialized and Focused Math and Science Programs in High School

Early, continuous and focused preparation in math and science is demonstrated to be a key of success in science-related fields (i.e., demonstrated by study findings and current practice in science and engineering communities). There is virtually no movement from non-scientific to math and science oriented education. Students who persist in science-related programs have a good start in high school math and science courses and persist along their initial pathways. The notions of "keeping all options open" and "making early career decisions," frequently used in high school, are somehow conflicting, especially in the case of very competitive careers, like science and engineering. It may be useful to consider a more specialized and focused high school preparation of students who demonstrate early ability and interest in science.

The Need for Information on Career Pathways

High school career preparation needs to include concrete information about the demands of various careers, and not only about formal ways to get into those career pathways. In most cases, "staying on" a career pathway is more challenging than "getting into" it. This is the case for science-related careers. Knowledge of specific career demands includes data regarding formal and informal education, work conditions, career growth opportunities, and the educational and career environment. This strategy may help individuals find out earlier in time whether their personality, goals, and intended lifestyle would fit into a specific career path. Especially in the case of students from families with less educated parents who have reduced access to resources, high school teachers should provide guidance in career planning by offering concrete information on educational and career pathways related to their subject of teaching.

Training of Teachers to Provide Information about Specific Careers

If school counsellors can provide general information about post-school pathways, then knowledge about specific careers has to be provided by subject matter teachers. The training of teachers has to include a mandatory component on "post-secondary education and high school career orientation". Teacher Education Programs should collaborate with Science Departments to promote mathematics and science education to undergraduate students. More
female teachers in these disciplines would contribute to changing current career stereotyping and would bring their views regarding teaching styles, curriculum and the participation of women in science-related professions.

**Stronger Links between Secondary and Post-secondary Instructors**

A stronger and more coordinated link between high school teachers and the post-secondary units related to each teacher's subject matter could be beneficial both for keeping secondary school teaching updated and for gathering useful career information to be transferred to students. Moreover, teachers in the subject may consider themselves better affiliated to the field, which would contribute to the growth of a scientific community at large.

**Examining the Structure of the Science and Math Offerings at University**

Post-secondary personnel, and in particular university math and science faculty, need to examine the structure of their undergraduate and graduate program offerings (e.g., the limits of studying part-time) in light of the findings of this study. While individual agency is one determinant of participation in and completion of studies in science and math, the structure of the system is another determinant. The emphasis needs to shift from students choosing science and mathematics programs to these programs choosing and retaining qualified students.

**Examining the Learning and Teaching Styles in Science at University**

Science departments, with their dominant male-faculty composition, are unlikely to consider the problem of diversity raised by research on gender and social-psychological or cognitive aspects. This lack of concern for the learning problems of undergraduate students affects both female and male students in their first years of university. More attention should be paid by faculty in developing and experimenting various teaching styles with equal emphasis on both the theoretical and the applied aspects of science disciplines.

**Stronger Links among University Departments**

Science departments should manifest more interest toward educational research regarding issues related to science learning, science teaching, participation in science, graduates outcomes, faculty development, usually undertaken within other University departments.
(Education, Sociology, Economics). Research findings concern science students, science faculty issues, scientific community relations, so they can constitute a resource for a well-documented policy-making process within science departments. Developing a line of communication among the departments that own a specific category of human potential and departments that study issues and relations related to that group of population would be of mutual benefit.

6.4 Implications for Further Research

Since the rigid high-school-through-calculus-to-PhD track is usually recommended for a scientific career, most universities do not offer flexible academic programs in science. As a result, many potentially talented candidates either do not embark at all in scientific fields or opt out of these fields at various stages. Since science-related careers cover a broad range of job market occupations, university needs to develop strategies to prepare graduates for a variety of fields and also, to offer these graduates the chance of educational growth while working. Therefore, the institutional structures and policies of academic science-related departments may need to adjust to the current demands of a rapidly changing society. More research needs to be done on the impact of institutional structures of academic programs on students' decisions regarding choice of educational pathways and future careers.

Likewise, research needs to be directed toward analyzing female students’ standpoints concerning their own abilities, achievements and experiences, in order to understand better the issue of gender within undergraduate education (i.e., the practice of science and science education). Research reveals that it is men who mainly exert control over science practice (taught, researched, or applied), as well as over the assessment of scientific success. On the other hand, it is acknowledged that science has gained increased social, political, ethical and cultural valences. Neither is science the exclusive activity of an isolated lab scientist any longer, nor should it be limited to the property of a privileged community or gender group. Since science is continuously enriching its content and bonds with society, the practice of science itself should be re-designed for an increased accessibility. Research on the ability of women to practice science in a social context that in fact tends to exclude them would also demonstrate the role women could play in the
social reorientation of science (e.g., science education, science communication, science literacy, improvement of relations within scientific community).

Research regarding the issue of balancing women's multiple roles in society, as well as the issue of dual-career for scientists' couples, is still scarce. The task of addressing these issues is meant to establish social justice between the two groups. The practice of scientific disciplines requires improvement, so as to offer multiple alternatives for professional choices and growth. Moreover, young girls should be aware that these opportunities exist and can lead to long-term plans. These issues could be approached as part of a socio-pragmatic feminist agenda meant to guide the feminist activism toward effectively gaining support for women. However, this range of social and educational problems exploring the socio-cultural context meant to favour women's growth in scientific fields is still a research topic.

The findings of this study could be significant, by raising the question of what is actually happening to those students who exit science paths and whether these paths still offer reasonable career alternatives. An important issue for educational practice would be the design and development of educational model for training scientists that would likely encourage students to assume the risk of scientific careers, without the fear of jeopardising their future personal and professional accomplishment.

6.5 Conclusion and Final Remarks

The major intent of my research is to inform educators, administrators, school and university policy-makers of trends in post-secondary educational, as well as occupational orientations of young women and men in relation to mathematics and science-based study and careers. Since the focus of my study was female students with interests and potential to succeed in scientific and technological fields, the findings and conclusions can also support further initiatives for improving practices within the scientific community. There is also a market-led concern that aims at ensuring that women who have been trained at considerable expense do not leave science and technology employments. A plenary use of the whole available workforce is also an aspect of a wise economy politics, the more as the human right of each individual is to have his/her contribution to the society recognized, utilized and valued.
What does *Class of ’88* tell us about the educational and career pathways in science of current high school graduates? (Andres et al., 2002) A legitimate question is whether math and science education have changed enough over the years as to produce outcomes that will differ from the ones obtained in this study. A logical hypothesis is that significant change along the post-secondary pathways can be expected only if the “science pipeline” is leaking fewer men and women at the high school level.

Table 14. Participation Rates in B. C. Provincial Exams

<table>
<thead>
<tr>
<th>Year</th>
<th>BIOLOGY (%)</th>
<th>CHEMISTRY (%)</th>
<th>MATHEMATICS (%)</th>
<th>PHYSICS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fem Male Total</td>
<td>Fem Male Total</td>
<td>Fem Male Total</td>
<td>Fem Male Total</td>
</tr>
<tr>
<td>1991-1992</td>
<td>39 26 33</td>
<td>24 30 27</td>
<td>38 50 44</td>
<td>8 23 15</td>
</tr>
<tr>
<td>1993-1994</td>
<td>41 27 34</td>
<td>27 32 .29</td>
<td>42 54 48</td>
<td>10 25 17</td>
</tr>
<tr>
<td>1995-1996</td>
<td>45 28 36</td>
<td>31 33 32</td>
<td>45 54 49</td>
<td>12 26 18</td>
</tr>
<tr>
<td>1996-1997</td>
<td>45 27 36</td>
<td>29 33 31</td>
<td>45 55 50</td>
<td>10 26 18</td>
</tr>
<tr>
<td>1997-1998</td>
<td>45 26 36</td>
<td>29 31 30</td>
<td>44 54 49</td>
<td>10 25 17</td>
</tr>
<tr>
<td>1998-1999</td>
<td>44 25 35</td>
<td>28 30 29</td>
<td>42 52 47</td>
<td>10 26 18</td>
</tr>
<tr>
<td>1999-2000</td>
<td>44 25 35</td>
<td>26 29 28</td>
<td>40 50 45</td>
<td>10 25 17</td>
</tr>
</tbody>
</table>

Table 14 shows the participation in math and science provincial exams for B.C. young women and men, over the last ten years. Had the participation rates been changed over years, one would expect that the science-related educational pathways would have also become more open and attractive to young women and men. This is not the case, since mathematics and science courses still receive insufficient attention by both female and male students. Advanced science and math courses that are supposed to open a broader range of post-secondary educational pathways to all students are still considered by less than half of B.C. high school students. Gender differences are still pronounced and are largely unfavourable for women. The issue of under-representation of women in science and engineering cannot be resolved as long as starting conditions are unchanged at the high school level. Therefore, the issues raised by this study are still current.
This study began by addressing the questions whether high school course selection is an indication of students’ interests and career preferences and whether course selection would limit future post-secondary choices. Study findings demonstrate that by selecting mathematics and science courses, students’ future options are broadened with respect to both the type of degrees earned and the variety of careers pursued. This is definitely a positive result that suggests that from an educational policy perspective, enhancement of mathematics and science education opportunities should be provided for all students. If the main scope of secondary education is to diversify students’ career choices, then promoting science learning to girls and boys and attracting more students toward science appears to be indeed a promising strategy.

However, the high school stage may not have only an eye-opening role in shaping students’ career dreams. For some students, high school course selection might already reflect their aspirations and expectations of continuing and succeeding in a specific field. If this hypothesis were valid for B.C. young women, then study findings would lead to the conclusion that science-related fields, supposed to be fed by the physical and life sciences high school profiles, present the highest loss of human capital in education and work force. It is definitely possible that women who are capable and willing to find their place in the science-related work force feel pressured to abandon their scientific career dreams when entering post-secondary education. Since these women have always set high standards for themselves and still have high expectations for their educational and professional accomplishments, they would naturally prefer to use their talent in fields where they feel welcome. Cases of women forced out of the science community or stories of those staying within it, yet being unhappy with their accomplishments are the ones who, directly or indirectly, shape the social image of science and perpetuate gender stereotypes. These voices need to be better heard and understood since they can provide invaluable information on what exactly actually hinders effective social change regarding the retention of women in science.
"Leaking science pipeline": this is the most frequently used metaphor in the research area of women and science and it portrays the current model of training and filtering of scientists along their educational and career pathways. Competitiveness (e.g., number of publications), aggressiveness (e.g., imposition of views), arrogance (e.g., belief that only science-related professions are worthwhile), elitism (e.g., exclusive network), are some of the features of the traditional style of training and succeeding along the pipeline system, conceived as having just two openings: a chosen “entry” and a potential, if successful, “exit”. In between, the pipeline “leaks” out plentifully all along, while remaining impermeable to any incoming flow of individuals from other fields. The above imagery may seem inconceivable, but the whole science-related educational and workforce system is built mostly on this rigid concept. A major conclusion of this thesis is that a revision of the socio-educational context of science practice, especially of structures and policies within academia, should be a priority for policy makers and administrators.

What should be expected from an improved and updated model of science-related pathways? The most important features would be career flexibility (i.e., over time and across disciplines) and openness to change (i.e., higher level of adaptation to societal needs). A metaphoric description of this new model would represent it as a more Open & Non-linear System with many entry and exit points (Hollensbead et al., 1996), various levels of educational or career achievement, and higher connection to the labour market and to other scientific or non-scientific fields. This model is not expected to affect the foundation and content of science, while updating its social context to the current societal needs and increasing the diversity of its human capital. Moreover, this change is meant not only to improve the condition of women’s participation in science, but also to create an environment that would offer equitable professional opportunities for all talented people who believe in the wonders of science.
REFERENCES


B. C. Ministry of Education Data (1999). Database and Reports on B. C. Provincial Exams. @ http://www.bced.gov.bc.ca/exams/standrep/


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### Grade 11 and Grade 12 Math and Science Participation for the Class of '88

#### Table 1: Non-continuance Rate in Math and Science Courses - Class '88 Graduates
(N = 9,998; Female = 5,168; Male = 4,830)

<table>
<thead>
<tr>
<th>Course</th>
<th>Grade 11</th>
<th>Grade 12</th>
<th>G11 school mark</th>
<th>Non-continuance (#students)</th>
<th>Non-continuance rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># studs (%)</td>
<td># studs (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>4,057 (79%)</td>
<td>2,326 (44%)</td>
<td>69</td>
<td>1,731</td>
<td>43%</td>
</tr>
<tr>
<td>Male</td>
<td>3,860 (80%)</td>
<td>2,738 (58%)</td>
<td>70</td>
<td>1,077</td>
<td>28%</td>
</tr>
<tr>
<td>Total</td>
<td>7,917 (79%)</td>
<td>5,109 (51%)</td>
<td>70</td>
<td>2,808</td>
<td>35%</td>
</tr>
<tr>
<td>Biology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>3,858 (75%)</td>
<td>2,499 (48%)</td>
<td>71</td>
<td>1,359</td>
<td>35%</td>
</tr>
<tr>
<td>Male</td>
<td>2,541 (53%)</td>
<td>1,537 (32%)</td>
<td>70</td>
<td>1,004</td>
<td>40%</td>
</tr>
<tr>
<td>Total</td>
<td>6,399 (64%)</td>
<td>4,036 (40%)</td>
<td>70</td>
<td>2,363</td>
<td>37%</td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>2,602 (50%)</td>
<td>1,394 (27%)</td>
<td>72</td>
<td>1,208</td>
<td>46%</td>
</tr>
<tr>
<td>Male</td>
<td>2,729 (56%)</td>
<td>1,724 (36%)</td>
<td>73</td>
<td>1,005</td>
<td>37%</td>
</tr>
<tr>
<td>Total</td>
<td>5,331 (53%)</td>
<td>3,118 (31%)</td>
<td>72</td>
<td>2,213</td>
<td>42%</td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1,629 (32%)</td>
<td>384 (7%)</td>
<td>72</td>
<td>1,245</td>
<td>76%</td>
</tr>
<tr>
<td>Male</td>
<td>2,637 (55%)</td>
<td>1,366 (28%)</td>
<td>71</td>
<td>1,271</td>
<td>48%</td>
</tr>
<tr>
<td>Total</td>
<td>4,266 (43%)</td>
<td>1,750 (18%)</td>
<td>72</td>
<td>2,516</td>
<td>59%</td>
</tr>
</tbody>
</table>
APPENDIX B

Description of Profiles and Groups Used in Correspondence Analysis Maps

The Correspondence Analysis maps are based on crosstabulations tables of row and column profiles. Across rows I used either four groups defined by gender (2 categories) and parental educational attainment (2 categories) or sixteen groups defined by high school profiles (4 categories) and gender (2 categories) and parental educational attainment (2 categories). The two categories of parental education correspond to at least one parent with university and no parent possessing university degrees. Tables 4 and 8 in the text introduce these categories and the distribution of respondents across them. Categories are explained below:

<table>
<thead>
<tr>
<th>Group Description</th>
<th>CA map notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female students; parents no university degree</td>
<td>fem_nonuniv</td>
</tr>
<tr>
<td>Female students; parents university degree</td>
<td>fem_univ</td>
</tr>
<tr>
<td>Male students; parents no university degree</td>
<td>male_nonuniv</td>
</tr>
<tr>
<td>Male students; parents university degree</td>
<td>male_univ</td>
</tr>
<tr>
<td>Nonscience profile; Female students; parents no university degree</td>
<td>NS_fem_nonuniv</td>
</tr>
<tr>
<td>Nonscience profile; Female students; parents university degree</td>
<td>NS_fem_univ</td>
</tr>
<tr>
<td>Nonscience profile; Male students; parents no university degree</td>
<td>NS_male_nonuniv</td>
</tr>
<tr>
<td>Nonscience profile; Male students; parents university degree</td>
<td>NS_male_univ</td>
</tr>
<tr>
<td>Mathematics profile; Female students; parents no university degree</td>
<td>MA_fem_nonuniv</td>
</tr>
<tr>
<td>Mathematics profile; Female students; parents university degree</td>
<td>MA_fem_univ</td>
</tr>
<tr>
<td>Mathematics profile; Male students; parents no university degree</td>
<td>MA_male_nonuniv</td>
</tr>
<tr>
<td>Mathematics profile; Male students; parents university degree</td>
<td>MA_male_univ</td>
</tr>
<tr>
<td>Life sciences profile; Female students; parents no university degree</td>
<td>LS_fem_nonuniv</td>
</tr>
<tr>
<td>Life sciences profile; Female students; parents university degree</td>
<td>LS_fem_univ</td>
</tr>
<tr>
<td>Life sciences profile; Male students; parents no university degree</td>
<td>LS_male_nonuniv</td>
</tr>
<tr>
<td>Life sciences profile; Male students; parents university degree</td>
<td>LS_male_univ</td>
</tr>
<tr>
<td>Physical sciences profile; Female students; parents no university degree</td>
<td>PS_fem_nonuniv</td>
</tr>
<tr>
<td>Physical sciences profile; Female students; parents university degree</td>
<td>PS_fem_univ</td>
</tr>
<tr>
<td>Physical sciences profile; Male students; parents no university degree</td>
<td>PS_male_nonuniv</td>
</tr>
<tr>
<td>Physical sciences profile; Male students; parents university degree</td>
<td>PS_male_univ</td>
</tr>
</tbody>
</table>

The columns in two-way contingency tables describe various profiles:

a) High school Profiles: four groups characterized by students' high school preparedness.
   - Non-science group (NS)
   - Mathematics group (MA)
   - Life Sciences group (LS)
   - Physical Sciences group (PS)
b) Post-school participation profiles: four categories describing respondents' status one year after high school graduation.

University participants (UNIVERSITY)
Non university participants (NON UNIVERSITY)
Non Post Secondary Participants (NON PSEC PARTIC)

c) Educational attainment profiles

University graduates (UNIV GRADS)
Non University graduates (NON-UNIV GRADS)
Attended & did not complete Post-Secondary credentials (NON COMPLETERS)
Never enrolled in a Post-secondary institution (NO PS PARTIC)

d) Post-secondary academic programs – one year after

General Academic (GENERAL)
General Science programs (GENERAL SCIENCE)
Humanities programs (HUMANITIES)
Science and Engineering programs (SC & ENG)
Other programs (OTHER)

e) University specialization fields

EDUCATION
ENGINEERING
HEALTH
HUMANITIES
SCIENCE
OTHER
APPENDIX C

Survey Questions Used in this Study

1989 Survey:

18. Using the 2 columns below, please indicate:
   a) the highest level of education that you WOULD LIKE to attain:
   b) the highest level of education you WOULD EXPECT to attain, as things stand now.

<table>
<thead>
<tr>
<th>(a)</th>
<th>(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Would Like</td>
<td>Would Expect</td>
</tr>
<tr>
<td>CHECK FOR EACH COLUMN</td>
<td></td>
</tr>
<tr>
<td>Grade 12 graduation</td>
<td></td>
</tr>
<tr>
<td>Apprenticeship certificate</td>
<td></td>
</tr>
<tr>
<td>One or two years diploma from a college or technical institute</td>
<td></td>
</tr>
<tr>
<td>Bachelor's degree</td>
<td></td>
</tr>
<tr>
<td>Professional degree (law, medicine, teaching, dentistry, etc)</td>
<td></td>
</tr>
<tr>
<td>Graduate degree (Master's or Doctorate Degree)</td>
<td></td>
</tr>
</tbody>
</table>

1998 Survey:

34. To what extent do you agree that the following describes your present or most recent job? (If you are currently working at more than one job, answer with reference to the one you consider to be your primary job) (check one for each line)

<table>
<thead>
<tr>
<th>Extent of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
</tr>
</tbody>
</table>

   e) The chances for promotion are good
   i) The job gives me a feeling of accomplishment
   k) The job is directly related to my education and training

43. In your lifetime, what is the highest level of education that you WANT to achieve? (check one)

   a. Secondary school diploma
   b. Apprenticeships, vocational, or trade school
   c. Some community college, no diploma/certificate
   d. Community college, diploma/certificate
   e. Some university, no degree
   f. Completed Bachelor's Degree
44. Given the realities of today's educational system and work world, what is the highest level of education that you EXPECT to achieve? (check one)

a. Secondary school diploma
b. Apprenticeships, vocational, or trade school
c. Some community college, no diploma/certificate
d. Community college, diploma/certificate
e. Some university, no degree
f. Completed Bachelors Degree
g. Completed Professional Degree (medicine, law, engineering)
h. Completed Masters Degree
i. Completed Doctoral Degree
j. Other (please specify)

46. Please indicate the extent to which you agree with the following statements about work, education and general well-being (check one for each line)

<table>
<thead>
<tr>
<th>Extent of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Disagree</td>
</tr>
<tr>
<td>No opinion</td>
</tr>
<tr>
<td>Agree</td>
</tr>
<tr>
<td>Strongly agree</td>
</tr>
</tbody>
</table>

u) It is still more difficult for women to succeed in the work force...

75. Thinking back to when you were in high school and the kinds of hopes you had then, how satisfied are you with the way things have turned out for you now in each of the following areas (check one for each line)

<table>
<thead>
<tr>
<th>Extent of Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very satisfied</td>
</tr>
<tr>
<td>Somewhat satisfied</td>
</tr>
<tr>
<td>Somewhat dissatisfied</td>
</tr>
<tr>
<td>Very dissatisfied</td>
</tr>
</tbody>
</table>

c) My work or career...
e) My educational attainments...