2006

Learning practices and teaching methods as factors in gender inequity in undergraduate computer science programs.

Dorian Stoilescu
University of Windsor

LEARNING PRACTICES AND TEACHING METHODS AS FACTORS IN GENDER INEQUITY IN UNDERGRADUATE COMPUTER SCIENCE PROGRAMS

By

Dorian Stoilescu

A Thesis
Submitted to the Faculty of Graduate Studies and Research
Through the Faculty of Education
in Partial Fulfillment of the Requirements for
the Degree of Master of Education at the
University of Windsor

Windsor, Ontario, Canada

2006

Your file Votre référence
ISBN: 978-0-494-17087-8
Our file Notre référence
ISBN: 978-0-494-17087-8

ABSTRACT

The primary purpose of this study is to detect student difficulties in adapting to the undergraduate computer science program. The research was conducted in the Department of Computer Science at a medium sized urban university in Ontario. Subjects were 16 students (ten males and six females) from the first to the third year of study and two professors. For this research mixed methods methodologies (QUAL+quan) were used. Qualitative methods were preponderant and were used in order to explore differences and difficulties both genders have in computer science program and modalities to deal with them. Quantitative methods were used to compare and analyze some of the details.

Most female students had initial experience in using computers but few of them had previous experience in programming. During the program they were focused more on academic achievements but they were not oriented to developing practical projects and preparing for the realities of work in the IT industry. In relation to teaching, female students were more sensitive to teaching than male students. During the program, anxiety, lack of confidence and underachievement of female students progressed.

The research revealed that the majority of males had initial experience in computer programming. During the program, they acquired more confidence and greater experience in programming and had more mature thoughts about the IT career than their female colleagues. Male students were oriented more on achieving "real" experience. Due to the fact that males were working in different informal settings, this helped them to extend and diversify their experience. Male students were more independent of teacher

performances, being more willing to take ownership of learning process, especially in cases when teaching was not effective.

Male students easily formed social networks that were able to help them. Female students had better social and communicational skills. However, because they were small in number and lacked initiative and support, they failed to coagulate social networks able to support themselves. Related feminism approaches, the author appreciate that liberal feminism is most likely to succeed in preparing women for a traditionally male dominated workplace.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to Dr. Clinton Beckford, Dr. Ian Crawford, Dr. Ziad Kobti and Dr. Dragana Martinovic for their encouragement and guidance in this dissertation. Gratitude is also expressed to Dr. Andrew Allen and Dr. Anthony Ezeife for their helpful suggestions.

A special gratefulness is accorded to the participants of this research, including students, professors and teacher assistants, who helped me with this study and answered my questions in a very insightful manner.

I would also like to thank my family for helping me to finish this paper: to my wife Paula, my parents, Maria and Enache for their full emotional support and finally, for my three sons, Iulian-Pavel, Daniel and David, that I love so much and who have brought my wife and I much satisfaction and happiness.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

General Statement of the Problem

Research indicates that there is a growing gap between male and female students in their performance in computer science (CS) courses. According to many researchers (Dryburgh 2000; Harrell 1998; Hancock, Davies & McGrenere, 2002; Todman 2000; Wilson, 2002) females feel less confident than males in pursuing computer science courses. The computer science discipline is growing rapidly. As a result, many teachers cannot or do not keep up with the latest technical and pedagogical practices (Margolis & Fisher, 2003). This failure perpetuates "old" ways of doing things and leads to the widening of the gender gap in computer education. This situation generates concern in improving the teaching methods in computer education (Jennings & Onwuegbuzie, 2001; Peterse & Sonnekus, 2003; Solvberg, 2003; Yuen & Ma, 2002).

This study investigated the impact of learning practices including teaching methods as factors that alienate female students and exacerbate the gender disparities in comfort level, performance, attitudes, and experience in computer education courses at undergraduate level. It studied tendencies and differences of each gender as they proceed through computer science program. The purpose of the study was to understand different strategies that male and female students have in pursuing computer science learning, identify teaching strategies that make female and male undergraduate students more effective, improve the communication between genders, and ultimately, reduce the differences in the performance of males and females in undergraduate computer science classes.

Definition of Terms

The following terms are used in this study:

Attribution

Attribution is "the explanation that people give for their success or failure in achievement settings" (Deboer, p. 325). The attributions for success or failure are: attribution to ability; attribution to difficulty of task; attribution to luck; attribution to effort.

Confidence in interacting with computers

Comfort with interacting with computers includes three aspects:

a. User confidence:

b. Programmer Confidence

c. IT Career confidence

User Confidence

User confidence relates to general confidence in computer use. It is a feeling of someone about his/her ability to complete different tasks, for general use. Researchers have developed several tests for this purpose:

- Technology Acceptance Model(TAM);
- Teachers' Computer Acceptance (TCA);
- Computer Self Efficacy (CSE);
- Computer Attitude Scale (CAS);
- Computer Anxiety Index(CAIN);
- Computer Opinion Survey(COS);
- The Theory of Planned Behaviour (TPB);

- Computer Educators who are Destined to Achieve Results (CEDARs);

These tests and the studies linked with them are presented in the Literature Review.

Programming Confidence

Programming confidence tests a person's opinion in performing specific tasks in developing software including designing, programming, debugging, and testing. One of the most popular tests is Computer Programming Self Efficacy Scale (CPSES). The test measures the feelings about one's ability to perform different tasks required in the C++ language (Ramalingam & Wiedenbeck, 1998).

IT Career Confidence

IT career confidence relates to confidence in technical and social aspects of IT management.

Mathematics Background

The number and level of mathematics courses taken in the high school and post secondary level.

Previous computing experience

This includes the use of the computer prior to entrance into an undergraduate computer science program in the following two ways:

a. previous computer programming experience

b. previous computer non-programming experience

Previous computer programming experience

These specific types of experiences include:

a. Formal programming course in a high school or occasional courses at a post-secondary institution

b. Self initiated programming in which a student learns programming outside of any formal class

c. Programmed learned in informal settings (friends, social networks, extra-class meetings, other)

Previous computer non-programming experience

These specific types of experiences include:

a. Information system tasks: installing/updating an operating system, configuring devices (printers, modems, monitors, and networks), installing/updating antivirus programs, and installing/updating different software packages.

b. Internet experience: using web browsers(i.e. Internet Explorer, Netscape, Fire Fox, Opera), search engines(i.e. Google, Yahoo, AltaVista), portals(i.e. Yahoo, MSN), e-mail programs, chat/messenger programs;

c. Office experience: using at least one of the following programs: text editors (MS Word, WordPerfect, Adobe PageMaker), spread sheets (Excel, Quattro), PowerPoint (i.e. MS PowerPoint),

d. Graphic programs experience (i.e. MS Paint, Adobe PhotoShop, CorelDraw, AutoCAD, 3DStudio)

e. Any software applied in any domain(i.e. in mathematics, business, engineering, science, education, arts)

STEM Disciplines

STEM stands for Science, Technology, Engineering and Mathematics. It represents the domains considered non-traditional disciplines for females, in which they are considered a minority.

Tokenization

The term tokenization means a reduced number of subjects with the same characteristics. In our case, the tokenization of women in computer science means few female students being in computer science courses.

Assumptions

In doing this research several assumptions were made:

1. The subjects voluntarily participated and gave honest answers to the questionnaire.
2. Previous research can be used as a basis for the design of this research study.

Limitations

It may be useful to keep in mind the following limitations:

This study does not propose to make any generalization about any other educational settings other than the Department of Computer Science of concern in this study. The period of observations was one semester consisting of the Intersession/Summer session of the year 2005.

Significance of the Study

The influence of computers is pervasive in all advanced countries. It is impossible to talk about progress without considering aspects of those who work in the Information Technology (IT) industry. Not having policies able to ensure a representative percentage of women in the IT industry, more than half of the overall working population, will deplete the human resources for IT industry (Margolis & Fisher, 2003). For this reason it is necessary to have both genders involved not only in using computers, but also in developing software.

A literature review reveals that a gender gap exists in computer science. Eliminating this gap represents one of the biggest challenges in computer science education (Solvberg, 2003; Young 2000). The goal of this study is to assess classroom learning practices in computer science courses, so as to identify factors that contribute to creating and perpetuating gender gaps and to suggest classroom strategies for eliminating or reducing these gaps. As such, this study will help benefit computer science educators and students as a whole. The university at which the study was conducted will benefit from:

- Recommendations regarding quality improvement on the computer science classes;
- The research process involved an evidence based-practice that may promote a decrease in undesirable attitudes for both genders.

Because of existing similarities among university curricula and the social environments of universities, this study may have implications for other Ontario universities.

CHAPTER II

LITERATURE REVIEW

Introduction

The review of literature has been organized thematically under four major aspects:

1. Socio-cultural facts about gender gap representation and performances in computer science;
2. Curricular settings that help learners to perform in computer science;
3. Specific ways to promote computer science learning for male and female students.
4. Policies required in order to establish a balanced activity between genders in computer science programs.

Socio-Cultural Facts about the Gender Gap in Computer Science

The problem of gender gap in computer science has been documented by many researchers (Margolis & Fisher, 2003; Wilson 2002; Gorski, 2005; Dryburgh 2000; Stoilescu 2005). The existing literature on the subject of females in computer science reveals four recurrent themes. These are:

1. The participation by gender in computer science has changed over time, with the number of females decreasing dramatically;
2. Different levels of experience and confidence between female and male students in computer science programs were observed;
3. Gender stereotypes, discriminations and allied feminist opinions about underrepresentation of females in computer science;

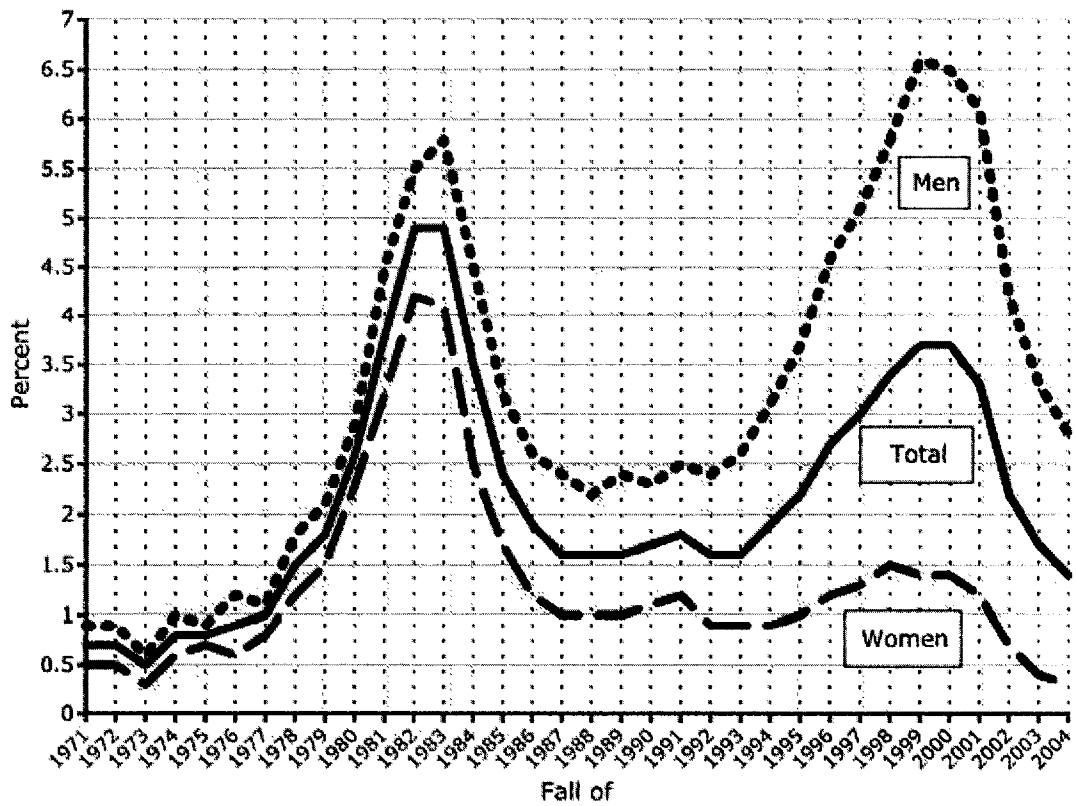
4. Social class, race, and ethnicity affect the percentage of women's participation in computer science.

The Number of Women in Computer Science Decreased Dramatically

Many researchers have observed the gender gap with regard to participation and performances in computer science programs after the 1980s (Ayersman 2002; Bhargava 2002; Greening 1999; Vegso, 2005; Wilson 2002).

In a study about trends among incoming freshmen, a survey from the Higher Education Research Institute at the University of California at Los Angeles (HERI/UCLA, 2005) indicates that computer science popularity decreased significantly. Alarmingly, the proportion of females who wanted to major in computer science has fallen to levels unseen since the early 1970s (Figure 1). The graph shows that overall, the number of students applying to major in computer science decreased from 3.5 % to 1.4%. Male applicants decreased from 6.8% in 1999 to 2.8% in 2004 while female applicants decreased from 1.5% in 1998 to 0.4% in 2004.

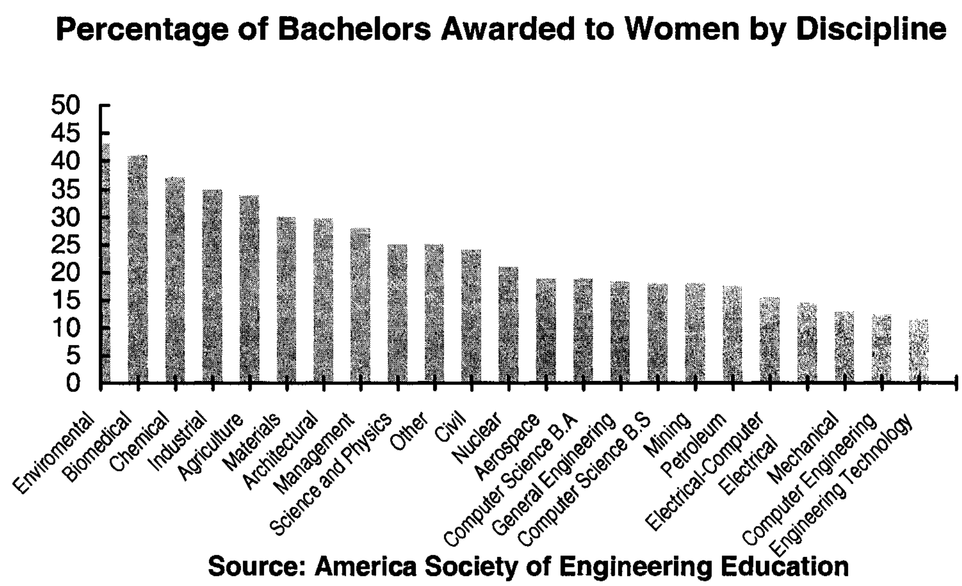
Figure 1: Computer Science Listed as Probable Major Among Incoming Freshmen (Source: HERI at UCLA)



In Canada, the percentage of women in computer science programs in higher education decreased from 27% in 1982 to 20% in 1992 (Dryburgh, 2000). The number of computer science undergraduate students follows the market tendencies. When the IT job market was high, the number of students going to computer science increased (HERI/UCLA, 2005). After the downturn in the IT market at the end of 2000, the competition to survive in IT field led to a dramatic decrease in the overall number of students enrolled in computer science post-secondary programs.

Figure 2 (ASEE, 2005) shows the percentage of science and technology Bachelor degree awarded to females in different disciplines. Of these 23 disciplines, computer disciplines ranked 17th. From this graph it can be inferred that computer science has one of the lowest degrees awarded among undergraduate female students.

Figure 2: Percentage of Bachelor's degree awarded to women by discipline (Source American Society of Engineering Education)



Dryburgh (2000) stated that the proportion of female students who graduated from a computer science program declined after 1985. At a time when there is an increasing demand for programmers and analysts, why are females becoming a smaller proportion of enrollment in computer science programs? Why do they fail to take this opportunity to enroll in a program that will lead to a good paying job? A review of the existing literature yields a multitude of reasons. At the elementary schooling level structural factors were important but by the post-secondary stage the emphasis was more likely to be psycho-social.

Before 2000, there were greater discrepancies between the male and female users. First, male users outnumbered female users. After 2000, researchers noticed that the number of female and male users was roughly equal (Sanders, 2005). Comparing the situation of females in IT industry in the UK, Canada and the US, Stoilescu, (2004) observed the same tendency in decreasing participation of women. In 2004, the percentage of women computer programmers in Canada and the UK was less than 10 percent. It was argued that an educational process able to keep up with the high pace of computer science changes, and teaching methodologies that integrate gender specificities would be necessary to decrease the problems of underrepresentation (Margolis & Fisher, 2003; Stoilescu, 2004). Improved teaching, mentoring and counseling activities can go a long way in reducing this gap (Stoilescu, 2004).

The Situation Is Different from Country to Country and Culture to Culture

According to a study by Charles and Bradley (2006), females are underrepresented in computer science in all 21 of the industrialized countries that form the Organization for Economic Cooperation and Development (OECD). The researchers found significant differences from country to country. For instance, Turkey and Ireland had the lowest rates of overrepresentation (1.778 and 1.84) while Czech Republic and Slovakia had the highest (6.42 and 6.36), more than three times that of Turkey and Ireland.

Grundy (2003) noted that the present trends are not the same over the world. While in Canada, USA, UK, and Northern Europe under representation is high, Eastern Europe, Southern Europe, Africa, Latin America, and SE Asia present a different picture. Grundy suggested that there is a lesson to be learned from the latter.

Galpin (2002) completed a study about higher education students from over 30 countries. He found the reasons females chose to pursue computing studies varied from country to country, and culture to culture. He suggests that designing solutions for the shrinking number of females require considering cultural and social facts. A solution from one country might not work in others. Many countries use all-girls schools such as India and many Catholic countries. In Israel and Mediterranean countries there is a strong family support to help female students cope with technological and scientific requirements. In other countries such as Portugal, Turkey, Latin America and India the computer science occupation is perceived as having a low social status. In Poland and Italy there are comprehensive requirements in mathematics and science which help female students to cope with IT requirements. Kheng (1990) found in Singapore more females in computer science than males because of government incentives for women, social encouragement and high social confidence that were created among them for IT careers.

In 2001, Statistics Canada in the Census of Population Report, presented data indicating shares of men and women in IT related occupations:

Table 1: Shares of Men and Women in IT related Occupations

Occupation	Men (%)	Women (%)
Data entry clerks	18.4	81.6
Desktop Publishing Operators	33.5	66.5
Electronic Assembler	46.1	54
Database Analyst and Data Administrators	57.7	42.3
Systems Testing Technicians	60	40
Supervisors, Electronic Manufacturing	62.1	37.9
Web Designers and Developers	66.7	33.3
Information System Analysts and Consultants	68.6	31.4
User Support Technicians	68.9	31
Computer and Information System Managers	73.5	26.5
Computer and Network Operators and Web Technicians	74.6	25.5
Software Engineers	81.6	18.4
Engineer Managers	89.1	10.9

It can be noticed that the jobs where women make up a significant proportion of the work force are the lower and least paid jobs.

Different Experiences of Females and Males in Using Computers and Programming

A considerable body of research(AAUW, 2000; Corston & Colman, 1996; Bush, 1996; DeClue 1997; Margolis & Fisher 2003; Selwin 1997;Scragg & Smith, 2001; Wright, 1997) revealed that females and males perform differently in terms of: (a) confidence; (b)time spent in front of computers; (c)user experience; (d) programming experience; (e) performances in classes; (f) selecting a major in computer science.

Bush (1996) found that female students had significantly lower self-efficacy in computing and less previous computer experience, and they had received less previous encouragement to work with computers. Analyzing the help that genders received and gave to others, the researcher noticed that female students received more task-related help but gave less task-related help than male students.

DeClue (1997) found that females and males differ in prior experience and process of attribution. The process of attribution works against females and benefits males. The researcher found that males had more prior experience in computing than females. In an experiment with 74 female and 76 male Romanian university students, Durndell and Haag (2002) completed experiments using Computer Self Efficacy Scale and information about using the Internet. Male students scored higher in computer self efficacy, lower in anxiety, and had more positive attitudes towards the Internet. It was noticed that males reported more confidence in tackling new tasks.

Bandalos and Benson (1990) used the Computer Attitude Scale (CAS) instrument in studying males' versus females' performances in graduate and undergraduate programs. CAS was designed by Newman and Clure (1984) and was used to measure the computer anxiety. The scale assumes that there are three factors that underlie the concept of computer anxiety: anxiety towards computers, computer liking, and computer confidence. The instrument highlightes that male students show more confidence than their female counterparts. Selwyn (1997), on the other hand, developed a research using the CAS and found that gender appears almost insignificant in playing and using computers. When choosing a major in computer science the number of males outnumbered the number females.

Corston and Colman (1996) designed an experiment with 72 subjects, 36 males and 36 females, with ages between 15 and 52 years. They were given a computer task and a test containing questions relating to computer-anxiety and competence in computing. It was noticed that males performed significantly better than females. In addition, for females it was noticed that they competed better in the presence of a female audience than alone or with a male audience.

Many researchers stated that females and males come into their undergraduate studies with different levels of experience (Margolis & Fisher, 2003; Dryburgh, 2000; Sanders, 2005). Scragg and Smith (2001) did a quantitative research in undergraduate studies. The study, comprising 297 students (133 women and 164 men) and having a consistent significance of ($p < .05$) throughout, revealed some important differences between genders:

- Female students had less previous experience in computers than their male colleagues at the beginning of the program.
- For most females, computer science was not their original (or initial) major.

Rowell et al (2003) surveyed 651 students from Middle Tennessee State University. From those surveyed, 163 students (27%) expected to major in STEM and 449 (73%) had no plan to major in STEM. The gender distribution was 60% females and 40% males, 27% from each gender being interested to major in STEM. From all, 93% females and 92% males reported interest in using computers. With the respect to computer programming 50% males and 33% females reported interest in it. Also, Rowell et al did not find significant gender differences in confidence and career understanding.

Researchers have found that male domination is not in all the domains of computing. Schumacher, Morahan-Martin and Olinski (1993), in a study with 31 males and 30 females from an MBA program, noticed a better performance of females versus males in using spreadsheets and software for accounting. Female subjects were more willing and better able to integrate tasks which were not related to programming than male subjects. Other researchers (Grignon, 1993; Modiamos & Hartman 1990) found the superiority of males only in programming and entertainment.

Gender Stereotypes, Discriminations and Feminist Opinions about Under Representation of Women in Computer Science

In the computer science field, social stereotypes are often present. Computers are often presented as tools designed for males (Grundy, 1998). Unfortunately these prejudices start very early in life. Boys are directed to use machines from an early age. Turkle (1984), a researcher from MIT, wrote about computing and its impact on psychological life. According to her, being an "interactive explorer" is essential to succeed in computer science. From this perspective, boys, who are playing more often with computers, have the advantage of having more independence and inclination to more risk taking activities. Also, she noted that by the age of five, both genders are keenly attracted in debates if an activity or an object is for females or males.

Starting from the first years of school until high-school, a considerable amount of research has noticed that the computer science curriculum is often poor (Pieterse & Sonnekus, 2003). It lacks diversity and gender policies. Starting with elementary school, female students lack confidence in using software (Dryburgh, 2000; Margolis & Fisher, 2003). They also lack role models and the software is often perceived as being designed mostly for boys (Margolis & Fisher, 2003).

Researchers observed that males were more active in classes and received more attention from teachers (Sadker & Sadker, 1992; Wasburn & Miller, 2005). Although some females have the required skills they did not select the computer science courses. Female students by the time they finish high school had decided not to pursue a career in computer science. This offers an explained why in the first year old study at college in computer science departments there was a low percentage of females.

Feminist research has noted that stereotypes and discrimination against women were often encountered in the computer science industry. First, the culture of computers was associated with men (Grundy, 1998; Margolis & Fisher, 2003). Second, at the beginning, mathematics was considered a mandatory requirement for students entering in computers (Butler, 2003; Grundy, 1998). Consequently, because male students were having better performances in math than females, many females were hindered in their effort to get into computer science. Third, more recently, computer science was associated more with technology (Grundy, 2003), less interesting for female students than mathematics.

Research often mentioned that female subjects view computer science as a hostile culture to women (DeClue, 1997; Rajagopal & Bojin, 2003). Many studies reveal that male students gain access to computers in labs to the detriment of female students (Bhargava, 2002; Beynon, 1993; Margolis & Fisher, 2003). Sometimes males could become bullies in their attempt to control the access to computer (Beynon 1993). This behavior cannot be followed by females who tend in this case to be more rational and passive.

Silcox (1998) analyzed differences between women in traditional vs. non-traditional academic majors. There were 135 female subjects who were selected from a large Canadian university from computer science, engineering, nursing and occupational therapy. The variables that were measured were: the Rosenberg Self-Esteem Scale (ME), Career Decision Self-Efficacy Scale-Short Form (CDMSE-SF), the Attitudes Toward Feminism (ATF) and the Women's Movement Scale (WMS), and a personal questionnaire about developmental attitudes (background, family attitudes, barriers). The results did not show a significant difference in career self esteem, career's self efficacy, and feminism attitudes. There were no significant differences between parental supports in the two groups. In terms of barriers to them achieving their professional goals, women from non-traditional fields (STEM fields and IT industry) invoked more external barriers while women from traditional fields (education, health care, social sciences and the humanities) mentioned both internal and external barriers.

In the last decade feminists pointed out many negative facts in computer science. The typical myth created by feminists about the typical computer science person is "white male geek" (Margolis & Fisher, 2003). This person is a terrible creature with no social skills, who only likes to compute "per se". He is willing to spend his nights in front of computers but is not interested in helping other people.

Sanders (1986) observed that females were failing to take advantage of the computer opportunities available to them in school because of societal constraints. For this reason, computer equity became more important. In fact, equity on computers countered fears of high technology. Also, computer knowledge was needed in an increasing number of jobs. For this purpose, Sanders proposed special programs such as the "Computer Equity Training Project" for the purpose of offering strategies that would narrow the computer gender gap in skills and number.

Scragg and Smith (2001) developed a survey to verify six general hypotheses about barriers fostering a "shrinking pipeline" of women in computer science:

1. General social pressures (i.e. discouragement of women from pursuing computer science, negative attitudes of family and friends).
2. Women experience crises in self confidence more often than men do.
3. Less chance of women to contribute ideas in school where their contributions are undervalued.
4. Computer science is too dominated by males.
5. Mathematics is an important part of computer science. Female students suffer more than male students from mathematical anxiety.
6. Social pressure to raise a family is much greater for a female student which is incompatible with the all consuming and long hours associated with a career in computer science.

The findings may be summarized as follows:

1. There was no difference between genders: female and male students did not receive a significantly different amount of encouragement.
2. Female confidence was discovered to be significantly different (lower) than their male counterparts.
3. Females and males did feel fairly and equally treated.

4. As a male-dominated field, females appreciated that computing is more male dominated. However, the real domination rate was lower than the domination expected by female students.
5. Females and males had almost the same degree of mathematical anxiety and the hypothesis that women leave the program because of mathematics was not verified.
6. Female and male student attitudes towards raising a family did not have a significant difference. Therefore, the hypothesis that women left the program because of family reasons was rejected.

Scott-Dixon (2004), a feminist researcher from York University, interviewed more than 50 female IT workers. She depicted in her book the rapport between male and females in IT industry, from 1990s to the present day, as dominated by male youth culture. She noticed certain trends like lower wages for females and the concept that the IT jobs are "men's work". She noted an unfriendly environment for women in some companies and noticed that males regularly went to strip clubs and discussed those experiences in workplace. This often made female workers uncomfortable. She found that IT workers spent a great number of hours in the job. Faye West (Pickett, 2005) found a contradiction with Krista-Scott's study. West found that:

1. The number of long hours required in IT industry was a cliché. In fact, over 84% IT personnel work 30-40 hours per week.
2. A youth culture was typical of some companies but not a general one.
3. Going to strip clubs is part of some social networks but not a typical one.

4. The culture of "geeks" was representative only in software development companies and not widespread in other parts of the IT industry.

In their study about gender differences at Brigham Young University, Bunderson and Christensen (1995) found the low number of females enrolled in computer science courses related to the absences of role models.

The Impact of Race, Ethnicity, and Social Class of Women's Enrollments in Computer Science

Being a minority woman in computer science incurred a multiple bias. Sexism, racism or even class distinction could interfere in order to produce serious prejudices to potential undergraduates in computer science studies. Ethnicity is also another important aspect that affects pursuing studies in computer science programs. Overall, in education Blacks and Aboriginals are underperforming in Canada (Davies & Guppy 1998). In the US, Aboriginals, Blacks and Hispanics are underrepresented. On the other hand, in Canada there are East Asians, East Europeans and South Asians minorities who are performing better than average Canadians (Davies & Guppy 1998). Although, there is a lack of information and research in studying ways that ethnicities are exposed to technologies, this overall pattern of performance is likely to carry over to technological education.

Foreign or immigrant women tend to be more persistent, despite a lack of computer experience and skills in communication (Margolis & Fisher, 2003).

Social class is important in technology. In lower income families, there are fewer chances to purchase computers and to have Internet connections at home. Also, poorer neighborhood, schools have fewer chances to have connection to Internet. Gorski (2005) advocated for a shift in the access of accessibility from equality towards equity.

Wilson, Wallin and Raiser (2003) acknowledged tendencies in the digital divide that rural areas, females, and minorities were less likely to have computers and Internet. Controlling socio-economic variables, the effects of rural areas and gender disappeared. However, Blacks were less probable to have home computer and Internet.

Curricular Elements that Influence Both Genders in Computer Science

Previous studies analyzing curricular aspects that might improve performances in computer science found the following factors to be important in helping both genders, although they might differentially impacted:

1. Computer skills required (Butler, 2002)
2. Cooperative learning and constructivism (Roulet, 1997; Margolis & Fisher, 2003)
3. Online learning (Sanders, 2005).

Researchers have noted the following negative practices that frequently take place in computer science education:

1. Teaching practices are often poor (Pieterse & Sonnekus 2003; Stoilescu, 2005)
2. The rate of dropouts at the beginning of IT courses is high(Butler, 2002; Margolis & Fisher, 2003)
3. Despite of sustained efforts in the front of computers, the anxiety toward computers could increase in time (King, 1993).

Computer Science Skills Are Different from Mathematics and Technology Skills

Kramer and Lehman (1990) revealed the stereotypes which existed in the past when academics, employees and public opinion felt no difference between math skills and computer science skills. Starting with the revolution produced by microcomputers the required skills changed. They suggested that computing "relies at least as much upon language, visual design, problem definition, and organizational skills as upon quantitative analysis" (p.171).

In the 1960`s and 1970`s, when the IT industry was demanding computer science specialists, the computer science discipline was in infancy (Butler, 2002). IT employers and independent groups developed tests and instruments in order to identify qualified personnel. They developed tests to identify categories of skills such as: intelligence, personality, interests, and aptitude. The most predictive factors were found to be mathematical background and GPA.

Cooperative Learning and Constructivism could help

Used to their full potential, cooperative learning and constructivism have proven helpful for students with different levels of knowledge in computer science. Martin (1998) reported that female students are more cooperative as a group and need more assistance. Savard, Mitchell, Abrami, and Corso (1995) discovered that female students who work cooperatively with a partner were more positive about their achievement and were more interested in exchanging ideas. Shen (1997) also revealed the beneficial effects of cooperative learning on college students in computer science.

Gilligan (1982) revealed that female thinking leaned to "connectedness". Females tend less to be less rule-bound and tend to relate to contexts and link learning to their personal world. Roulet (1997), a professor form Queen's University, observed that some females often carried resentment toward mathematics. In order to correct this, he proposed social constructivist settings which could help female students retain mathematical interest. He also suggested that computer science could benefit from social constructivism when females would receive more specific assignments, more practical, more social related problems, things that would enhance females' interests for programming.

Williams, Wiebe, Yang, Ferzli and Miller (2002) did a study to analyze the support of pair programming groups. They assessed the educational efficacy of this technique in an introductory computer science course. Results indicated that students who worked in pairs performed better on programming. The self-sufficiency and retention rate was better. Students who worked in pairs were more likely to succeed. The collaborative technique for paired students achieved higher order thinking skills than students who worked alone. In addition, they were not anxious about the teaching performances of their instructors and demonstrated more reliance in the process of learning.

In order to help female students, Margolis and Fisher (2003) offered advice that has constructivist implications:

- The assignment should be useful and personal
- The assignments should interface with other programs
- Their ease of use and reliability should be considered.
- Complex data should be used, derived from real-world contexts.

- The assignment should be socially relevant and flexible
- Observation from the real world and interactions with experts should be included.

Cooperative learning will not be beneficial if the teams do not offer enough support to their members. In this case, some female students are probable to have only "support jobs" (Margolis & Fisher, 2003; Scott-Dixon, 2004) or become passive and wait for other members to do their job. For this reason, teachers should check the quality of interactions between cooperative team members.

Online Learning might Help Learners

Online learning could help females to perform better than on-campus instruction. In New Zealand, Linn (2005), in a web design course, found that females performed better online than in face-to-face classrooms. Gunn (2003) revealed that more women posted more frequently than males in an online course and their frequency of posting was positively correlated with course achievements. Also they revealed that women tend to hide their gender using pseudonyms. On the contrary, males tend to show their gender and tend to have the same role as they do when they learn on campus (Gregory, 1997). Family problems could also be a reason for females selecting online courses as these facilitate flexible schedules.

Male aggressiveness could be encountered also in online learning and is able to damage seriously the process of learning. Researchers revealed that gender stereotypes are often encountered in online discussions. Despite the fact that online learning processes do not require the direct presence of student participants, there have been cases when male students have became hostile or aggressive (Cook, Leathwood & Oriogun, 2001; Myers, Bennett & Lysaght, 2004). Also, there are cases when females do not have access at computers at home (Gunn, 2003). Campbell (2000) recommended taking into account needs of the female students when instructors design an online course.

Other Factors that Might Help Learners

Venkatesh (1999) experienced the effectiveness of game-based training in computer science. This research used the Technology Acceptance Model (TAM) to determine learning capabilities of employees. The experiment proved that people who practiced learning using game-based training methods learned easier than traditional learners. Perception is necessary not only for initial acceptance but also for progressing in learning (Venkatesh, 1999). Venkatesh proposed incorporating game-based training programs as an introductory procedure for learning. The strategy was more effective for younger ages. It helped them to interact better within teams, and to ease the use of the Internet and networks.

Knuth (1974), articulated a vision of programming by linking the programming to art:

> Computer Programming is an art, because it applies accumulated knowledge of the world, because it requires skill and ingenuity, and especially because it produces objects of beauty. A programmer who subconsciously views himself (or herself) as an artist will enjoy what he (or she) does and will do it better (p.16).

Teaching Practices Are Often Inadequate

Many researchers explain the current situation by the poor quality of computer science education at all levels (Margolis & Fisher, 2003; Pieterse & Sonnekus 2003; Stoilescu, 2004). The effects of poor teaching in computer science were felt not only in high schools but also in universities. In high schools, many teachers came from different backgrounds such as mathematics or science (Margolis & Fisher, 2003; Stoilescu, 2005). Many instructors in university do not have experience in programming. In addition, the salaries from the IT industry encourage teachers and professors to switch from teaching to programming (Stoilescu, 2005). The result of poor teaching is felt especially by female students (Margolis & Fisher, 2003). As a result gender inequalities increase in a poor teaching environment.

Rowell et al (2003) found that teachers are more likely to influence students (33%) in interesting them in computer programming, while families are more likely to influence their children as computer users (37%). This shows again the importance of the quality of teaching for future specialists in computer science.

Pieterse and Sonnekus (2003), proposed a test to detect persons suitable for teaching computer science. They created an instrument to assess Computer Educators who are Destined to Achieve Results (CEDARs). One of the capabilities that CEDARs assessment has is the fact that it tests the teachers' capacity to promote gender equality in computer science. This test could be used in the recruitment of potential CEDARs. The test uses methods from both qualitative and quantitative researches to assess the personality of computer science candidates in teaching.

The First Courses in Computer Science are Very important

First courses in undergraduate computer science programs have a high rate of dropouts (Butler, 2002; Margolis & Fisher, 2003). Margolis and Fisher (2003) mentioned that the normal strategy is the "weed-out" formula, in which students are tested from the first year of study about their capacity to think at algorithms.

For this reason many researchers tried to determine what should be the criteria to test undergraduate students in computer science. While many studies found that mathematics skills are very highly relevant and very similar with the skills required by computer science, these are not a guarantee for success. After the 1980's, the focus shifted to cognitive skills and attitudes (Butler, 2002). Problem solving and critical thinking have been at the top of the list of needed skills. Now computer science is becoming broader and encompassing attitudes from psychology, management, science, math and art. Still the attrition rate is over 40 percent.

Despite the Frequent Use of Computers, Anxiety towards Them Could Increase in Time

Time is not the only factor in using computers successfully. Frequent use of computers is not always a guarantee of success in computer science. Several researchers found quality to be the most important factor for achieving experience. For example, Simonson, Maurer, Montag-Torardi, and Whitaker (1987) developed a test of computer literacy named the Computer-Opinion Survey (COS). A Computer-Anxiety Index (CAIN) scale was associated with COS in order to measure anxiety that subjects have in using computers. In 1993, King designed an investigation using COS and CAIN in schools examining computer usage and computer anxiety within a group of 11–12 year-old elementary school students. There were three classroom groups in the experiment, each with roughly 30 students. They were exposed, over nine months, to more computer interaction hours than other classes. The survey was administered as a pretest and posttest over a nine-month period. It was hypothesized that anxiety levels would decrease. Results of repeated-measures using ANOVA indicated an unexpected turn: the computer anxiety scores on the CAIN increased. This was contrary to the expected results, namely, the more computer experience a person has, the less computer anxious they are likely to be.

Interviews conducted with six purported high-anxiety students revealed that these students felt more dissatisfaction with computer access and with the lack of game playing than actual fear about computers (King, 1993). These results challenged the validity of the Computer Opinion Survey at the high-anxiety end of the scale. King hypothesized that the test could be measuring frustration. The results of this study prompted a more detailed investigation of the measurement characteristics of the Computer-Anxiety Index (CAIN) scale.

Broos (2005) did a quantitative study with 1,058 students to analyze and compare computer attitudes between males and females. Results indicated a positive relationship between computer experience in self perceived evaluation on using computers and Internet. To analyze the impact on gender on this correlation (experience and self-perceived evaluation) the General Linear Model was used. It was noticed that males showed lower levels of computer anxiety than females. For males, computer experience had a positive experience on decreasing computer anxiety but the effect for females was not similar.

One of the most interesting research studies in computers user anxiety was conducted by Compeau, Higgins and Huff (1999). The researchers used the TAM model to measure reactions to computer learning by some students with low self-esteem. The TAM is the theory that models how one comes to accept and use an IT technology. They observed that low self-efficacy will eventually spread to the entire individual's behavior. Even though they increased the number of hours of experience, this proved not to be enough. The relationship created when the learning process involved a lack of confidence was one of downward spiral. Lower self-efficacy leads to lower performance, which leads to lower estimations of self-efficacy and so on.

In addition, Compeau, Higgins and Hull (1999) concluded that because successful use requires confidence, training programs and other support mechanisms to increase self-efficacy need to be reconsidered. Although not a new requirement, this provides additional support in favor of investing in activities, during the implementation of new methodologies, additional support in favor of investing in computer training. More broadly, given the enduring effects observed here, influences, individuals' self-efficacy and outcome expectations would pay off both in the short and long terms.

Specific Ways to Consider Computer Science for Male and Female Students

Researchers have a great amount of research that underlines different characteristics of learning for male and female students in computers.

Differences in Communications

Studying communication in computer science classes it is important to present first the main patterns of communication between males and females. Tannen (1991) in her book, *You Just Don't Understand*, showed differences in communicational styles between men and women. Men emphasize their independence and status and make more decisions without consultation. They don't like lengthy discussions about what they see as minor issues. In public meetings and mixed groups discussions they talk more and are quicker to offer advice. In a public situation men often talk about themselves than women do. Sometimes they feel that women often complain without taking action to solve the problem.

Women emphasize connection and intimacy, feeling that it is natural to consult their partner at every turn. During conversations, they emphasize being equal with others, sharing and giving support. They tend to be more tactful that men and are less direct in their conversation and think that men are often insensitive to their problems.

The general communication style in STEM and computer science classes is classified in two different patterns: defensive climate and supportive climate.

Defensive Climate

A defensive climate according to Gibb (1961) is one which is:

- Evaluative: Judgment on an idea or questions. It is characterized by "blame or praise";
- Controlling: The explicit attempt to change and influence based on the implicit idea that something is wrong;
- Strategic: Discourse engaged in manipulating other interacting people making him/her believe that s/he is making her decision;
- Distant: Fails to express concern for others. Speech patterns suggest objectivity, clinical relationships, distance rather than engagement.
- Superior: Indicates the speaker's higher attitude relative to others such as more intelligent, a better educated and tends to give others a sense of inadequacy.
- Certain: Dogmatic and closed to discussions and mutual exchange of ideas, feelings.

Supportive Climate

A supportive climate according to Gibb (1961) is characterized by:

- Descriptive: avoids passing judgment. Questions are asked for information only.
- Problem-Orientated: Desire is expressed to work together to solve a problem or a challenge.
- Spontaneous: Natural and genuine rather than containing hidden and multiple motives.
- Emphatic: Demonstrate respect for other participants.
- Equal: Demonstrate belief and willingness to enter in a truly collaborative relationship with others.
- Provisional: Demonstrate willingness to and interest in exploring speaker's own ideas and behaviors. Focus on investigating rather than taking sides.

As Gibb (1961) argued more than 40 years ago, a learning environment where students feel free to interact and ask questions should be a supportive climate. A supportive climate would favor both genders while a defensive climate affects especially female students (Garvin-Doxas & Barker 2004). The researchers mentioned that higher education often tended to have a "too traditional" approach to teaching that produces in the end a defensive climate. They noticed also that, a supportive climate is too easy overlooked in today classes, fact that often have produced many inadequacies in the educational process. Subsequent effects consist in reducing the participation of ethnic minorities and female students in classes and labs (Garvin-Doxas & Barker 2004; Sanders 2000).

Differences in Learning between Genders in Computer Science

Turkle and Pappert (1992) found that males and females developed different programming styles. One style is described as formal, abstract, rigorous, "restrictive" to creativity. The other style is less formal, more concrete, focusing on potential creativity. Damarin (1989) and McKenna (1999) were more radical. They noted that the formal style is the traditional one in computer science classes and tend to discriminate against the "soft style".

McKenna (1999) pointed out that the IT work style operates in a monotonous way starting first with planning and design, continuing with documentation, coding and debugging. This style was considered 'hard mastery', suited more to males, and considered too abstract for females. In contrast, 'soft mastery' is characterized by sensitivity and intuitive artistic feelings: one will try different things and try to have the final outcome more concrete and less abstract. One will try in a nonlinear order and let the overall image emerge from an interaction with the environment. Hard mastery style is typically for males and recognized today as the only way to do programming. This would make women feel intimidated by today programming style. In the contemporary real IT world, large projects make women feel uncomfortable and resentful with them (McKenna, 1999).

DeClue (1997) did not discover any evidence to support that females had greater logistical problems than males. Also his research did not show that female students have different programming style than males which impact negatively on their performance in introductory computer science courses. Evidence was discovered that computer science is perceived as hostile to female students. Also the attribution phenomenon was revealed as working in favor of males and against females.

Cooper & Weaver (2003) mentioned that boys like learning programs in a game format. In particular, they relied in eye-hand coordination, aggressiveness and competition. Boys liked sound and special effects. They appreciated sports and violence as in wars. In contrast, girls preferred their IT programs to be learning tools avoiding sound or special effects. Girls communicated in words rather than in violent images.

Shih (2001) explored possibilities of adapting undergraduate computer science curriculum to female students, by altering the course content. The course selected was about programming in Java in the School of Computer Science, Carnegie Mellon University. The alteration consisted of the insertion of analogies to facilitate the understanding of the course's content. Two groups of 21 students, with each having 11 females and 10 males, were selected for this experiment. The experiment showed that the use of analogies increased the interest of females for the course. Fewer females and a greater number of males wanted code examples. In the control groups, the majority of females had negative values of attitude and wanted more samples related to day-to-day life. The lack of analogies turned the attitude towards learning Java language from positive to negative. Using analogies in the control group helped female students to understand and be more interested in the course. These changes, observed Shih (2001), affected more females than male students. Although these results bring new attention to teaching methods, a considerable amount of research should be invested in the future, in order to achieve more rigorous conclusions.

Starting from widely inferred observation differences between males and females in attitude towards computers and the usage of computers, Dickhauser and Stiensmeier-Pelster (2002) proposed a study to check if gender differences in computer science were related to the large body of research on gender differences in math and science. The researchers tested whether the Model of Achievement-Related Choices, a model designed for math, could be used to explain gender differences in computers. The result showed that the values obtained did not vary as a function of gender. This experiment showed that the quality of achievement is important and not only the experience.

Venkatesh (1999) revealed that a "playing" attitude, if it is not viewed only as entertainment, increases greater flexibility in adapting to the new challenges. This explains why so many boys who adopt playful styles finally feel fewer difficulties and became more confident than girls.

Wilson (2004) did a survey with more than 850 students analyzing preferred ways of learning using computers. She noticed that females spent more time in assignments and e-mails, while males spent more time in surfing and games. As preferred assignments, women selected applications for applied fields (education, medicine, agriculture) while males selected applications in gaming. The lowest preference for both genders was mathematical application. However, women were more interested in selecting mathematical applications than males (14.1% vs. 9.1%). As a work style, individual work outperformed cooperative work without significant gender differences ($p<.01$).

Rowell et al (2003) found the following gender differences in comparing the computer behavior between high school students:

- Males have more interest in installing software and are more curious about how computers work.
- Females receive more computer enjoyment, both intellectual and entertainment.
- Females are more likely to be influenced by family (39%), friends (26%), and teachers (19%) while males are more likely to be influenced by their friends (30%), family (27%), and teachers (20%).

Similar General Practices Have Different Gender Influences

There are many features to which males and females reason differently. Included are the following: (a) competition and performances; (b) grades; (c) same gender classes and groups; (d) anxiety level; (e) defensive style; (f) online learning; (g) cooperative learning; (h) constructivism.

Competitions have different impact on males and females

Bush (1996) investigated whether gender and group composition had any impact on the level of activity and cooperation. Bush found that students with low self-efficacy in computing and students in groups with a majority of females, cooperated more than any other categories in their work with computers. In terms of gender, the level of activity was highest in majority-female or majority-male groups.

Margolis and Fisher (2003) found that women "looked around and experienced their male peers knowing more and doing the work with greater ease. We found too many American women fall victim to the 'computer gene theory', even if unconsciously." (p.101)

Grades are Perceived Differently

For males and females, grades indicate to different extents whether students will pursue computer science as a major or not. A survey was conducted at St. Francis Xavier University, (CREW Project, 2001) a catholic university from the US. Among 942 students, roughly two thirds were males and one third females from 19 schools, taking courses in math and advanced programming in computer science. From girls and boys with A and B grades in Math and/or Computer Science, 48 percent from boys and only 17 percent girls were considering computer science as their major. This fact is of serious concern related to the relevance of marks in computer science. If the marks are not significant in determining the future in majoring in computer science then what could be a significant criteria? Asked if with more encouragement, students would select computer science major, only 3.2 % females and 9.5% males answered 'yes' and 21.5% females and 24.1% males answered 'probably yes'.

Same gender classes and groups

Crombie, Abarbanel and Anderson (1999) in one of the few high schools from Ontario which has offered all-girls classes in computer science, compared two all-girl classes and six coeducational classes from the 11th grade, with the same curriculum and teacher, with the respect to the following parameters:

- Perceived teacher support
- Student computer attitude
- Student occupational intention.

The results showed that females from all-female classes and males from mixed classes felt that they received more support while females from mixed classes felt they receive less support. The attitude and student occupational intention followed the same pattern. Female students from all-female classes felt more comfortable and were more willing to select a future career in computer science than females from mixed classes. In addition females from all-female classes were very involved and more vocal than females from mixed classes. The implication is that when administrators and teachers are committed to support all-female classes, this proved to be an effective way to engage female students into a career in computer science.

Dryburgh (2000) mentioned that all female groups developed a more complex variety of skills than females from mixed groups. These results were supported by similar research (Cooper & Weaver, 2003). This problem raises the concern whether in the mixed groups, female students are teased or looked down on by their males peers. However, today, this idea to have single-gender classes or schools is not very popular although Rajagopal and Bojin (2003) in a survey posted online about IT students from North American universities found that the percentage of female students who want to learn IT in same gender classes was significant (41% females vs. 26% males).

In studying the level of confidence from non-major programs in computer science from an UK university, Carter & Jenkins (2001) found that female students who come from single-sex school where more confident than females from coed school. Also, in the US, Cooper and Weaver (2003) revealed that high school female students from same-gender classes achieved better skills and greater confidence in computers than females from coed classes.

Not all researchers believe that a same-gender class is suitable as a form of education in our times. Sanders (2005) mentioned that same gender classes are difficult to extend on a large scale. In addition, she mentioned several cases in Canada, US and Western Europe where students and parents disagreed with the enrollment into same-gender class education when they were required to register. Also, a research study from Canada mentioned a case when parents and faculty were reluctant to take one-gender class in computer science (Jenson, de Castell & Bryson, 2003).

Anxiety Level and the Attribution of Success have Different Impact on Genders

Cooper and Weaver (2003) argued that intense competition in computer science classes is beneficial for males, but hinders the performance of females. Also, they revealed the current phenomenon that takes place for female students under the process referred to as tokenization. The major effect of tokenization of females in computer science classes is to produce both a lack of confidence and under-achievement among them.

Margolis and Fisher (2003) found that 40 percent of male students and 65 percent of female students came from households where at least one parent had computing as hobby or occupation. Because of lack of experience, females "are disproportionately affected by problems like poor teaching, hostile peers, or unapproachable faculty" (Margolis & Fisher, 2003, p. 140).

Deboer (1984), and Margolis and Fisher (2003) used the attribution theory to study the student persistence in computer science college. They found that students who related their success to their ability were more likely to succeed while students who attributed their success to luck were more likely to be unsuccessful.

Many researchers found that females tend most to attribute their success in computer science to luck and their failures to lack of ability (Bernstein, 1991; Howell, 1993; Moses, 1993; Pearl et al, 1990). If these tendencies were substantiated, they could obviously be a barrier to an increase in motivation and self-confidence for women in computer science and certainly could, at least in part, explain the high attrition rates reported in computer science programs. Bernstein (1991) found that males who were uncomfortable using computers attributed this feeling to "inadequate experience or poor teaching," while females tended to criticize themselves for feeling uncomfortable with the computer.

Policies Required in Order to Establish a Balanced Activity for Both Genders

Researchers and administrators used complex curricular and administrative measures to decrease the level of attrition in undergraduate computer science programs. Sturm and Moroh (1994) developed projects designed to increase the enrollment and retention rates of female undergraduate computer science students. The projects incorporated presentations of female profiles that had a successful career and the advantages of being in computer science industry. Also, a series of introductory computer science courses and mentoring programs provided by alumni were introduced. Career opportunities and encouragement of women to pursue graduate degrees in computer science were also considered. In addition, women undergraduates were actively recruited to participate in the research projects.

Margolis and Fisher (2003) considered different changes in the curriculum at Carnegie Mellon University. First, they changed the curriculum for the computer science students who were in the first year of study, providing them with courses with four levels of difficulty, and registered them according to their level of experience. For those with few experiences in computers, the designed course had discovery-based approaches, the general level being lowered. In contrast, for those with experience in programming, the students were prepared with more advanced courses. Another important contribution was giving more preparation to teaching. The best instructors were assigned to the beginning courses where female students reported difficulties. Teaching assistants were involved in the training of teaching diversity, in particular gender equity. Another concern was to contextualize the computer science curriculum. A series of lecturers were included for the purpose of student adjustment to university. Female role models in computer were presented.

Stoilescu (2005) has described possible policies and methodological directions for computer science teachers to follow in order to increase the retention rate of students. These include:

- Gender policies: Gender sensitive policies should be considered to encourage both genders and a positive attitude towards the classroom.
- Communication strategies: Students should be taught to adapt, communicate and learn to deal with difficulties efficiently, using digital technology.
- Hands-on experience: Students should develop an active attitude of experiencing all challenges encountered in the instructional process.
- Collaboration: Students should learn to cooperate with each other in collaborative efforts such as complex projects or in discussion groups

- Mentoring: The teacher should advise students about possible models, networking contacts, future professional events and inform of career opportunities IT and the requirements for such careers.

A Reduced Number of Female Students in Classroom Negatively Affect Their Performances

Sanders (1985) considered that the reduced performances of female students are not produced by male students' discouragement but the nonexistence of "girls' girlfriends". Cooper and Waver (2003) described the negative effects of tokenization for female participation in computer science courses. Tokenization has a strong effect on minorities by amplifying social stereotypes. In this case, the tokenization of female students produced among them anxiety and underachievement.

The "shrinking pipeline" has a negative influence in female students' retention. In a study in Virginia universities, Cohon (2001) found out that a critical mass of female students are the most important factor in females' retention in a computer science major. Due to the fact that a small number of female students produce the tokenization effect, the enrolling of too few female students in computer science programs should be avoided.

CHAPTER III

DESIGN AND METHODOLOGY

The Researcher's Perspective

The author was a high-school computer science teacher and a part-time instructor in computer science department in a university in Romania. Gender differences in learning style in computer science have long been an interest of the author, from his first observations of differences in learning preferences and practices among students. Those observations, in an Eastern European social context, prompted the author to focus on gender differences in computer science. To his surprise, although Canada had more gender equity policies than Romania, gender differences in computer science in Canada were perceived as more critical than in Romania.

The papers written by the author could be viewed with suspicion by feminist groups. Was the author, as a male, writing from a biased or essentialist perspective? A bias is always in any researcher. Just as replacing female actors with male actors is not a viable, universal perspective in theatre (although in the Chinese theatre tradition this has done for centuries), neither does having only one gender producing software make sense in contemporary life. This, then, is the reason for a study on gender learning differences in computer science, to promote the view that computer studies should be developed from both gender perspectives.

The Context of Study

The study took place in a medium size university of roughly16, 000 students with more than 11, 000 being full time students. The Department of Computer Science has over 1,000 students and around 40 instructors.

Subjects

The research involved a convenience sample of 16 undergraduate students (ten males and six females), studying computer science either as a minor or a major. Students were selected from the first year to the third year of study. The study consisted of:

- two male and two female students from first year
- two male and two female students from second year,
- six male and two female students from third year,

This composition provided an opportunity to compare the characteristics of the new entrants to the program with the students who have already experienced the program and are about to graduate. The selection of the subjects took place at the end of each course, so that the sample of students consisted of subjects who persisted until the final exam.

Courses

The courses taken by those in the sample courses selected represented the main areas of preparations for computer science undergraduate students (algorithms, programming language, and web design). Specifically, the courses were:

- Key Concepts in Computer Science, (first year);
- Introduction to Algorithms and Programming I, (first year);

- Introduction to Algorithms and Programming II, (first year);
- Data Structures and Algorithms, (second year);
- Object-Oriented Programming using Java, (second year);
- Advanced Website Design, (second year);
- Object-Oriented Software Analysis and Design, (third year);

The first three courses were selected for the first year of study and were mandatory for both major and minor programs. The next three courses were from the second year of study and the first two were required for both minor and major programs while the third entitles Advanced Web Design course, was not required by either major or minor. The last course was required only for students who major in computer science.

The author taught the first five courses in Romania and studied and practiced the skills required for the other two courses so he is familiar with the content of the learning and teaching in undergraduate computer science courses that were selected in this research.

Research Questions and Focus Area

The questions and the focus areas were developed to enable the researcher to investigate the following key aspects:

For the purpose of exploring the fundamental factors that might explain the gender disparities in attitudes and performances in computer science program, the following research questions were asked:

1. What experiences did students have when they selected the computer science program?
2. How do males and females perceive their computer science program?

3. How students perceived the typical profile of successful computer science students?
4. What challenges did each gender experience during the program?
5. What opinions have each gender about teaching computer science?
6. How did interact students in classes (males/females, males/males and females/females)?
7. Which elements of learning environment help males and females learn in computer science?

For the purpose of improving the retention of students from both genders, the research question asked was:

8. What strategies should be applied in order to improve the participation of male and female students in undergraduate computer science classes? This last question was treated in chapter five, *Summary and Recommendations*.

Instruments and Protocols

The Interview and the Questionnaire Protocol

The study used the interview techniques to gather data. In the interview, the researcher used open-ended questions, exploratory and in-depth questions and allowed the students to freely express their opinions. The interviews were used as a starting point in order to build a questionnaire. The questionnaire (Appendix E) consisted of two sections containing:

- Closed-ended questions about different preferences such as: (a) learning style; (b) things perceived to help students learn, (c) self-evaluation of computer skills; (d) self-management skills; and (e) confidence.

- Open-ended question, asking exploratory questions about (a) level of knowledge before starting the program; (b) reasons that made student willing to select the program; (c) student's perceptions about computer science (using, programming and IT career attitudes); (d) student's interests; (e) student's perception about his or her capabilities; (f) difficulties that students have in the program; (g) gender awareness; (h) students opinions about current teaching; (i) suggestions to improve the program.

The questionnaire was created following the principles developed by Johnson and Christensen (2000).

Observation Protocol

The researcher observed both theoretical lectures and practical labs. Participating at lectures and laboratories, the researcher analyzed the following aspects:

- The number of male and female students who attended the classes
- The classroom dynamics (the way that class was conducted and students grouped)
- The knowledge and experience levels showed by males and females
- The interaction with the instructor
- The answers that students gave to instructors
- The pace of work that teacher required
- The confidence or anxiety levels exposed at labs during the assignments
- The teaching style of the instructor, the teaching pace, the level of explanations
- How students from the same gender and from different genders interacted with each other.
- The communication among students

Discourse Analysis Protocol

The course outlines, textbooks, assignments and courses web pages were analyzed. More specifically, the following issues were treated with:

- What were the outlines of each course?
- What were the online resources that instructor offered for the course?
- What typical mistakes presented the programs realized during the labs?
- Did the students complete the assignments during the labs?
- What textbook did students use and how much did they rely on them?

Methodology

The study employed a Mixed Method Research approach (MMR). This approach uses what a pragmatic method and system of philosophy (Creswell, 2003; Johnson & Onwuegbuzie, 2004). The inquiry selected analytical induction focusing on:

- Discovery of patterns (induction).
- Testing of patterns and theories (deduction).
- Uncovering the best set of explanations for constructing meaning related to research findings (abduction) (Johnson & Onwuegbuzie, 2004).

For the purpose of this study, the following definition of mixed methods research is being adopted:

> The class of research where the research mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study.
>
> (Johnson & Onwuegbuzie, 2004, p. 17)

The fundamental principle of mixed research consists in collecting data that show complementary strengths and non-overlapping weaknesses (Johnson & Turner, 2003). From the mixed methods approaches, the Simultaneous Exploratory Design (QUAL + quan) (Creswell, 2003) was used. This method is qualitatively driven with quantitative and qualitative simultaneous design (Morse, 2003). More specifically, in the Simultaneous Exploratory Design, qualitative aspects are dominant with some details obtained by using a quantitative approach. The bulk of the data collection and analysis is approached from a qualitative perspective. The data gathering techniques sought to illuminate a broad range of issues related to the research questions. First, the study started with a qualitative study trying to understand and explore the themes promulgated by the research questions. At this stage induction was used to identify the themes and categories that emerged from each question. In parallel, the study quantitatively measured some variables for the purpose of enhancing qualitative aspects.

Data Gathering

Data was gathered using three distinct procedures: interview, observation and document analysis. With the respect to quantitative data the variables identified during the research were collected for:

- Self- evaluation of students' confidence
- Self-evaluation of students' skills
- The preferred learning style for class and for labs
- Communication styles for students
- Methods that help students achieve better

Quantitative variables will be used for the questions 1, 4, 5, 6, and 7 and are presented in Table 2, Table 3, Table 4, Table 5, and Table 6. The variables from the questions 4, 5, 6, and 7 are integer values from s scale from 1 to 10, 1 being the least significant 10 being the most significant value. The variables used in question 1 were discrete values.

Table 2: Quantitative Variables Used in Question 1

Themes	Variables
a. Reasons	1. Previous programming experience;
	2. Previous User Experience;
	3. Social Network;
	4. Family Help;
	5. Mathematics;
	6. Science.

Table 3: Quantitative Variables Used in Question 4

Themes	Variables
a. User Experience	1. System Information; 2. Networks;
b. Computer Science Skills	1. Math; 2. Algorithms; 3. Data Structures; 4. C++ Programming; 5. Java Programming; 6. Web-design.
c. Confidence	1. The confidence level at the entrance and in the each year of study; 2. Need regular assistance.

Table 4: Quantitative Variables Used in Question 5

Themes	Variables
a. Instructor Importance	Importance that student give to instructor.
b. TA Importance	Importance that students give to TA.

Table 5: Quantitative Variables Used in Question 6

Themes	Variables
a. Learning styles preferences	1. Individual Study; 2. Learning in groups / Working on team projects; 3. Competition with peers;
b. Communication characteristics	1. Likeliness to ask peers; 2. Understand directly from textbooks/ class; 3. Find easily examples and documentation from the Internet/Intranet and integrate in projects; 4. Avoiding asking help in general; 5. Evaluating her/him communication skills; 6. Evaluating her/him team skills.

Table 6: Quantitative Variables Used in Question 7

a. Things that Help Students	1. Class size; 2. Being in all-males/females class/teams; 3. Being in mixed class/teams; 4. Experiencing by yourself; 5. Finding a role model that motivates; 6. Having a counselor able to help; 7. Having a mentor able to help; 8. Having peers able to learn from them and learn them; 9. Learning by examples; 10. Trial and error tests; 11. Online discussions groups; 12. Internet research; 13. Intranet research; 14. Programming and research books/journals; 15. Finding a real project to participate; 16. Finding employment in IT industry; 17. Assignments that are more practical and specific; 18. Assignments in a team; 19. Assignment flexible that offer more choices.
b. Preferred Type of Learning	1. Individual; 2. Cooperative; 3. Competitive.

Data Analysis

The interview transcripts were saved in a digital format. The observations were transcribed and saved also in a digital format. These transcripts were divided according to each question of the research. The findings from the interview and observations were compared for the purpose to identify points of departure and correlations. These findings were correlated with the analysis of different documents. Cross validation among data sources, data collection strategies, and explanations were achieved by using Onwuegbuzie and Tedlie's(2003) seven-stage conceptualization model. These steps are:

a) data reduction

b) data display

c) data transformation

d) data correlation

e) data consolidation

f) data comparison

g) data integration.

For assessing the correctness of approach, the legitimization step was pursued at the end (Johnson & Onwuegbuzie, 2004).

Procedures

Establishing Contacts

Upon approval from the Research Ethics Board of the University, the researcher contacted the instructors involved in the study and informed them about the research. After receiving their approvals, the researcher attended in their classroom and started to take notes. The subjects were selected after a brief introductory presentation involving

Letters of Information (Appendix A) and Consent Forms (Appendix B). All the interviews took place in the Graduate Students Lounge area of the Faculty of Education. It was explained to the participants that they could skip any question and that they could withdraw from study at any time they want. Confidentiality was assured. Those who selected the interview option filled in the Consent for Audio/Video Taping letter (Appendix C).

Initially 27 students agreed to participate in the research and gave their phone number and email. Four subjects selected the interview, 12 selected the survey and eleven did not return any answer. First, the researcher interviewed the subjects who opted for the interview. Based on facts obtained from the interview, the researcher designed a survey and sent the questionnaire by e-mail to the other twelve subjects. From the five instructors, two instructors agreed to answer to another survey, especially designed for them.

Limitations of Design

The qualitative nature of the study raises dependency on the data gathered by the interview and classroom observation. The perception of students, teachers and researcher are the source of possible inaccuracy and provide opportunities for distortions. Also, the presence of researcher in class and labs might have influenced the data obtained. The number of students, especially the small number of females, limits the generalizability of the findings.

CHAPTER IV

DATA ANALYSIS AND FINDINGS

Introduction

After the data was collected, themes, patterns and items which became relevant were explored, selected and presented. This chapter presents these themes.

General Observations

All seven classes had a majority of males. The number of female students was highest in the web-design class where the number of females in each class was almost equal to males. In all other classes, males were the large majority, being at least two thirds of the total. The names of the students and instructors were confidential and changed using the following notations:

- F1, F2, F3, F4, F5, and F6 were the six female subjects
- M1, M2, M3, M4, M5, M6, M7, M8, M9 and M10 were the ten male students
- T1, T2, T3, T4 and T5 were two female instructors and three male instructors in the undergraduate program who participated in this research.

The settings, activity, behaviors and methods were presented in Table 7.

Table 7: *Teachers Participating in this Research*

Teacher	Course	Gender	Number of TAs?	Tech in Graduates Programs?
T1	KeyConc	F	2M	No
	IAP2		1M+2F	
T2	IAP1	F	3M	No
T3	Java1	M	2M+1F	Yes
	OOSAD		-	
T4	ADS	M	2M	Yes
T5	AWD	M	1M	No

The data representing the participants for each gender in all courses is shown in Table 8.

Table 8: Students Subjects and Their Participations in Course

Subject	Course taken	Minor/ Major
F1	Java1	Minor
F2	Java1	Minor
F3	OOSAD	Major
F4	AWD	Minor
F5	KeyConc	Major
F6	IAP1	Major
M1	Java1	Major
M2	Java1	Major
M3	ADS, OOSAD	Major
M4	OOSAD	Major
M5	Java1, OOSAD	Major
M6	AWD, OOSAD	Major
M7	OOSAD	Major
M8	KeyConc, IAP2	Minor
M9	KeyConc, IAP1, IAP2	Major
M10	OOSAD	Major

The greatest degree of student attrition was in first year courses: Key Concepts in Computer Science, Introduction to Algorithms and Programming 1, and Introduction to Algorithms and Programming 2 all had a record number of students dropout. (Butler,

2002) For instance, in Key Concepts course, more than half of the students dropped the course so that at the final exam there were only two females and 17 students overall. Other courses had only few female students from the beginning. In the OOSAD course, there were only three females out of 30 students who participated in the final exam.

Document Analysis and Physical Classroom Observations

Due to the fact that the instructors from the Department of Computer science are skillful computer specialists, many resources helpful for students were posted on the Internet, special webpages being designed as technical supports for each course. These web based support resources contained many samples, tutorials and explanations useful for current courses.

A decade ago, previous literature in computer education signaled conflicts between students in not accessing enough computer resources, often finding cases when male students gained their access disadvantaging female students (Margolis & Fisher, 2003). This fact caused female students to feel frustrated and discouraged in their hope to receive a fair treatment. Now in any Canadian or US university, this case is not encountered anymore.

A decade ago insufficient number of computers was a serious problem, not only for the university in this study. An alumnus in computer science who studied ten years ago confirmed the general situation at that time. "The times were really stressful. It was almost a fight to get access to a computer. But now I don't believe how many computers we do have." Before, this elementary lack of resources caused many frustrations, especially for girls.

Now the number of computers in each lab has well surpassed the number of students registered in courses scheduled for these labs. During each observed lab many computers were unoccupied. In addition, almost all students owned a home computer, desktop or laptop. Being supervised by at least two teacher assistants it is obvious that these labs were safe. In addition, there was a computer lab for individual study, whose only purpose was to let students practice themselves almost all day. If these labs were left without surveillance, some researchers (von Hellens & Nielsen, 2001;Sanders, 1994) mentioned before that it could be inconvenient for female students being possible to be sexually harassed in these labs. May be the lab for individual study was not always surveyed by the technical staff but the spot was pretty accessible to public, so female students could feel safe. In fact, in the majority of cases when the researcher was visiting the lab, there were students from both genders who were working in the lab and the lab was never fully booked.

Sometimes software packages installed on computers did not correspond with the textbooks, a fact that produced discomforts in some labs. For instance, the programs that used graphical libraries in Java had a different version from those printed in students' textbooks, requiring therefore some clumsy modifications in the code. Another course, Object Oriented Software Analysis and Design (OOSAD) did not offer lab class hours. For the course assignments, students could select in this case one of the software packages available and work by themselves.

The Description of the Observed Courses

There were seven courses observed in this research:

The first course, *Key Concepts in Computer Science (KeyConc),* was an introductory course for first year of study, which introduces them to fundamental concepts in modern computer science. The course contained the following topics (a) data types; (b) induction and recursion; (c) algebraic characterization; (d) formal logic; (e) completeness, and decidability; (f) Algorithm, implementation, determinism and complexity. The time was 3 hours lecture and 1.5 hours laboratory per week in intersession and summer. Basically, it contained a lot of mathematics and tried to provide students first concepts of general programming. .

The second course was *Introduction in Algorithms and Programming I (IAP1)* and required 3 hours lecture and 1.5 hours for laboratory weekly for 12 weeks during an entire semester but in intersession there were six weeks with six hours of lecture and three hours of labs per week. This course provided the first concepts about software. Students were taught the major general steps required to elaborate an algorithm. After theoretical preliminaries, students were familiarized with the first notions about programming. In labs they learned how to use a C compiler, how to write code and debug programs. The course contained the following topics: (a) hardware and software; (b) problem solving steps; (c) concepts of variables, constants, data types, algorithmic structure; (d) sequential logic, decisions, loops, modular programming; (e) one-dimensional arrays.

The initiation in programming continued with the course *Introduction in Algorithms and Programming 2(IAP2).* This third course from the first year of study, as the name suggested, exposed students to a more detailed level of designing algorithms and computer programs. The objectives of this course are to develop students' ability to design solutions from a large variety of problems. Topics covered included: (a) multidimensional arrays; (b) pointers; (c) strings; advanced modular programming; (d) records; (e) binary files; (f)recursion; (g) stacks; (h) linked lists. The length of time allocated for this course was the same with IAP1 but the course was scheduled in summer session after it.

For the second year, *Object-Oriented Programming using Java (Java1)* usually required 3 hours lecture and 1.5 hours for laboratory during an entire semester but in intersession the time per week was doubled. The course was designed to familiarize students with the concepts and philosophy of Object Oriented Programming (OOP). To understand the OOP students learned the framework of Java, a pure OOP language. The course included the following topics: (a) concepts of classes and objects; (b) control structures; (c) data structures in Java: arrays, strings; (d) OOP notions: inheritance, polymorphism, interface, abstract classes, anonymous classes; (e) exception handling, (f) introduction to graphical user interfaces. This course provided the acquisition of the second programming language and the OOP concepts, things very useful for future programmers.

Algorithms and Data Structures (ADS) had the same time with the previous and was scheduled also in intersession. The course was designed to bring more advanced concepts in students' skills design of algorithms and data structures. The course taught students how to analysis the time-complexity for an algorithm. Topics included the presentations of data structures such as: linear lists, stacks, queues, linked structures, trees (i.e. binary trees, red-black trees, B-trees) and hashing tables. Also presented were fundamental algorithms such as: sorting techniques (i.e. heap sort, quick sort, merge sort, shell sort) searching techniques (i.e. binary search, binary search trees, external sorting), algorithm design paradigms (divide-and-conquer, dynamic programming, greedy).

Advanced Website Design (AWD) was intended to teach the students about the designing of websites in order to give them an understanding of fundamental concepts and technologies behind websites, as well as an understanding of the emerging web-related technologies. Topics covered included JavaScript, Style Sheets, Dynamic HMTL, XML, XHTML, Web browser compatibility issues and web servers.

Object-Oriented Software Analysis and Design (OOSAD) was the only course in the third year of study and introduced students to the design of object-oriented software techniques. They were introduced in Unified Modeling Language (UML). The concepts included in this course were: (a) architectural design; (b) association; (c) diagrams (class diagram, collaboration diagram); (d) components; (e) consistency; (f) execution; (g) implementation. The course was running during the intersession and summer, with classes of 1hour and 20 minutes, two times per week.

The Research Subjects

A short presentation of subjects is provided below.

F1 is an international student from Africa. She was interested in mathematics, science and engineering. Her previous experience included tow years in Japan as an assistant analyst and she had the opportunity to see how a financial application works. She had excellent interpersonal skills, so highly required for an IT manager and was upbeat and positive during the entire interview.

F2 is also an international student from Africa. Previously, she had experience in teaching English and Math and was very enthusiastic about the world of computer applications. She decided to pursue studies in the undergraduate computer science program. Unfortunately, her confidence decreased yearly.

F3 is an Eastern Asian student and had a strong experience in using and programming computers, almost a typical "male" one. She started to take classes in programming in high school and had a variety of programming experiences before coming to the program. She was previously exposed to Turing, Logo, C and Visual Basic. Even though she did not achieve mastery at a level that allowed her to find a job, her background studies facilitated her to continue without serious anxieties in computer science at the undergraduate level.

F4 is the only White Canadian female student. Although she was taking computer science as minor, she considered herself skillful, "born for" computer science. However, she selected computer science as minor. Asked why, she said that women were socially prone to fail in the computer science path. Due to negative opinions about females in computers around her and the lack of social support she selected not to major in computer science.

F5 is an Eastern European student who has been living in Canada for long time. Computer science was one of the many possibilities to choose from. She considered herself average, usually scoring between B and C but without failures. She had some abilities in computers and considered herself gifted in mathematics. She was not sure whether she would select an IT profession, would go in education or something else.

F6 was a South Asian student. She is an immigrant, a mature student, mother in a family with children already teenagers and intent on achieving a major in computer science. She had an optimistic view, convinced that women could perform equally with men in computer science and felt no fear to "compete" with them.

M1 was an Eastern European, who has lived in Canada for five years. He already has a job in IT, working as a system administrator and a programmer-analyst in a small company. The company gave him flexible schedule, sufficiently enough to have time to pursue his computer science program at the university.

M2 was an East Asian student. He started to study computer science since in middle school. Now, he just switched from general science undergraduate program to computer science and seemed very enthusiastic about his abilities in computer science. His performances were quite good. However he still did not have the ability to score in the A range and had no enriching practical experience that could make him confident that he had a future career in computer science.

M3 was the only White Canadian male student. He had very good academic skills. Although he had only little knowledge in computers before starting the program, he was doing very well in his coursework. He already had IT professional experience, taking a placement in co-op program. For him, computer science means "art and a number of sciences together." Of the male subjects, he looked the most aware of gender issues existent in IT industry. He hoped to continue to study computer science at the graduate level.

M4 was a student from the Middle East. He started computer programming from high school and remained very passionate about computers in different areas: system administration, software development (algorithms, C++ and Java) and web development. In addition, he was considering his full time status in computer science "as a full time job". However, he was not exclusively oriented to do programming. In fact, he wanted to do business after graduation.

M5 was a South Asian student. Although engineering was his first choice, together with his friends, he decided to go into computer science. In the year before starting his computer science program, the IT market collapsed and darkened his visions about the social status of IT workers. Also, having some conflicts with professors, he was not happy with his evolution during this program. In his preparation in computer science classes, in the first two years he missed the basic things. He seemed to have some familiar trouble and was the harshest in his remarks about women in computer science.

M6 was a South Asian student. He seemed to be very advanced in mathematics and programming. He mentioned that in his second year he became addicted to playing computer games. Consequently, in that period the marks had lowered considerable. He realized this drawback and repeated the courses where he underperformed. Now, he intends to pursue graduate programs in computer science and wants to be the man who makes the difference in a company.

M7 was a South Asian student. He was initiated into computers by his older sister and later took computer science classes in high school. This was one of the reasons for him to be sensitive to gender differences in computer science and willing to help female students to improve their performances. He was interested in programming and software design. In undergraduate program, he was very confident that computer science is the best choice for him. In addition, he had experience in IT job market.

M8 was an international student from East Asia. He was not sure what his strongest skills and aptitudes were, and was not convinced that his next job would be in computer science. Although he was in the major, he was almost sure that he is going to work on business relate to hardware selling and not in computer science area. With all of these issues, he had some personal projects in business and hardware. He had serious problems in understanding and communicating in English.

M9 was an East European student and an electrical engineer. Once he emigrated from Eastern Europe, he did not succeed in finding a job in engineering. Consequently, after 14 years since he finished his first studies, he changed his career to something similar, computer science. He did not have the opportunity to practice the programming skills, so he started to learn programming from scratch. Now he was very confident about his future in computer science.

M10 was an East Asian student. From high school he got a Diploma in Information Technology. He was very passionate about computer and mathematics and had some previous knowledge in programming. For the future, an IT career is what he wants. He already had some professional experience in the IT industry using .NET, Enterprise Application Integration (EAI) and Biztalk Server.

Question 1: Initial Considerations to Select the Program

The first question explored student experiences when they selected the computer science program. The first thing that students had in common was that most of them were impressed by the pervasiveness of computers in day-to-day life. In almost all the cases, the parents' job was not related with a computer science choice. This is a normal situation, considering the fact that computer science is a relative new profession. However, the majority of parents was at least middle class and invested a serious amount of effort in buying computers for their children and in educating them to take computer classes. Only three subjects had siblings with computer experience. Hence, families' professions had little importance in influencing directly their children to select computer science profession as "internship". The general reasons for selecting the program and the initial experiences were quite different between males and females.

How they Became Interested

The initial motivating factors for female subjects are summarized in Table 9.

Table 9: Initial Factors Influencing Females Subjects to Enroll in Computer Science

Student	First Interests	Family Expertise	Social network	Initial Experience	Had Mentor, Counselor or Role Model
F1	Math, Science, Engineering, Financial Applications,	Yes-Brother	No	Programmer	Yes
F2	Math	No	No	User	No
F3	Games	Yes	Yes	Programmer	Yes
F4	Graphics Games	No	No	User, Algorithms	No
F5	Math	No	No	User	No
F6	Math,	No	No	User	No

For male students the initial reasons for starting the program are presented in Table 10.

Table 10: Factors Influencing Male Subjects' Interest in Computer Science

Student	First Interests	Family Expertise	Social network	Initial Experience	Mentor/Counselor or Role Model
M1	Games, Engineering	Cousin and Uncle	Yes	Programmer	Yes
M2	Games, Internet,	No	Yes	User	No
M3	Games,	Brother	Yes	Programmer	
M4	Multimedia, Office	No	Yes	Programmer	
M5	Engineering,	No	Yes	Programmer	No
M6	Math, Games		Yes	User	Yes
M7	Math, Engineering	Yes – Sister	Yes	User	
M8	Games		Yes	Programmer	
M9	Math, Engineering, Electronics	No	Yes	User, few Programming	No
M10	Science	No	Yes	User	

Based on the observations from the above table, games helped most male students to enjoy computers. Starting from playing computer games, most of males but also some females started to enjoy computers. This fact was encountered before by many other researchers (Sanders, 2005; Margolis & Fisher 2003). M1 described his beginning experience in computer science related to computer games and hobbies for engineering:

"My cousin bought a computer. I started to enjoy playing games. After a while, I just used to play. So, I got my first computer and my interest took off."

M2 mentioned his fascination with games and the Internet as a primary reason for his interest in computers. Also, the fact that his best achievements were in computer classes boosted his confidence in selecting computer science as a major:

> I became interested in computers during the mid 1990's when one of my classmates showed me his computer at his house. Computer games and the Internet fascinated me. My decision to major in computer science was based on the fact that I had very good grades in computer related courses.

M3 and M6 mentioned games as helpful for building their skills in using computers and attracting them into the computer world. M5 was a student in a model high school in his country. He did not mention any special interest about computers, but a general interest in engineering and the influence of peers in selecting computer science. Initially, he was not prepared to select a computer science program and missed some fundamental skills in programming: "I was supposed to go to engineering but all my friends wanted to go in computer science and unfortunately I also chose this field."

Although M9 took some courses in computer science while he was a student in electrical engineering in his first faculty, one of the best universities from Eastern Europe, these courses were not useful because of obsolete content and lack of practice: "At that time, the university was given only a little idea about what programming was about. We were taking the basics and we were taking the basics without any practice, which was very damaging." In his description, in the previous faculty, they used only punch-cards which were very ineffective and now these are totally obsolete. He started to effectively learn computers since he got his first job as an electrical engineer. Practically, his job was to set electrical configurations from Motorola equipment:

> It was the fact that I was working in this area with computers. After I finished my degree, the first job that I had was very demanding. I had access to computers. From the first week that I was going to the job, they told me, look we gonna have a laptop computer for you, so you have to know how to use it. I had to go up and down all over the places and to program some Motorola equipment. This was not so complicated. Basically, it was a program with some options that you have to decide to activate or no. The software was not a programming language. It was more like a setup. There were just some functions. It was Motorola radio system.

In consequence, he took a one year full time program that gives to those with a background in electrical engineering the opportunity to recertify in computer science. As a shocking comparison, in order to receive a certificate as Ontario Professional Electrical Engineer he needed to study full time at least three years. "Good positions in electrical engineering are well protected" he mentioned.

Another first year student from South Asia mentioned the same reason of discrimination that made him feel hopeless in his previous professional position. Although he had a master in physics, a bachelor in education diploma obtained in Ontario, Ontario Teacher Certification from Ontario College of Teachers and several years teaching experience in his native country, during one year he was not solicited one single day to work as a supply teacher in Ontario school boards. He hoped that computer science will offer him more equity and more opportunities to get a well paid job.

Females mentioned attraction for math and science and also, in using computers.

F1 mentioned her academic excellence. She had experience and passion in science, math and using computers, especially text editing. In addition, she had been encouraged by her mother in using computers:

> I was interested in science: physics, biology, chemistry and math. I was interested in engineering first. We bought a computer and my mom encouraged me to type. Gradually, I became more attracted to computers. After finishing high school, I received a bursary from the Japanese government to study and work in Japan which I did. After studies, I started to work a couple of years in Japan.

F2 mentioned also about the attractiveness of using computers. She though that knowing math and being fascinated by computers would be enough to reshape her future in a computers' career:

> I first developed my interest in computers about three years ago. I just thought it would be interesting to be able to work with computers and discover what makes them up and all that. I decided to study computer science myself, nobody really influenced me, and I just took the interest in it and decided I wanted to study it.

F3 mentioned that she became interested in computing more than 12 years ago:

> I became interested in computers when I first got an Intel i486-DX processor which used DOS operated PC back in 1993. Playing computer games and working with computers became a spare time hobby. I was introduced to the fundamentals of programming through Turing, which is a simple object-oriented programming language created in honor of Alan Turing.

Different Levels of Previous Experiences

In general, a lack of previous experience in programming for females was observed. Generally, it could be noticed that male students based their decision on previous programming experience, social network, computer games and attraction to engineering. Female students based their motivation to select the computer science program on having experience in using computers and mathematics skills. Looking at Table 10, it can be noticed that all but one male student from the computer science program already had programming experience and a social network of peers able to sustain their passion for computers. On the contrary, the Table 9 shows that only one of the girls had a social network of peers able to help her cope.

An observation made by F4 was interesting. She said that in any academic course, she usually looks to get together with another female colleague. Not all the students thought the same. Subjects from both genders, F2, F5, M6, M9, and M10, mentioned that they don't care if the people they collaborate with were male or female. However, I would say that subjects spoke about different things. F4 looked for a long term support, a support that required many extra hours and not just asking for some information in class. As Margolis and Fisher (2003) wrote, female students were looking to have a supporting group and not just a short term information exchange.

Also, another observation was the relatively small number of high school graduates from the local community. The faculty had a majority of international and immigrant students with very few students having come from high school in the area. This could mean one or more from the following possibilities:

- A lack of communication between high schools and the university in this study
- A passive campaign in recruitment of computer science students
- A low level of quality in teaching computer science in high school level
- The Department of Computer Science in this University lost ground in competition with other universities.

Another observation relating to the decision to study computer science was related to the age of students. The typical female student was the traditional young student, who entered in the program, a few years after finishing high-school. The only noticed exception was F6. In consequence, almost all mature students were males. Why did older female students avoid computer science courses? Was it because of the lack of confidence or due to additional difficulties involved in raising a family? Was the computer science career unfriendly because of its high pace involving in updates and novelties?

Levels of Experiences and Ethnicity

A minority woman in computer science faces a multiple bias. Ethnicity affects pursuing studies in computer science programs. Although, there is a lack of information and research in studying ways that ethnicities are exposed to technologies, the overall influence of ethnicity affects also technological education, in particular the confidence and performance of undergraduates in computer science.

Considering facts mentioned in the literature review (Davies & Guppy, 1998), it was expected that few Aboriginals or Blacks would be seen. Unfortunately this expectation was confirmed. For instance, there was not a single aboriginal student registered in the Department of Computer Science. Also, there were very few Black students, most of them being international students and not immigrants or Canadian citizens.

Previous research proved that foreign or immigrant women tended to be more persistent, despite less previous computer experience and fewer language skills in English (von Hellens & Nielsen 2001; Margolis & Fisher, 2003). The interactions between genders was also interrelated with other types of interactions, the most important one being ethnicity. As expected, students from the same ethnicity, sharing the some native langue and socio-cultural values, were closer. When they were in large ethnic communities they tended to stick together for the most part. As confirmed after observations and interviews, they proved to be the majority in this program and they were academically successful. Even the female minority students from computer science were more probable to have success. In this department, they outnumbered White Canadian female students.

In the computer science program in which this study was focused there were not many "Whites". Many students from minorities are often encountered (East Asians, South Asians, Arabs, East Europeans) while others are strongly underrepresented (Blacks and Aboriginals). These students are oriented to the IT stream because having "native" English skills and knowing detailed information about local or national customs and culture are perceived as not necessary. In fact, in Canada and the US, in computer science studies and IT industry, Whites are not at all dominant.

As was mentioned before, in the IT industry there are not "bottlenecks" as in medicine, education or engineering, where in order to practice in a province people are required to (re)certify, often having to start their studies from the beginning. Credits from other countries or from other programs are accepted readily. This study showed different cases of discrimination in engineering and education that made students switch their careers into computer science. As a result, it was attractive for minority students to consider a career in computers. For these reasons many future specialist and future leaders were not "Whites".

It was observed that because the majority of women were recent immigrants or international students who often faced barriers particularly in terms of language, they chose technical careers where language was less of an issue rather than careers in the humanities, nursing, social studies or education. White Canadian females, on the other hand, tended to pursue studies in traditional fields with very few considering technical careers like computer science. These could help to explain the small number of White Canadian students in the program.

Sometimes the communication of the ethnic members groups from outside is not seemed as friendly by White students. M3 mentioned that: "There are some good people in computer science for the most part. There are a lot of groups, or 'clichés' that form, mainly by nationality, which I dislike. Certain ethnic groups tend to stick together and shun outsiders."

The relationship between gender and ethnicity are complex and are not the main purpose of this research. However, as was mentioned earlier, these influences strengthened or weakened differentially students from different ethnicities. In this case, the most disadvantaged were Canadian White-female students.

Social Aspects of Computer Science Program

Social class is an important source of assuring technology and instruction in computer science. In lower income families, there are fewer chances to purchase adequate computers and have Internet connections at home. Also, in poor neighborhoods, schools have fewer chances to have connections to the Internet (Ebo, 1998; Gorski, 2005). During the study, it was noticed that all students who mentioned parents' job were from the middle class. None of the subjects' parents had professional jobs in computer science so parental career path was not a factor in their career choices.

Both gender considered the social aspects of having a computer science career. This is a perception that a career in computer science usually is characterized by interesting work and good salaries. However, having a social network with people already involved in IT field, male students were more able to see computer science "naturally" as their job. Also their descriptions were more realistic and some of them had direct experience. They had more detailed insights from their acquaintances in IT and were aware of the IT job market. As pointed out by Rowell et al (2003), peers were more likely to influence male students about their future. Let's consider the example of M5. Initially, he wanted to select an engineering course. However, because his friends were willing to take computers and IT job market was flourishing, he ended up in the computer science program: "I didn't want to take the computer science but in 2000 the economy was really good. "

M3 also had other opportunities than programming. He could pursue as well a career in arts and had his parents already in this field. However, a computer science career made him feel more secure:

> I enjoy parts of computer science and I have the skills to handle it, but it's not the only thing I could have done. I would have done just as well in a number of other fields, and have often considered what it would be like to be in another one. I also consider how much more fun an arts degree would be. But computer science gives me an opportunity to make a good living and it's enjoyable at times, so it's the lesser of the evils.

Females were also aware of the social aspects of having a career in computer science. F1 wanted to make radical changes in her life. Placed in Japan with a bursary, she had an excellent academic record and did not want to remain in a low paid job position as an assistant analyst. She realized that upgrading her working skills in both computer science and finances would enhance her social benefits. She lived in Japan and did not have any relatives in Canada. Despite this she applied to the computer science program as a minor. She was considering herself to work in software analysis, software design, or in a management position.

Initial Levels of Experiences

The initial level of experience for each subject was considered. From the beginning, all students had experience in using computers. With respect to the initial experience in programming, the majority of males already had experience in programming and showed confidence for success.

Although all female students had previous user experience, with the exception of F3, they did not have previous programming experience. Also, when they entered in the program, they had very little knowledge about the computer science jobs market.

Males and females had different levels of experience. In fact, the North-American educational system changed its curriculum and started to introduce computer science in high school a long time ago. In the US and Canada at least, usually the initiation in programming starts in the 11th grade and is not mandatory. Overall, students entering in the program did not take the advantage that the curriculum from high-schools offered. Where were the female students who finished these classes? Why did they not continue with undergraduate programs in computer science?

Levels of Anxiety at the Beginning of the Program

When students started the program, they had not only different reasons and levels of experience but also different levels of anxiety. A high level of anxiety at the beginning was caused by different reasons:

- Initial experience. Some students did not have previous experience in computer programming. The contact and competition with students who already had experience in programming made them feel unconfident. Especially female students experienced this phenomenon.
- Teachers who skipped the "basics" made students' adaptation to the curriculum very difficult. At this point, mostly females were again in difficulty but also some males such as M5.
- Lack of focus and determination to pursue the academic program. Many students are aware that a postsecondary program is more demanding than previous high-school courses. Yet, although they had computer programming skills they did not transform these into academic skills. Maybe both students were exposed here but males were exposed most.

They learned different things unrelated to direct courses but that could provide them IT experience.

- Gender stereotypes. Many female students are affected by socio-cultural stereotypes. They associate computer science with technology and technology with male domain. In consequence, they consider computers science typical for males. Unfortunately, F4 was one of them. As was mentioned before, although she proved to have certain skills in computer science she did not select computer science as major.

  On the other hand males take advantage of this. Even though males did not directly show disrespect to female students, many of them thought that they were "born" for computers while women were not. Some male students came into program just because their peers decided to do so.
- Possibilities that other domains offered to candidates. For instance there are traditional females' jobs (i.e. nursing, education in primary/junior, social studies) that are well paid. Many female students, although they took computer science classes in high school they did not continue in this direction. These female students would use computer as tools but they do not want to be involved in producing software.
- Lack of social network. Unfortunately when students have difficulties they did not have around people able to give them an effective solution in order to cope. Female students had this type of difficulty. This raises serious concerns about the relations among female students. Feminists often cite a lack of support from family or males as barriers to female success in

> computer science yet females do not support each other, like males do. Only because the number of female student is less is not a good explanation. Researchers found many organizations that pretended to help women but in fact were ineffective (Scott-Dixon, 2004).

The fourth question will explore in detail challenges that both gender encountered during the undergraduate program.

Question 2: Students' Perceptions of Computer Science

This research question explored the perceptions of male and female students about computer science in three fundamental aspects: using computers, programming and social interactions. An important observation was the lack of focus on narrow hacking. This occurrence of the "end of epoch" fascination toward *hacking* was revealed again in the interviews with undergraduate computer science students. The theoretical representation of computer science resulted in similar answers for males and females. However, there were differences in the role that programming, Internet and game playing represent by gender.

What Represents Computer Science for Each Gender?

The purpose of the current research was not to find definitions for computer science but to see how genders see themselves in the computer science program, how they see themselves in a future career in computers, and what they like and dislike about computer science current practices. Successful or unsuccessful, each student was aware of increasing importance that computers are going to play in day-to-day life. The importance of computers was viewed in much the same way for both male and female students as pervasive. For example:

F2: "Everything we do is to do with computers."

M10: "Computers will be integrated into the fabric of our lives. "

M3: "Computers have so many applications that it is clear they will continue to grow until most things are at least somewhat linked to some sort of computer."

M8: "Basically, computer will help people to handle most work in the future. The only thing we need to care about to control the computers well."

F3 was impressed by the high pace of IT advancement: "It is the science of computation using 0's and 1's.... The science of computer is constantly developing at an exponential rate. Who knows what computers will be like 20 years later, that's what I'd like to find out."

F6 viewed the learning of computer science "as steps made through algorithms, from mathematical and theoretical ideas towards programming." She was very confident that her mathematic skills will make her resilient in achieving computer science skills.

Asked why he likes computer science, the vision of M1 was more related to engineering. He answered:

> I like computers from a science engineering point of view. But I don't like, you know.... Some people get obsessed. I am very interested because in computers it's all electricity, it's all engineering. So you do programming, hardware, software. It requires knowledge. It's all pretty much science. You know, this is why I like computers, from that point of view. It's so cute!

The Role of Social Interactions in Computer Science

The traditional approach of individual programming no longer holds sway and there is a greater focus on team programming in the IT industry today. The increasing number of demands increased the complexity of software. The new products cannot rely only on a few perfectionists acting independently. As a result, the number of IT professionals on a software project team has increased.

For this reason, social interaction has started to be prized more that individual technical skills. The mainstream of professionals has moved ahead, according only a scant admiration for someone who is capable of finding leaks in software packages but is probably not able to be on a software team. Both male and female students valued social interaction and software design more than hacking, “favorite tricks” and “blind typing”.

The Role Played by Experience

The questions about experiences were related with many observations and the findings that could not be compressed in an occasional paragraph. In fact, this finding is one of the most important of the current research.

Students from both genders were aware that employees asked for practical skills, for the possibility to work with *real projects*. Employers were less willing to wait a couple of months until their new IT employers learn the needed technology and spend extra money for training. Students knew that the employers wanted the results right away and that practice and experience were the most important while the academic record had little importance or none.

However, male and female students behave radically different. Keeping in mind this aspect, the majority of male students mentioned an interest for real practice and less for academic record. As was mentioned before, among male students, only those interested in pursuing graduate studies were working to achieve good marks. Many of the male subjects were just waiting to finish the program.

Female students were also aware that in the absence of practical experience, their academic record was of almost no importance. Many seemed resigned to the fact that their grades would not get them jobs in the IT industry. Missing useful contacts in order to help them work in real world projects, it was noticed that female students did not even try to practice beyond the academic requirements. This fact was an expression of anxiousness that female students face. This failure to prove that they have real practical experience did cause the great lack of confidence that researchers often mentioned in comparing gender achievements in computer science (Margolis & Fisher, 2003; Sanders, 2005).

Gender Perspective in Programming

Asked about the role that programming represents for computer science students, MT1 mentioned that: “initially they think of computer science as just programming.” Researchers often mentioned that males outperform females in programming (Cooper & Weaver, 2003; Margolis & Fisher, 2003; Pickett, 2005). This research confirmed these results. The majority of the male subjects participating in this study enjoyed programming and performed well in it.

Describing programming, M7 had this to say: “I like programming because of the creativity involved. ... What I dislike in programming is the fact that it is sometimes time consuming.” Despite this, he confirmed that programming is what he enjoys the most. He was very interested in learning more object oriented programming techniques. In addition when he started to learn writing code, he also started to enjoy learning software design, UML, and software architectures.

M8 did not consider himself working in programming. In fact, he mentioned mostly courses related with hardware interfaces the most interesting things in the program and tried to avoid courses that required programming skills. He mentioned that "the least interesting on computer science is coding" but appreciated that programming is very beneficial for people who practice it.

M9 also enjoyed that in contrast to his previous job in electrical engineering, in programming anyone can quickly achieve his or her results. Compared with his previous job when he had to wait for the designed product for months, now the results of his software activities were seen instantly:

> I like the fact that I can see very quickly the result of my work. You know the steps you have to take and how is going to be. I don't like to use the keyboard. [Laugher] But I have to do it.

Although the material was challenging for him, M9 was very attracted to do programming. He was much focused to surpass any obstacle that could interfere in accomplishing the required assessments and mentioned that learning programming is the only way to have solid foundations for a future career in computers:

> I like the feeling after I have done something properly and it works. I put the equal sign between programming and computer science. You cannot do computer science without programming. Someone who is going to take computers should go deep inside with programming. It doesn't matter the language.

As mentioned before, M9 just started to learn programming. Although his schedule was very crowded, he was able to get A grades in programming courses. Moreover, he saw himself able to work in programming in the future and said he would be able to relocate with his family to anywhere there is an opportunity for jobs in programming. He was very confident that computer science is equal with programming. He confirmed this again later but added: "at least it starts with programming." His attitude helped him to improve his programming skills dramatically. At the beginning of the semester he did not know even the basic rules, how to use arrays or use the instructions for cycling (i.e. while and for). After these courses, he achieved with amazing speed the basic skills for C++ programming and mentioned this language (considered by experts as the most difficult one and avoided by almost all females (Margot & Fisher, 2003) as his main passion in computer science program.

M5 mentioned that:

> I like programming because it tests your skills of computer science .... You can always try something different and new. The only draw back of programming is that if your basic concepts are not clear, your survival is very hard.

Female students also recognized the importance of programming. F3 mentioned that she was very attracted to programming: "I like programming because it is a tool to create something that actually exists, and is real in a virtual environment. It allows your inner creativity and problem solving skills to work together and develop something interesting." Different from previous subjects, she mentioned that she enjoyed keyboarding and coding. However, she did not reduce computer science to programming. "No, programming is just a part of computer science. There is more to computer science than just lines of codes."

F1 recognized the theoretical aspects of programming. "I like programming because it is very important. We cannot conceive actual society without programming."

Also she acknowledged the failure of many IT teams: "But sometimes it is very demanding and requires a lot of leadership and coordination with others, which is not accomplished in real situations." Asked for pros and cons about programming F2 mentioned: "I like programming because it gives me an opportunity to challenge myself but I do not like programming because it is very difficult and takes up all my time."

Although F1 took three courses related to C++, she cited this programming language as the least favorite because she did not enjoy the "aridity" of the language. And so did F2, when she mentioned "I do not like C++ because it is difficult." However, Java was one of the preferred courses for both, because it was not so demanding and also probably because the professor helped and encouraged them. Mainly, what was understood from female students' attitudes was that they would accept programming tasks. They simply adopted a "must do" attitude but their target was not to remain in programming. For F1, her target was to work as an IT software analyst or an IT manager. F2 agreed with the importance of programming: "You need programming everywhere but it is not my greatest strength." In fact her experiences both in C++ and Java languages were unsuccessful. As a result she started to seriously lose confidence and enthusiasm.

F4 was also interested in web programming, but "not in something that take 100% of my time." Because F4 was very keen in web design, she was interested to relate programming with web design, where her graphical aptitudes would mix successfully with programming tasks. F6 perceived programming as a tough job but, she mentioned "I like to do programming. I would insist on finishing the program spending as many hours as are required in order to finish the program." Excepting F3 and F6, all other females accorded an important place but only a theoretical one to programming, a place in which they did not take a participative role.

Software Preferences

Asked what software interested her most, F1 answered: "I was working before as an assistant software analyst in a financial environment and remember its significance. … For me, computer science is more software analysis and design." As technical skills, female subjects considered themselves better in mathematics than male students. Also, females obtained good scores in web-design. Males considered themselves better in algorithms, C/C++ and Java programming. The greatest difference between males and females was in C/C++ language. It's no surprise, considering the fact that C language has a component considered to be a low level programming language, related to Assembler. Margolis and Fischer (2003) found similar observations in their study where mastering C++ language was considered for experts not for "Java wimps" (Margolis & Fisher, 2003). Also a big difference was noted in information systems, males being more interested in issues related with how computers are working.

Asked what significant accomplishment he would like to achieve, M9 mentioned: "Something that was never build; something to take from scratch." M5 answered "UNIX programming. It's interesting."

M1 was pretty advanced. His high expertise in the IT field in programming and administration made him see a unity between hardware and software. And so were his projects that he was working on. First, he wanted to design computer games:

> I have a lot of projects in my mind. I don't have enough time to do all of them but here are a couple of them. One of them is I'm thinking of designing a game. But

> it's not something new about technology itself. It's about story, how it's implemented differently. I look at games, big companies, how they are doing. It's very nice how they are doing, but it's more that they can do from that point.

Second project mentioned was related to create "virtual desktops":

> I am interested also about virtual desktop. There is more to it. There are a lot of companies like Microsoft, Apple, IBM, etc. They already did those kinds of things. Microsoft doesn't have it. But they are saying they will develop it. Apple has such thing, Dot Mac. Now IBM has Lotus Notes. It's a virtual desktop. You just log in. My idea goes further. I'm not sure if technology is there, but I'm pretty sure. You just open your desktop, and have your applications like browser, e-mail, ready; everything you need.

A short remark should be mentioned about current trends in computer science industry that were not covered by current undergraduate curriculum with respect to Visual C++, C#, .Net, Rational Rose, etc. Although these programs are frequently requested in IT industry, female students were not willing to learn these products by themselves. This tendency was different from male students. Almost all male students, not only those who were considering themselves successful, already started to track a software product and consider its future impact.

Least Preferred Activities

Females were interested least in "pure programming". In consequence, C++ language was not their preference. For instance, as I mentioned before, although F1 took three courses to master the C++ language, she mentioned this language the least favorite. Asked what interests her least about computer science she answered "programming.

Although it is important, I do not consider myself doing programming activities for a long period of time."

Interestingly, F3 and FT1 gave almost exactly the same answer about what interest women. FT1: "The history of how things were developed least interests them." F3: I am least interested in looking at the history of CS, or to study what has been done in the past.

For some of the male students this question was difficult since they mentioned they like all computer science courses. Male students who remained in programming avoided tasks in network administration. Also M1, M2, M5 did not have the required time or patience to understand the relations between theoretical concepts (grammar, automata, etc) and software applications that they use on a day-to-day basis. M8 who mentioned a future in computers' business world mentioned that debugging is the least pleasant activity.

Thoughts about Careers in Computer Science

Asked about experience in IT jobs, the genders provided different answers. Asked about their experience about having a career in computer science, the majority of female subjects did not have a clear image. They had no experience in the IT job market. They had very little information about real IT jobs. This could be identified as another reason for the failure of female students in computer science. At best, they saw the programming as inevitable, but a boring job, at least at the beginning of a career. As was mentioned before, they tried to avoid it. Also, they were not concerned with finding the real aspects of the job in order to learn different situations. MT1 mentioned that female students were "better at social skills, in computer science they are more likely to succeed as IT managers than (often socially isolated) programmers."

During the classes the researcher met a female student who was in a biotechnology program as major and computer science as minor. It was an informal discussion about jobs. She knew nothing about IT jobs but also about her future career in biotechnology. In fact these remarks could be valid also for the majority of female subjects. Excepting F3, all other subjects were not aware about their future job. They did not have clear ideas about IT careers.

The male attitude towards a career was different as several students had worked as professional IT. In general, students who considered themselves fit for computer science program were sensitive of the requirements of an IT job.

Question 3: Opinions about Successful Computer Science Students

The third question tried to explore the image of the successful computer science student.

The Role of Mathematics

Old paradigms often related the successful skills in computer science with high aptitudes in mathematics (Grundy, 1998). In fact, of all required courses, only the first course, Key Concepts, was very connected with mathematics. With the except of this course a strong background in mathematics was not required in the general bachelor of computer science. However, students who wanted to pursue a bachelor with honor were required to pursue additional courses requiring high skills in mathematics. In addition some courses required for the undergraduate program had topics in pure math. Few of the subjects considered mathematics crucial to success in computer science. Of the male subjects, M6 felt that mathematics has a very important role and more courses with mathematical background should be included "although this is not what colleagues want." M8 considered an essential role that mathematics is playing in computer science but he did not have good mathematics skills. "Good understanding of math... I do not have such skills"

Many female students had a good background in mathematics. Unfortunately, although mathematics helps in algorithms, this is not enough to have success in programming. Some female students with good background in mathematics found out the hard way. In a recent discussion with a very successful female student in mathematics she indicated that in the last year of high school she was very confident that being an outstanding student in mathematics, the computer science program would be piece of cake. In the first year of programming, in the 11th grade, she learned the basics of the C language and wanted to have a career in computer science. In the second year of studying programming, when she was in the 12th grade, her teacher switched the programming language from C to Java. Although almost all of the specialists agree that C is more difficult than Java, this should not be interpreted in a simplistic way. Java offer more flexibility in programming using advanced facilities and the same code for different platforms (i.e. UNIX, Linux, Windows, Mac OS). C and C++ programming languages does not offer a standard set of facilities so required in actual programming (multithreading, graphics, visual interfaces, databases, Internet) as Java does.

This student's big problem was to master this complexity. Although her teachers had experience in standard C++ she did not have experience in OOP and the hierarchies of classes mentioned before. As a consequence, the framework of Java language and its classes, interfaces and libraries that were considered advantageous, transformed the students' efforts to learn programming into a nightmare. Her classmates were taught very poorly and as a consequence the female students felt unconfident and avoided taking further computer classes. Now she took some courses in computers only because she was obliged to. Some male students learned Java by themselves, using extra school time and efforts. They looked on the Internet for code samples and projects in Java, collaborated with each other and finally succeed in learning something practical. Finally, they pursued an undergraduate computer science program. This final outcome was confirmed again in this research with new cases of women successful in mathematics but not successful in computer science.

Of the female students, only F6 felt that a strong background and competence in mathematics was what helped the most her to adapt to computer science program. However, in my opinion she under estimated her confidence in using computers. Observed over time, she showed high confidence and hard working in both using and programming computers but she did not appreciate her own skills enough. The general sentiment among the students was that while a strong competence in mathematics might help it was not critical.

Enjoyment and Satisfaction with Technology

In contrast to the decades of pioneering, when working in computer science was related more to mathematics (Butler, 2002; Grundy, 1998), the last decade in particular saw computer science more linked with engineering than any other domain. Computer science was viewed as a technology and the IT worker was seen as engineer.

The majority of male subjects in this study saw computer science as being more closely related to engineering. M1 and M5 mentioned engineering as a potential career. M9 had an engineering degree and ten years experience in this field. He mentioned proclivity to use computer as a tool: "You have to be very computer oriented. It's not enough to be good in logic and mathematics. You have to like to stay in front of computers in order to understand."

Females recognized also the similitude between computer science and engineering. F4 mentioned a link between these two. F1 was also attracted to engineering before. In fact, as an assistant analyst, she had many tasks in the administration of computers. Her engineering skills helped her cope with the requirements. In administrational tasks she was the most skilled of the female subjects.

As Grundy (1998) mentioned doing a program that will process some data finally will produce an impact on physical devices. It is more obvious that during the last decades, when microcomputers started to be widespread, computer science started to be more associated with technology than with mathematics. All in all, the links between computer science and engineering attract in a greater measure males than females.

Fast, Self Directed Learner

Students were aware that the computer science area is a very dynamic domain which requires frequent updates. Both genders mentioned that many additional hours are necessary in order to cope with the shock of novelties from computer science. They were committed to studying computers as a full time job. All female subjects were studying computers at least 40 hours per week. Male students recorded strong differences. Some of them mentioned that they worked "all-day." Other male students mentioned that they do not work at all after classes.

Importance of Hardworking

None of the subjects viewed programming ability as an "innate" trait. They all felt that success could be achieved through hard work. Male students in particular felt that hard-work was the only recipe for success.

M4 mentioned: "Hard work and very good aptitude. Yes, I fit that mostly." M7 suggested that the ideal student was someone who "works hard with patience" and that he was this type of student. M5 mentioned "Well, they tend to be very hard working, so I miss out…." A common characteristic of both genders was that hardworking is a "should have" characteristic, for computer science students to be successful.

All subjects were well aware that computer science requires a sustained effort to update their knowledge. Sometimes, this was mentioned as a bonus for computer science, some time as a disadvantage. M5 mentioned "If you don't update yourself in computer science you are out of the market." F3 mentioned her enthusiasm for the high pace of change in computers. This is why she liked computer science.

F6 was aware that she had to sacrifice extra-time for the frequent changes in computer science: "Computer science it is updating itself at a very fast pace. If you do not want to or if you can't dedicate time to update your knowledge, you are outdated." F4 mentioned that fast update of the content in computer science could be difficult for a female who has a family: "Competing with male students, I believe that family life makes female students more difficult to adapt in their IT careers, in the long run."

Both male and female subjects felt that to be highly successful, computer science students needed to put in over 40 hours per week. F2 mentioned that "computer science students are very serious and talk about the subject all the time; I do not think I really fit in because I am not that serious of a person." However, she mentioned that she worked 42 hours per week and spent many extra hours on the Internet, which was more than the "average time" required "for a job". When she was asked if her grades in computer science were related with her real potential she answered: "No, they are not because I know I am a very hard worker and a fast learner but this is not reflected in what I have done so far in computer science."

Some See Computer Science as Typical Male Area

Asked about the picture of the ideal student in computer science, some students perceived this area as traditionally male. The close links between computer science and engineering and mathematics greatly influence this perception among the majority of male subjects but also among some female subjects. For example, M1 mentioned that because of strong requirements in logic, mathematics and technology "there are very few girls in computer science."

M3 explained the difference in the following way:

> Because it's traditionally a male oriented job, and people, whether they like it or not, are conditioned to do things that fit into traditional roles. That's why I'd never take nursing, even though in reality it's a perfectly good profession. These things are changing, but slowly."

F4 and F5 mentioned that from early childhood they viewed computer area as "boys' expertise". F5 mentioned that "women are not interested in selecting a major in computer science."

Not all students had the same opinion. They believed that gender is not an issue to perform well in computers. F6 mentioned that her culture tries to encourage females to compete in mathematics and computer as well as males. M9 suggested that females do not need to further prove their competence so he rejected any negative female stereotypes: "Some of them I realize are doing very well so it is not something related with gender. Some of them are not."

The Importance of Social Skills

The IT work market showed that during the 1990's the idea of focusing narrowly on mathematics or computer skills did not pay off. Sometimes gifted technical people, because of the fact that their social skills were not at the same level with their technical potential, could not adapt themselves in a team. For this reason employers started to seriously consider and assess social skills. This caused a shift in students' attitudes towards being more aware of the importance of teamwork. The respondents in this study identified this aspect as being very important. M6 mentioned: "social skills, I think, are very important nowadays. You might be the most intelligent person in the world but if you don't conduct yourself in a social gathering you gonna have a hard time."

This observation was in contradiction with what former researchers noticed in the previous decade that males were individualistic and females were more social. M5 wrote: "it was programming, now it's more CONTACTS." Asked what is important when he is part of a team, M3 answered: "the people involved. I want to work with smart people so I don't have to carry all the weight."

FT1 confirmed the importance of social skills: "Students must learn to be team-players. It is an important trait that employers are looking for in their potential employees. Female students usually take more passive roles."

The Old Myth of the Geek Is Irrelevant but still Persistent

From the experience of the researcher, the major characteristic of the 1980s and 1990s was the fascination of people around hacking (Kersteen, Linn, Clancey, & Hardyck, 1988; Margolis & Fisher, 2003) but this trend was not followed for the next decade. Rather this was the impression that the mass-media had created in its hunt for sensational news.

The image of the geek attitude persisted in some of images provided by subjects. M5 mentioned that the successful student from computer science is "Dry humor and bookworms… No, I do not fit in this." M2 gave a hilarious thought: "I would think a typical CS student would be skinny, wears thick black glasses, very shy, and talks about computers all day long. I do not think I have these characteristics." However he was skinny, was often wearing black glasses, was pretty shy in class, and stayed in the first row, always frequenting the Java classes and paying complete attention to lessons. In fact, his image about hacking was artificial from futurist movies about computers and technology. It should be noticed also, that for M2 and M5 the successful computer science student had some characteristics of geeks and hackers.

However, the image of "geek" and "hacker" was not found to have so much importance generally. Hacking was not perceived as important anymore because finding bugs could be jobs for testers, not for experienced people in computer science. In any event, this is something of only minor importance. However, exploiting a bug for the purpose of deception is a felony punishable by jail time or fines. There are tough laws implemented in order to combat computer frauds. For this reason the mass-media does not propose this kind of image in movies anymore. The shift from hacking to "social programming" was confirmed again by this study.

From the stand point of the current research, the stereotype of the "geek" is an outdated picture of the ideal IT specialist. It came from people who were far removed from IT specialty. M3 mentioned that there are not so many "geeks" around anymore: "The stereotypical computer science student is portrayed as an introverted "geek" who sits at his computer all day. While I've run into some of these people, it's not really the case with most of the people I associate with."

In observing all these seven courses, the author noticed only one student who could be labeled as a "geek". He participated regularly in lectures and labs but never asked a question. He was excellent in labs; an assignment that took him more than 30 minutes was something very rare. Other students identified him as an excellent technologist and his status was established as he was already working for an IT company. However, he was not sociable. He worked alone all the time and did not collaborate or cooperate with others.

Question 4: Challenges That Each Gender Experienced

This research question tried to explore challenges that students faced during their undergraduate program.

Levels of Anxiety

In analyzing the difficulties specific to each gender, a pattern was noted related to the perpetuation of gender differences. First, the initial differences were not going to decrease in time as common sense suggested. If students are not able to have positive experiences during a course, staying in the front of the computer will not solve the problem (King 1993; Rosen, Sears & Weil 1987). Secondly, without achieving the expected results, anxiety increased (King 1993; Rosen, Sears & Weil 1987).

In this study two female students were observed working hard for several weeks in labs. At the beginning, both were enthusiastic. For them it was “tough but doable”. However, during the midterm they felt unhappy and mentioned that they could not cope with the course requirements. They couldn’t keep up with the pace of the course so they left the course after the mid-term examination.

Initiation in programming is a new type of literacy. A programming language is different from a natural language. It is another kind of language, artificial, simplified, and designed for computers, which seems unfriendly for beginners (Margolis & Fisher, 2003; Turkle, 1997). However, in general, when someone masters the requirements of a programming language, he or she starts to feel more confident with programming. Due to the fact that the majority of programming languages use almost the same few paradigms (structural programming, modular programming, and objected oriented programming) additional programming language is usually very easy to learn. Once you master one programming language, it is easy to transfer the needed skills towards the learning of other programming languages. It is crucial to learn the first programming language. As a consequence, it is very important to observe for a researcher how students learn their first language.

In an introductory course in programming, the researcher noticed a female student whose major was mathematics. She was present at each class, in the first row, along with her friends. Without knowing the identity of the researcher and unsolicited, she divulged that she is in a mathematics major program and that she loves mathematics, but hates computers, especially programming. When the researcher asked why she refused to give an explanation. She had one of the highest degrees of anxiety this researcher has seen. More exactly, during the course her anxious behavior was distracting. She often used to take breaks or let the teacher know that she was tired and could not follow her anymore. The teacher was quite understandable and flexible, trying to cut from the time and content of the current lesson, teaching only the core things. In labs, the student just started to type some bunch of code from assignments, without succeeding to control the code. After a couple of labs, she no longer tried to correct the programs for assignments. She gave up in the first few minutes of the labs. While the teaching assistant was checking the previous assignment she regularly left the program. Her female colleagues were not able or willing to help her either. They could barely cope with the content of the course themselves.

The researcher observed F2 several times during her lab in the Java course. In the beginning she was very willing to work on her assignments. However, her body language showed a high anxiety level. Most of the time she did not ask any questions at all. She just left disappointed at the end of the lab. As she responded to the questionnaire, her level of confidence was 10 before starting the program, 8 during the first year and had sunk to a 2 at the end. Only at the final assessment, where a lot of new things appeared, she repeatedly called the TAs to help her, but it was too late. At that moment, they were very busy so the TAs had very little time left to spend with her. When asked if she had any contacts with other computer science students or professionals, she said that she did not have any extra school contacts from people with experience in computer science.

The only difference between F2 and the female student from the mathematics program was the presence of contacts. Both were good in mathematics. F2 enjoyed using computers while the math female did not. F2 was oriented first to major in computers while the other didn't. But this did not make her able to cope. While the former did not have any social network able to help her, the latter had. F2 did not have any friends, male or female who could help with the coursework. The latter had two female colleagues and a male colleague who worked with all three female students and assist them outside of class.

Informal discussions with a female computer science alumnus revealed that the male dominance was not new. In her year of study, there were only two females left in the computer science major and over 45 male students. She, who was an Eastern European student, and a South Asian student were the only women who remained in the program until they graduated. She confirmed that the two worked together. They had a learning group consisting of five students, two females and three males, from different countries but from the same year of study, who were willing to learn together. She called this strategy crucial for her success.

The researcher spoke with another male alumnus who graduated in 1996. The situation was almost the same with the previous alumni: two female students and almost

50 male students left in the final year of the computer science program. Analyzing these aspects, it can be concluded that although insufficient females' participation is improving.

When F1 was interviewed she stated that what helped her to cope were two essential things: one was social network and the second was previous experience at an entry level in an IT job. Even though she had not practiced software programming or software analysis in Japan, working as a user with financial software helped her and gave her a good perspective about the requirements of the software needed in the financial world. After courses in business and accounting, she hoped to qualify for co-op, and would give her a clearer view of her future.

What was different from the previous two female students was the fact that she used to regularly ask her for TAs and the instructor in each course for help. Also, she mentioned, that computer science required practice: "It is not enough to learn a theoretical concept; you should implement it, write code and practice it in order to master the concept and to let the stress subside." Very importantly, she had a social network of peers in computer science.

Outside Influences Advantage Males

Usually male students from computer science programs spoke with interest about their passions and hobbies related to computers. Being aware that experience is the only thing that matter for employers, male students were focused more on long term projects that provided hands-on experience. They were willing to dedicate time and effort in order to learn a software product beyond the current academic limitations.

Males and females gave contrasting patterns about their extra curricular activities. At university they just started to learn software design and M7 was already interested in UML designing and software architecture. With M4 the situation was the same: he already promoted the software design as a major interest in his future career. Asked what projects he is drawn to, M4 mentioned Flash, J2EE, Web development, software development, software analysis. M4 mentioned Enterprise Application Integration using Biztalk Server, things that were not taught in the Department of Computer Science. As was mentioned before, M8 was not very interested in programming but he was interested in hardware and business with hardware. This fact helped him to learn more about hardware part from computer science, to learn about designing processors and external devices.

In contrast, female students had a relatively limited interest in learning software requirements not related with any course. They were less willing to manage in detailed their efforts in order to master a software package. Also, they did not have a software project or have one planned to extend their practical experience. It seems that they tried to avoid dreaming in code lines or objects. F5 was interested in databases. F1 was interested in developing financial software design. But most of the females were interested in web design (F2, F4, and F6). Other research confirms the attraction of web design courses to female students (Scott-Dixon, 2004).

As an outstanding outliner, F3 wanted to be involved in developing games "Anything that can interact with you once it has been successfully coded, rewards you with a great sense of accomplishment." In fact, she was the female subject who had a project extending over the conventional level of school.

Different Levels of Experience Continued During the Program

This study revealed that different levels of experience were perpetuated during the undergraduate program. Sometimes this caused students a lot of frustration.

Usually, male students who had previous computer programming experience easily mastered the introductory courses. For example, one first year student always finished each of his assignments in less than half an hour, almost as fast as a mature, professional programmer. It turned out that he was working already in an IT company, so the introductory courses presented very few problems for him.

Starting with the second year of study, male students extended their gap in all three aspects: user confidence, programmer confidence and career confidence between them and female students. For instance, in the second year of study, when there is supposed to be more focus on object oriented programming, male students already had some projects and easily mastered the new coursework. They were more prepared to learn object-oriented programming. Because of their previous experience in programming, when software design started to be taught in the third year of study, students with experience in programming, usually male students, were much clearer in designing software architecture and extended their advantage in this way.

In all cases, male students had peers that helped them to cope with difficulties of literacy in computer programming. In contrast, female students did not effectively develop peer relations. Although credited in general with better communication and social skills (Sanders, 2000), female students in this study generally did not form a social environment able to stimulate and to encourage them in their pursuits for computer science.

Another important factor found was the practical experience. Many of the male students had prior working experience in a software company. M1 was already hired as programmer. M3, M4 and M10 also had IT job experience. None of the female students mentioned IT job experiences although F1 and F3 mentioned that they were considering this possibility.

Social Stereotypes Are Strongly Presented in Profiling Computer Science

Gender is not only a biological reality but also a socio-cultural one. More exactly, gender is a socio-cultural construct which update its content in space and time (Margolis & Fisher, 2003; Sanders, 2005). Asked why female students underperformed versus male students in computer science programs the answers were generally convergent. M3 mentioned that the IT market had traditional male jobs. M1 suggested that the relatively small number of female students may be due to traditional family obligations. He argued that because a woman is important in a family they might not have the time to invest in a computer science program. “I admit the possibility to find female role models in computer science, although I never found any in my day-to-day experience." He and M8 mentioned that the required logical skills could be too much for females. According to M8, “generally speaking, women do not have good logic in this field.” M5 expressed views which could be considered extremely chauvinistic when he said that “[computer science] it’s drier and more thinking” so women are not selecting a career in IT industry.

F2 generalized her personal case: “Probably women find it too challenging.” M10 mentioned: “Maybe they’re less interested in computers.” F5 suggested that “probably females do not get attracted to this field. Maybe they like to use computers for other purposes just not programming.”

Unfortunately social stereotypes of females in computer persist. Sometimes strong stereotypes are closely related to discrimination. Margolis and Fisher (2003) mentioned that 'the gender stereotypes associated with computing tend to pull boys in and push girls away. To balance this influence, a concerted campaign is necessary."(p. 119)

The Greatest Chasm and the Influence on Students

The researcher was able to identify the critical point where the students were failing. Regardless of gender, the majority of students who did not have enough experience in programming had great difficulties at the same point: modular programming. They failed to implement subprograms (modules) and manage them properly. More exactly, it was noticed that almost all students were able to assimilate the first step (structural programming). Unfortunately when some operations needed to be often implemented, it was required to recognize their identity and treat them separately (i.e. data input, printing data, applying the same operations for all items from vectors or matrices). Students from both genders had difficulties in managing these modules. Not having enough practice in using modular programming they had an increased amount of difficulty at this level. For them, the majority of courses that followed in the second year were difficult to master.

Do Females or Males Feel Discriminated Against?

May be the students who could answer yes to this question had already left the program. However, asked this question, none of the female subjects said they felt discriminated based on gender. Still, the academic environment is different from the IT industry. F1 mentioned: "Females have some disadvantages in IT industry, not here at this university. But I'm willing to take the things as they are." F2 rejected any gender discrimination in her case. "I do not really feel a difference; gender has never been an issue for me." F5 did not consider any discrimination against her or her female colleagues as female students. "It is only case by case", she suggested. However, F4 felt what has been called positive discrimination (von Hellens & Nielsen, 2001): "I don't see for women the need programs special for women. It's humiliating! Why should we be taught watered down stuff?"

Sometimes some stereotypes go too far. Asked how gender inequity could be addressed M8 argued: "That is the difference between female brain and male brain I do not think any motivation can help." M5 argued that "women might actually have been helped more than might generally seem to be the case." He sustained an offensive and discriminatory posture by suggesting that "...woman aren't that good at working hard. They should be encouraged to sit quietly more, maybe that helps."

About games software bias, M3 wrote: "Computer games are certainly targeted for their main audience as any smart business would do, which happens to be composed of males. It's not like they don't like women, they just know that they don't buy many games." Most of subjects agreed that there are some games which target only male consumers. M6 mentioned that: "Males are more aggressive than females and action games are more for males."

Another issue of equity discussed in the general literature was about equity to have access to computers. Some researchers had indicated that traditionally, women had encountered problems accessing computers (Anderson, Welch & Harris, 1983; Campbell & Gulardo, 1984). Now it is not the case anymore. In all Canadian and US universities, the access to computers and software is at least satisfactory. However, access at home could be still an issue. This could still pose serious concerns for future development, especially when we consider the extent of time and the flexibility that a home computer could offer (Linn, 2005). Even though computers are affordable for almost every family in Canada, access of females depends on the extent of the patriarchal degree, poverty or familial obligations of each family. In this case we do not have inequality in school but in the family that could extend the gender gap from school. For example in this research, F6 was the third user of the computer at home after her husband and her son.

M10 mentioned that there is not any advantage in being a male in computer science program: "Being a man, there wasn't any discouragement.... Being a man has no advantage. It all depends on your skills." M9 mentioned that computer skills are all that matter: "It should be an advantage knowing programming before but not being a man or a woman."

M3 mentioned that "None of the listed factors play an important role as far as I'm concerned; it's just that there is a stigma around computer science and traditionally males go into it." MT1 mentioned that there is "reverse discrimination–at play (e.g. scholarships for women only whereas never scholarships for men only). Talent should be above gender in the selection criteria."

Asked if females have advantages MT1 mentioned: "Yes, due to equality laws – we must have equal number of women (regardless of qualifications; as long as an artificial minimum is met)." He mentioned also cases when scholarships targeted to women brought into the program unsuitable students who proved to not have anything in common with computer science and failed at the end of the course. They were aware that the instructor did not shortchange them but they were not able to cope with the program's requirement.

FT1 was optimistic predicting a gradual increase of female students in computer courses:

> I think the male/female proportion in computer related field is not bad, and I believe that more and more women are joining the field. Computer Science is taught in high school, female students are now less intimidated by the technology.

Organizational and Administrative Problems

Five of the seven computer science courses observed were scheduled during the mornings and afternoons, while the two other courses were scheduled during the night. Four of the courses required for a major in computer science, were scheduled during the day. The courses required for a minor were scheduled after 5PM. This means that students who were registered in the major were obliged to attend classes during the day, making it impossible to take regular jobs. In contrast, the students registered in computer science minor could take it either as full time or part time.

Question 5: Males' and Females' Opinions about Computer Science Teaching

An important theme was to identify the expectations and interactions that male and female students have with professors and teaching assistants. What characteristics and practices from teaching would be viewed as most effective and why? More exactly, what were the criteria for granting instructors good evaluations? It was noted that there were different attitudes from males and females about effective teaching.

Female Students Relied More on Teaching

Male and female students in computer science had different expectations of teaching. Female students had more hope for formal instruction. Since they had less experience in programming and lacked a social network to enable them in their computer science program, for them the role of instructor was crucial. As Rowell et al (2003) mentioned computer science teachers were more likely to influence their future decisions of students in selecting an IT career than their parents or friends.

Another explanation deduced from this research is the fact that not having a peer network, females related almost exclusively in the formal relationship with teachers and TAs. F1, for instance, mentioned that "not having good teaching could hurt me the most." This is why the attitude held toward teaching was found to be very important. Compared with males, female students usually tended to rate the contact with teachers and then TAs as being the most important to their academic success in computer science.

The contact with teachers was not as important to all male students. An outsider in his attitudes, M3 graded the importance of teaching in a scale from 1 to 10 with 5 and of TAs with 2 and mentioned that: "With the exception of sitting in class and listening to lectures, I've never really spoken to Profs or TAs, because I've never had the need to." Another opinion of M3 was somewhat in contradiction with the one mentioned before: "Going to class helps the most.... Bad professors hurt." There was something unclear in M3's remarks: he did not consider the instructors and TAs important; however if they were not good he felt hurt by them. In essence, he relied upon teaching supervision and their methods during class but did not seek extra assistance. What would happen when he had a "bad teacher"? He mentioned that he would "take the learning into my hands." This attitude was reflected by other male students. If the teaching was good for the male students this was normal, if not, they would feel hurt but they would manage by themselves.

Neglecting to teach the basics was disadvantageous for students of both genders. M1 mentioned he took the Java course before but dropped it. The basics concepts about Object Oriented Programming (OOP) were not taught and the instructor started too early to insist on graphical interfaces which seemed very difficult for a large part of the class. In contrast, the current instructor insisted that the entire semester be spent on OOP concepts and only in the last week did he engage the students in graphical techniques in Java. M9 was puzzled for the same reason. When he started the Java course, the neglect of the basics of OOP made him very anxious. While that course was very practical in its goals, it was not realistically designed. Without the basic principles of object oriented programming paradigm, the students did not master the basics of Java programming and were not able to master visual programming.

Mastering the paradigm on designing modules should take time, at least 200 hours of practice. M3 mentioned "just pay attention in class and understand the concepts, don't get hung up on thinking that it's all about studying, because it's not." Teachers and professors should be aware of the necessity to make them practice. Without mastering the concepts of modular programming it's impossible that students will have any chance in mastering future concepts and paradigms. In particular, they will not have any chance to properly learn object oriented programming or a database because of missing this important step. In our case, someone who did not learn modular programming would have difficulty learning Java, a language which is entirely based on object oriented programming.

However, if the quality of teaching is inadequate it was found that the outcome for males and females differed fundamentally. Females tended to be often discouraged by poor teaching, while males tried to persist. M3 pointed out that "if the professor is bad, you need to know when to take the learning into your own hands." M9 was not concerned too much if he understood from class or not. He took the learning into his hands also, to refresh his recent lessons, relying heavily in reading the assigned textbooks in order to cover current lessons. Even though an expert would finish the assignment in 20 minutes and he would need a couple of days, he said this would not make him to become discouraged. Generally speaking male subjects were committed to taking ownership of their learning and were less affected by inadequate instructors than were females.

Female students appreciate teaching, but they did not have any alternatives to bad teaching. They were less successful in taking learning "into their own hands". As Margolis and Fisher (2003) mentioned they were more sensitive to teaching. Take the case of F1. She mentioned that she would always ask teachers questions in order to understand the issues of the current class. Unfortunately, very few females had the same level of perseverance as F1 did.

The same context existed for F2 and F4 but they failed to interact properly with their instructors and colleagues. However, the situation was different for F3 and F6. F3 showed a high level of determination working many hours daily and already had good skills in programming when she started the program. In addition, she had quite a few peers from her country who were able to help her. F6 also had a high level of determination. Although having family obligations, she was willing to spend many hours per day until her assignments were done. She also had strong cultural support from colleagues.

Often Marks and Knowledge are Two Different Things

The researcher noted that attitudes and professional achievements differed in respect to marks. Asked if marks are important in computer science program, the majority of males were interested more to get through the program than in achieving excellence in school. As discussed earlier, M1 already worked as a full time programmer. Although he holds a mature view about computers and has experience in programming, he was not interested in getting great marks. He wanted "just to get it done." He perceived a great difference between people who know computer science and people who want to have a computer science degree:

> There are many people who like computers but they are not in computer science field. I also encountered the opposite. People who finish in computer science but they don't like computers. I was asking them why did you take this program and they answered that it is because it is a three year program.

M9 mentioned also that he is not interested in getting high marks. He mentioned that he doesn't want only to finish the degree but also to be knowledgeable in computer science: "I like to finish getting a degree. Not only to get a degree, but also to know those things learned in school and be able to apply them in the real world."

M3 mentioned a gap between real experience and marks. When asked if the marks that he received represented his real potential, he mentioned: "They are and they aren't. If you're smart, you'll get good grades. If you're not, you can still get good grades. So bad grades implies that you aren't smart, but good grades don't imply that you are."

Also, M3 mentioned the difference between being successful and having good marks:

> That depends on what you mean by successful. If successful means being good at it, then I would say you need good problem solving skills and creativity, which I believe I have. If successful means passing and getting a degree, well anyone can do that, no skills required.

M6 was more radical and said: "Marks and real knowledge are two different things." However, he and M3 were interested in pursuing graduate studies in computer science so they were aware that good grades are required. They were the only males who were concerned about grades.

M7 mentioned that "female students were more hardworking." TM1 confirmed also that females are better focused on assignments: "Usually female students get better grades than males." It is not the purpose of the study to do a statistical work to check this affirmation, but other researchers also mentioned better presentation skills and focus on assessments by female students(Margolis & Fisher, 2003; CREW Project, 2001).

An explanation might be that the IT industry usually considers only the degree and not the academic record. Rather than comparing the candidates for their academic records, the recruiters would be definitely interested in the experience of candidates and their social skills. As a consequence they were interested to achieve practical skills. The marks were required only for those who intend to pursue graduate studies. From this point of view male students had very pragmatic attitudes.

The most difficult question for me was to understand why female subjects did not try to achieve practical skills in computer science. Why were they focused so narrowly in achieving good grades? Was it because of a lack of support from their social network? In this case, the grades they earned were the only way to justify their abilities. This substantial difference in the way genders prepared for their future career was found to be very important.

The computer science program offered an opportunity to gain practical experience by offering co-op placements. The students with the best grades were selected and trained in order to learn more about an IT career. The goal of co-op was to make them able to obtain work experience in an IT company. In this case, the explanation for good grades was that female students wanted them in order to have a placement in co-op. For example, this was the first reason for F1 to be extremely willing to pursue good grades. Her grades were between B+ and A-. She explained that she was willing to study as hard as this was necessary in order to achieve good grades and be selected for co-op placement. For her, having a co-op was a first step in obtaining a job in IT. Having previous experience in the IT area, even in an inferior position and having obtained a co-op placement increased her chances of getting a professional job after graduation.

Unfortunately not all female subjects were able to receive the co-op placement. Because F2 received low marks, she did not have any hope to get a placement. F4 said that while she achieved good grades she was well aware that "marks are no guarantee that she will get a job." F6 was also focused on getting good grades, but for her, the grades were not as crucial as for F1.

The Teachers' Interactions with Students

Another important aspect in IAP1 and IAP2 was the level required by instructors. Where it was supposed that students would achieve the basic skills for programming the material taught was often difficult to bear for the following reasons:

- The exercises practiced too many lines of code that were difficult to be read by a student who did not have previous experience in programming.
- Many concepts were not presented. Yet, the instructor worked with them normally.
- Modular programming was not presented enough. As a second important concept in programming in the first year of study, this concept was not being taught from scratch. As a result, students who did not master this concept had great difficulties in the second year of course, especially in Java and Algorithms and Data Structures.

As with any demanding course, this affected especially female students. In fact, all courses observed used "objectivist" methods. More precisely, these teaching methods were designed for students who had already reached their maturity in learning IT skills. The textbook was excellent and the webpage tutorials provided by teachers were very clear but they required a strong effort.

In contrast, cooperative practices and constructivism were not noticed. It could be said that these perspectives were nonexistent. However, from the perspective of students who already had knowledge in programming, the first year courses were enjoyable. The samples selected were very realistic and practical. In addition, especially after the first year of study, the instructors did a great job keeping students alert. The instruction was effective. No gender bias was detected in the computer programs selected as assessments.

But, as was mentioned before, the major deficiency was to ignore the individual effort, the only thing which made students accomplish any requirements.

Some students disliked the slow pace in classes:

M3: "I also dislike how slow moving most classes are, as they have to pander to the students with the most difficulty that maybe shouldn't be in university if they are having that much trouble."

Others found it too challenging. For example, F2 commented that:

"The atmosphere is generally somewhat stressful. … It is very challenging and intriguing most of the time. I find it difficult actually."

One female professor in computer science suggested with pride that her course was very tough, and for this reason there are not any female students in her class. Asked about her opinions of doing research in computer science education, she answered that she did know what educational research meant. Her only interest was the mathematical rigorousness of the assessment. She would only agree or disagree with the respect to the mathematical ideas expressed by her students. She did not realize that there is a way that computer science content should be exposed to students in order to be understood. For her, computer science education was too far from the real content of computer science.

Subjects Perception of "Good" or "Bad" Teaching

In evaluating "good" or "bad" teaching, the researcher sought to identify students preferred teaching styles. An important finding was that students felt very anxious about the overwhelmingly theoretical approach without any practical perspective. In computers it is very important to present not only the theoretical perspective but also to be sure that students are capable of applying these concepts. In one of the courses, it was noticed an instructor that taught almost exclusively from a theoretical orientation, to the dissatisfaction of students. Some of them, especially males, regarded the professor with open hostility. Others, especially females, were anxious. The majority of students felt very frustrated not being able to work in details in order to have practical implementations in the course.F3 mentioned that the aspects of theory often became fruitless:

> I do not like the fact that most of the CS courses focus on asking for the definitions of technical terms and the theory aspect of programming on tests or exams. Too much emphasis is placed on the theory of 'how to become a good programmer'.

In contrast, the researcher observed another instructor, considered by many students "the best professor". The researcher was present in his classes to see how the different genders behaved during his classes. Male and female students interacted with the professor directly during the class. Female students behaved naturally in the class, without feeling anxiousness. His lectures contained many hands-on situations and observations. He explained tricks, practices and stories about hacking. The effect was not what some feminists would prognosticate. Female students did not feel anxious. On the contrary, these experiences seasoned with well explained details gave the hints they needed. After discussions with some students it was noticed that this kind of teaching was appreciated. Students who lacked hands-on experience were empowered. His assessments were very flexible to pursue and gave them many choices to practice in creative ways.

The researcher observed also another teacher considered successful by students. As with the previous instructor, the things that counted the most seemed to be his strong experience in teaching and practice. He really covered the topics very well and was very open with students. Both female and male students liked his style and interacted well with him. He was sensitive to the needs of students and catered to the needs of female students.

The researcher observed also the female instructors. They seemed to be more committed to teaching than their male peers. Their style was more articulate and intuitive. The teaching pace was very lively. The only problem encountered was that female teachers seemed to have less IT experience. Their teaching style was rather "classical" based on gradual covering of the curriculum. Although the purpose of this study was not to study gender differences in instruction, these marginal observations are important not only to see the teaching process per se, but also to realize the influence of role modeling and mentoring that teachers are able to offer. As expected, female students were more comfortable approaching teaching assistants and instructors of the same gender. This was recognized by teachers. TM1 mentioned that he usually try to have at least one male and one female teaching assistant.

Interactions with TAs

As mentioned before, the importance of TAs was considered to be very important by students. For female students, the importance of TAs was significant. For male students, different views were expressed. For instance, M3 gave very low importance to TAs. In contrast, M5 and M8 considered TAs to be very important, even more important than instructors.

It was observed that teaching assistants had different aptitudes. Many were not proficient in the English language, and most had very little teaching experience. In addition, most of the TAs had limited experience in the IT industry. It was also observed that TAs often appeared disinterested and more focused on their own studies. According to F2 some TAs did not respect their schedule. She suggested that they "are not very resourceful and usually do not even show up for their office hours."

Question 6: Class Communication and Interactions

An important aspect of this research was to observe and examine the existent trends of gender relations in computer science studies. The researcher was interested in observing the behavior of students in order to study male/male, female/female and male/female interactions. The same kinds of interactions between students and their instructors and TAs were also observed.

General Aspects of Communication Styles between Teachers and Students

It was noticed that in the first year courses, the communication between students and professors was poorest. Usually, here, the first obvious problem was the isolation. Students did not communicate each other. Very few students took notes in classes. Passive attitudes among students were also observed during labs when first year students often left the lab without finishing their current assignment. As a consequence, there were assignments in ALP2 where nobody did the assigned programs correctly.

M9 mentioned the poor communication among his colleagues:

> The communication! ... The fact that most of the time we can communicate only with the teachers. Even with the teacher we communicate only by emails. Everything has a lack of personality, it's impersonal. Even though from time to time we are going to do those labs, we cannot share with others. It's not ok, most

of the people have the feeling that they should keep should not share information even after the exam.

Indeed, the first year students were not used to communicating with each other. In fact, "many of them were not aware why they are in that program."(TM1) This was the reason why there were so many students who dropped their courses. When a lab was incorporated in a course, usually students were required to submit their assignments at the end of each lab. Also, it was expected that their assignments be original, and independent. These restrictions hindered the communication between the first year students. For this reason, the teaching assistants did not help students enough during the labs. They gave them only general hints. Sometimes, these generalities were not enough to finish the assignments. In general, first year students were too cautious in communicating each other.

In the second year of study it was noticed that the students started to be much aware of the computer science program requirements. MT1 told me that they just start to realize why they were here. Indeed the communications skills of the second year student were much better than those from the first year. Also, the communication of the third year study was better than those of the second year of study. The researcher noticed more interactions between students.

Leaders in Classes

An important aspect was to observe criteria for being a leader. Who was reviewed as a leader and why? What were the qualities that student leaders had? How did they communicate with their colleagues? How did students from each gender behave towards each leader?

The researcher found that leadership appreciations were based on experience criteria. Those who had more IT experience had more chances to be considered leaders. As M3, M9 and M1 mentioned, good marks did not have relevance in the appreciation of leadership. Male subjects did not associate leadership with academic performances. They had different criteria and strategies for assuming leadership roles.

Some of them tried to impress their colleagues and instructors with their knowledge. They took it as a challenge to try answering all the questions from the course. Also they enthusiastically spoke about their projects. Most of students who wanted leadership proceeded in this way.

Not all the students tried to show their leadership. At the beginning of the course, M9 presented me the "geek" student presented before, as "probably the best fellow". But his colleague never talked with others. After the presentation of the current assignments, his colleague left without helping anyone. This made some male colleagues angry. If M9, believed first about his colleague as a leader after he realized that his colleague had had a problem. In fact, his colleague was not helpful on purpose. M9 started to treat him as a selfish person, not being interested anymore in him.

In the third year of study, a student tried to put questions that were not related with the current content. Rather these questions were posed only to show his connections with other software knowledge. Although his level was pretty advanced, his answers were not as savvy as he pretended to be. Sometimes, he did not know the answer to easy question that the professor addressed him. Other male colleagues treated him with irony, speaking about him aloud. In replica, another male student tried to answer at the same questions more concise.

Because female students did not have much practical experience they were not considered as leaders. However, M3 and M6 were pretty relaxed in their courses. Although they were not seen as leaders, they were pretty confidents in themselves and performed relatively well.

There were, however, some notable exceptions when female students answered better than their colleagues. For instance, one of the situations was at the end of the course in Java, when the professor gave students three quizzes related to the just completed topic, to answer in class. On the first quiz, the professor answered the question himself, explaining in detail what is happening at each step. On the second quiz, only one female student gave the correct answer, and on the third the male who volunteered to solve it, answered it incorrectly. The female student who wrote the right answer went very timidly to the blackboard. She did not speak with anybody. Despite of her awareness of the course content, she was not treated as "leader" by her colleagues and did not feel comfortable during the class.

Do Males and Females Have Different Learning Styles?

An important aspect in exploring communication patterns was the learning style that male and female students use in their current program. Many researchers stereotyped the learning process as followings: females have a cooperative style while males have a competitive one. Indeed, the attitude for girls toward competitive style was much lower that the male style. But the attitude of males towards cooperative style was not low. On the contrary, cooperative style dominated concurrent style and was almost equal with individual style. For both, males and females, individual learning was dominant.

Female Students Communicate Better

Teachers mentioned that females had better communication skills than males. FT1 mentioned that "Students in this level usually have good communication skills. Female students are more capable of expressing their thoughts." For MT1 was not satisfied by the students' level of communication skills at all. He mentioned this as a major deficit for both genders. However, he noticed that females had better social and communication skills.

Interaction between Males and Females

An important part of the current research was to observe the existent relations between males and females computer science students. The researcher was interested to observe the behavior of students to verify the nature of relations between genders. As many researchers observed, (Margolis & Fisher, 2003; Sandburg, 2005; Tannen, 1991; Tannen 1994) males were expected to be more assertive and aggressive in order to seize the leadership. The main issue was how to interpret this behavior in the particular case of computer science.

In considering female interaction and their low aggressiveness, Beynon (1993) wrote: "Some female students, who are aggressive in gaining access to computers, risk becoming unpopular both with males and females; as a result, other females may find it rational and safer to be passive in this regard… About males Beynon noticed "Males could become bullies in their interactions with females because of their attempts to have dominant control over computer access and use" Aggressive behavior by females was not observed in this current study. The often assumed male aggressiveness was not observed either, excepting few outbursts in the second and third year program.

Previous research found that in mixed classes female students are sometimes confronted with ironies and sarcasm when they do not know something (Margolis & Fisher; 2003; Sanders, 2002). During this study such behaviors were not observed. However, misconception that female students cannot achieve the same level of skills in computing as male students was revealed during interviews and surveys.

(For instance, M1 mentioned that a woman is different than a male because she is usually more involved in raising a family and hence not able to cope with having a challenging computer science career.

One observation in this study was the tendency of male students to monopolize the teachers' attention. F1 remarked that in class there is "more male participation". This was not unexpected given that 75% of the classes were male students.

M6 mentioned that his interaction with other colleague was not based on their gender:

> If a female is beside me I would ask her and she could ask me I don't have any problem with that. I don't believe in gender differences I believe only in person. If a person studies at home he or she will be more interested and will ask the professor in class.

It was observed that males were more visible in class and asked more questions. Their attitudes were rarely aggressive and for this reason females did not seem to be intimidated by them. F1 suggested that males were simply more proactive in seeking reassurance that they were on the right track. F5 conceded that there was more male participation but thought that were simply due to the greater number of males in the class. Another explanation is that male students had a greater level of confidence.

Males Students Have Better Support from Their Peers

Sanders (1985) mentioned that it is not male hostility that discourages girls but the absence of their female friends. The sentiment was confirmed in this research. Males seemed to receive better support from their peers while females often missed the support.

M5 for example, mentioned that he always have peers who are able to support him: "I have few friends who are really good in computers like they know in and out about programming, networking and any related stuff to computers." This confirmation should be mentioned for almost all most male students. Even though sometime male students did not have close friends, they managed to ask questions to other male peers and receive guidance sufficient to make them able to cope with day-to-day difficulties.

On the contrary, F4 mentioned to the researcher that for a female student, whenever she had a question that her TAs or instructors did not answer, often it remained unsolved. In time, many unsolved question erode the confidence and increase the level of anxiety.

Male Students Were More "Visible"

Usually researchers agree that males were more visible in computer science classes. They put more questions to the teachers. In the past, when there were few computers, it was noticed that males got access to computers leaving female students without computers. They were more insistent than female users and sometimes they even used verbal pressure to make others give them access to computers.

Asked about male students, FT1 mentioned that "they seek reassurance that they are on the right track." Observations and explanations pertaining to why males are more active and aggressive can be found starting with general aspects of genders when they communicate (Tannen, 1991). This aggressive communication style is ubiquitous in the computer science community. Other researchers have observed this aggression (Margolis & Fisher, 2003; Cooper& Weaver, 2003; Sanders, 2005). In Advanced Web Design course and in Object-Oriented Software Analysis and Design, M6 was very present (if not too demanding) and asked teachers a lot of questions. During the Java course there were three students who tried to answer almost at each critical step. All of them were males. However, the researcher did not find them exaggerating or intimidating with their presence.

M9 did not agree that there was too much male participation. He mentioned "It is more males' participation but this is because they are in greater number in class." Usually, the ratio of males versus females was 3:1. But this was not the only explanation.

Male Students Are More Confident Even When They Are Not Knowledgeable

Males more frequently overestimated their skills than females (Margolis & Fisher, 2003; Sanders, 1986). This was often observed during the observations from classes and labs. For example, in the Key Concepts course, a group of three males was observed. After 15 minutes, they started to chat and kept talking during the entire assignment. However, when the TA went to check their assignment it proved that two of them did not accomplish it properly. One of them needed time to correct his mistakes, but the other was not able to finish the current assignment by the end of the lab.

M9 was also very confident about his competence. One of the assignments that he had to accomplish during ALP1 was to find all the digits for an integer number with six digits. First he succeeded in finishing the program early and seemingly correctly.

However on closer examination it was found that the task was poorly done. Despite advice and suggestions from the TAs for him to improve his work, he was content with his performance

Sometimes Males Were Too Demanding

Male students also tended to be more impatient with teachers and TAs and sometimes had unrealistic expectations. The researcher remembers the last lab in Java when there was huge pressure from all students to finish the final project. One of the male subjects brought his laptop to class and raised some questions. Although the problems seemed to be on topic, concerning with the current lesson in fact the problem has an additional aspect. It was the fact that the particular Java version installed on his computer worked differently from those installed in lab. Although the problem seemed simple, in fact the case lengthened unpredictably. Two of the three teaching assistants stopped by and tried to fix the current problem. One of them stayed half of the entire lab and the other stayed for the entire lab. Unfortunately the problem was not solved. The student was angry after this incident. He mentioned to the researcher that although they might know the content of the course, they do not know how to express themselves. About TAs, he said that they were "completely useless" because he had only two questions in the all course and they were not able to answer either.

The researcher did not have the same opinion: the teaching assistants were not obliged to know in detail all Java versions. It was the student's obligation to use the same version as the course. In addition, the fact that in the last lab he took one half from the entire TAs' time resources was not a good idea. At the same time there were some female students who expected help and nobody had time to help them. However, he was furious even a week after and hoped that the results of this study would help to fire the TAs.

Males Were Not Always Willing to Communicate

One of the biggest difficulties of undergraduate computer science students according to TM1 was the lack of skills in communicating their ideas. However, TM1 mentioned that female students had better social and communication skills. It was clear that male students had more deficiencies in this respect. Let's take M9, for example. He was very independent from his colleagues mentioning that he would not ask the advice of other people about his computer science career: "Doesn't matter. If I'm going to do something, I would not ask anybody anything." He mentioned also that he can communicate well with his actual classmates. However, this communication would not be outside of current classes:

> No, there is a difference in age, social interest. Other kinds of differences that are not making me to have other kind of contacts with them. They are younger than me. They are not married so we don't share the same values.

M5 also mentioned that he lacked the skills to communicate properly. In fact, all answers that were provided by M5 revealed bitter accusations for professors but also for himself. The conflict with instructors was pretty strong before but now in the third year it started to subdue. Now he started to accommodate to computer science program although he still wanted to switch to engineering.

How Did Female Students Behave

It was observed that female students had good theoretical concepts and communication skills but they were not always able to put them into practice. In the same assignment mentioned before (the finding of all digits from an integer) there were two female students who were not able to finish the program. Each of them worked isolated. First, they started the program more clearly, using from the beginning an array to store all digits and a repetitive sequence in order to extract each digit. Comparing with M9, they had more clear notions about the requirements of the task. They knew how to use arrays and why the iteration was required. They were not, however, able to finish the program and to correct some ideas incorrectly implemented in the current program. No colleague showed them how to fix their mistakes and how to sketch an overall plan for the program. TAs also did not show them "the final solution". Also, they did not try to get help from other students. As a result, they were not able to finish their assignment in class.

FT1 made the following observation about female students: "They seem to be more willing to ask for help. However, if they do not receive the expected response, they give up more readily." Maybe in this case it was because the assignment was supposed to be done without the TAs' help. But also, nobody from their peers helped them to finish the program. In consequence, they took back the program unfinished in order to complete it at home, being a little anxious at the end of the lab.

Question 7: Learning Tendencies for Males and Females in Computer Science Classes

This question was designed to investigate the response of students to a range of aspects of learning settings that might help them and tried to explore ways that they felt it helpful from each gender's perspective. The aspects considered were:

- Learning style;
- Mentoring, counseling and role models;
- The role played by the Internet and computer games;
- Learning from samples, testing, trials and errors.

Which Learning Style Did They Prefer?

One of the big problems of the program is that it had considered the students as if they were mature self-learners. It was supposed that they would understand the day-to-day lessons from classes, books, or WebPages. In fact the framework was far from being enough. Students needed other interactions such as cooperative work, real projects, mentoring, counseling, groups study, and online interactions in order to learn. As TM1 remarked, in online discussion, female students were more participative than in onsite classes.

Individual, Cooperative and Competitive Learning

Researchers considered that male students, due to their innate temperament, tend to be more competitive but we should not unilaterally reduce all attitudes to this aspect (Beynon, 1993; Turkle, 1984). Previous feminist researchers (Margolis & Fisher, 2003; Rajagopal & Bojin, 2003) mentioned that females are more cooperative and social while males are competitive. This "myth" was that by sitting in front of computers, students were isolated while leaving computers and talking frequently suggested stronger social attitudes.

These opinions seemed to be too simplistic and revealed a deep misunderstanding. Sitting in front of a computer for long hours is not necessarily individualistic. It depends upon the goal that is behind that persistence. Males had all of the aspects of cooperation, cooperativeness and competitiveness. They tended to have more complex actions in all three directions. Due to their extended experience, there were activities where males exhibited all these three styles. Female students' style was a mixed between individual and cooperative styles. Female students rated the competitive style the least important.

Constructivism and Cooperative Strategies

Constructivism strategies empower students in order to take the ownership of learning in their hands for the purpose of resolving more realistic problems, from multiple perspectives, in a collaborative manner (Vygotsky, 1978; Wilson, 1997). Both male and female students required more realistic problems in their curriculum.

Unfortunately, there was very limited use of constructivism and cooperative learning philosophies and activities. Cooperative learning activities were not structured into the pedagogical style. If the students were good communicators they could survive. If they were not, then they have to fend for themselves. More precisely, if they couldn't keep up with the current work, not having enough personal initiative to address the current challenges, this could fail them.

MT1 mentioned that "students are able to understand and solve the problems if they simply have a chance to talk it out with their peers. Female students seem to enjoy sharing their knowledge." Also, students enjoyed trial and error tests. "Trial and error provides insight. The debugging process prevents future mistakes. Female students seem to have more patience in trying out different strategies and algorithms."

The Role of Games

Games are double edge swords for players. The main positive aspect is that plying games allow the players to become familiar with technology, without deliberate effort. This point has been made by others researchers (Venkatesh, 1999; Gee, 2005). Not only do games familiarize people with technology but they steadily attract them to using computers. Also, the other important advantage in using games is that they can test and improve different skills while the software emulates the real challenges.

The main negative aspect is that sometimes the direction of playfulness cannot be controlled. Games are not designed yet in the most profitable way for students. Some social categories are still underrepresented (women and ethnic minorities). Also there is not a clear policy in education related games. As a result, many students play computer games at the wrong time. The subjects from the current study experienced all these aspects.

M1 and M2 said they became interested when they started to play computer games. M8 played a lot of computer games and also spent a lot of time browsing on the Internet. Not considering himself a future computer programmer, for him, these technologies were mere diversions. He recognized that games are not helpful for him: "I play computer games all the time. I do not think playing games are helping me in any way."

M6 mentioned that games had influenced him in both directions. First, he mentioned that the games he played made him enjoy using computers. But in the second year of the program he became game addicted. As a result his marks suffered. After he got rid of this problem, his marks were again high. He had to retake previous courses to upgrade them. In the current course, he achieved an A+. When asked if playing computer games helps someone with a computer background M6 stated:

> It depends if it's a strategy game. Obviously, it will test your strategy, your mental skills. ... If you are a better thinker, you can outplay your enemies. It could boost your confidence. Some people look only for fun when playing computer games. It depends.

M1 recognized also that games could help. If someone thinks about how was the game designed, how the software was elaborated, what programming techniques were required, how that person would design this game, and if someone thinks of the game from a software designer's perspective, not just that of a player, this helps a lot.

Among female subjects, only F3 was enthusiastic about games. She not only enjoyed playing games but she considered developing computer games as a principal option.

Online Discussions, Internet and Intranet

At the first view, familiarity with the Internet technology made male students more confident in using online discussions. MT1 mentioned that female students were more active when they use online learning. This opinion was shared by FT1: "It provides students with quick answers. However, it does cause potential problem as students may be led to wrong conclusions. Female students seemed to enjoy more online discussions."

F4 confirmed the fact that she enjoyed taking online courses. The reason was that she enjoyed the anonymity afforded by this medium.

Students did not find the Internet directly helpful with their day-to-day classes. However, TM1 mentioned that students considered as "helpful in some situations. It can be very time consuming and there is no guarantee that the result meets the teacher's expectations. Female students showed more patience in these researches."

In commenting about Intranet research, she appreciated that it is more efficient: "Narrow the results down. It should be quite desirable for male and female alike."

Using Books and Journals

Male and female students had different views about the helpfulness of textbooks and journals. Female students in particular, were more interested in reading textbooks. Males had different opinions about the importance of reading textbooks. M6 and M9 mentioned that they regularly read the textbooks assigned for the course, while M8 was not interested in reading textbooks except when preparing for the final exam.

FT1 appreciated the textbooks and journals grading their importance with an 8: "Provides knowledge and it is always a good thing. Some individuals (male or female) enjoy seeking knowledge more than others." Asked if students understand directly from textbooks/ class she mentioned: "Students do not like to read the textbook to start with. They much prefer to have the materials explained to them. Female students seem to enjoy reading a bit more."

Both Genders Supported Co-ed Classes

The idea of single gender classes is not popular in Canada. There were some one-gender classes in elementary and secondary school but not after this level. There is some research of successful experiments with single gender classes (Cooper and Weaver, 2003) but even in these cases the professors and researchers did a lot of work trying to convince students and parents in advance about possible advantages of mono-gender classes.

A review of literature provided no examples of implementation of single-gender classes in computer science at the post-secondary level. This research did not find support for this idea among the participants. There was consensus among both student subjects and instructors that single gender classes were unlikely to have an impact on the gender disparities that exists. FT1 mentioned:

> University students are mature enough to overlook the co-ed issues. The materials involved in computer science do not have to be discussed separately in male/female (only) groups.

F5 found that sometimes male students are critical of female students but she thought that to separate the female students in special groups, was not the right solution: "I'm afraid that one gender classes would give us a false confidence or competence."

Real Projects, Hands-on Experience, Working in a Team

FT1 recognized female students' need to practice more. She mentioned that "hands on experiences are worth a thousand words. Female students seem to need more encouragement to take on new challenges." MT1 and FT1 considered students' participation in real projects to be very important for both genders. MT1 mentioned that: "real projects provide valuable experience to male and female students alike".

An example of hands-on experience is represented by debugging skills. In the first year of study, during their labs, students from both genders were not encouraged to debug the programs. These notions were just some theoretical concepts. Even at the end of the course, the programs were left without being debugged as if students were afraid to debug the program. At the second year of study, the situation considerably changed. Male students were willing to take the ownership of the programming content and debugged easily. In contrast, female students still struggled with debugging.

About working in a team, FT1 mentioned that: "Students must learn to be team-players. It is an important trait that employers are looking for in their potential employees. Female students usually take more passive roles." However, she mentioned that in the first year of study the assignments are individual, because the projects are small and simple. While this is true, waiting until the fourth year of study to incorporate cooperative strategies, did not give students enough opportunities to practice vital teamwork skills.

Especially Males wanted smaller class size

Some students accorded a special attention to class size. For instance, for M9 who based his assessments entirely in discussions with TAs and attending courses and laboratories, a class with a reduced number of students was ranked as an aspect of maximum importance. Class size was usually related with the importance that students gave to the teacher or TA.

Although he did not rank teaching too highly, M3 argued for smaller class sizes which would finally facilitate greater teacher supervision than in large classes. TM1 gave the maximum importance to class size. TF1 mentioned "Large classes, to some extent, distract the students (male and female)."

Finally it should be said that male students relied more on small class size which finally would provide more opportunities for peer interaction and more time to discuss with teachers. Female students also desired smaller class sizes to facilitate greater interaction with instructors and TAs. For instance, F6 mentioned that small classes gave her more opportunities to speak with TAs who helped her to address many difficult questions encountered during the course.

CHAPTER V

DISCUSSIONS AND RECCOMENDATIONS

Summary of Findings

This section summarizes the main findings of this research. The summary is organized according to the key themes which emerged.

1. Reasons for Taking Computer Science Program

Both males and females had experience in using computers but most males already had experience in programming. The majority of female students did not have programming backgrounds before entering the program. Parental role modeling was not a major influence on their decision to enter computer science program. Both genders were aware of the role that computer science plays in changing the society. Male students had a social network of peers which stimulated them to pursue further computer science courses and to cope with course difficulties while these were a glaring absence for female subjects.

2. Perception about Computer Science

Male subjects had greater confidence and less anxiety in using computers and programming than female subjects. Female students were interested more in web-design, web-programming, and databases. Male students had a very complex palette of interests: hardware, networks, OOP languages (C++, Java, .NET), web-programming, web-design, games, software design. Overall, female students were less interested in programming than male students. Female students were less self-directed and less willing to find detailed information about current IT market. Both genders were aware of the importance of social and managerial skills involved in this discipline. Male students built an active interest towards having a social career while females remained passive.

3. Profile of Computer Science Students

Both males and females mentioned some common characteristics such as hardworking, high rationalization skills, and technology enjoyment. Nine of the ten male subjects in this study saw computers as primarily a male area. An interesting finding was that the image of the "geek" either white or otherwise was not considered an accurate portrayal of the typical successful computer science student.

4. Challenges Faced

The anxiety, the lack of confidence and underachievement of female students continued during the program. Also, there were some problems detected in the organization of computer science programs, with some classes inconveniently scheduled for students who have a regular job and were registered part-time. Due to the fact that males were working in different informal settings, this helped them to extend and diversify their experience. During the program, the differences between the levels of experience changed. In trying to identify the socio-cultural stereotypes, both males and females tended to be convinced that computer science is usually a male domain.

In the preparation of first year students a big gap was detected in learning modular programming. Without having enough time to practice, modular programming was difficult to master. This made it difficult to understand other programming paradigms. The successful achievement at the next levels of programming practice, object oriented paradigm and software design, were therefore fundamentally affected. Having less practice in modular programming, female students were particularly disadvantaged.

5. Importance of Instruction

Males and females had different opinions about the importance of teaching. For males, teaching was not as important as for females. Female students were fixated on the goal of achieving top grades. Female subjects were more focused on completing assignments than males. They tended to be more hardworking and had a better attendance in lectures and labs. Students' perspective on the effective instructor relegated academic qualification to a minor importance. Having a Ph.D. did not make one an effective teacher. In order to be a good instructor for undergraduate classes, programming experience, mentoring and teaching skills were emphasized.

6. Social Interaction and Communication

The interactions between male and female subjects were somewhat superficial in the sense that the support between a male and female was occasional and weak. Males were more direct, confrontational and competitive. However, as pointed out before, males displayed the ability to be cooperative. They also had better support from their peers. The female style was more cooperative. They had better social and communication skills. However, because they were a small number and because of lack of initiative, they failed to coagulate social networks able to support them.

7. Preferred Learning Settings

Female students preferred learning environments which were characterized by large elements of social interaction and collaborative and cooperative learning. They needed more encouragement and mentoring. In online interactions female students were more active and confident and posed more questions.

Male students were not as dependent on cooperative environments in class where they needed to be individualistic. However social network outside the classroom was important to their success. They understood better the importance of mentoring, counseling and role models. Both male and female subjects in this study rejected female only classes as a feasible strategy at this level.

Recommendations

The following categories of recommendations were found to be helpful in order to improve the learning performances of undergraduate computer science students:

- Adapting recruitment and admission policies
- Combating gender stereotypes
- Curriculum adaptation
- Improving teaching
- Preparation for the real world
- Improving the conditions for learning
- Feminist perspectives in computer science

Adapting Recruitment and Admission Policies

Usually, people split the problem of recruitment and retention into two independent problems (Wilson, 2002). From the standpoint of this research, these two problems are closely related. If the process of recruitment is not efficient what can we hope for retention? First, the admission criteria should be reviewed. Although the purpose of this research was not to improve the admission equity, improving the criteria admission will bring students who are able to perform better in the computer science program. An important issue was the fact that the university failed to recruit candidates from local community. In addition, very few female students from the thousands of first year university female students selected computer science as their major. This Department of Computer Science has a rate of admission of female students well below the national average.

Speaking with several alumni computer science teachers and instructors from the Department of Computer Science the researcher found out that although the school board gave considerable importance to learning and acquiring technology, it did not encourage students to learn programming. As MT1 mentioned, the consequence of this deficiency is seen when students enter the university. In his opinion, both male and female students should receive formal instruction about computer programming earlier, before starting the undergraduate degrees.

At issue is the small number of female students who start the program. Cooper and Weaver (2003) showed in their research the danger of itemization. More precisely, if the number of female students in computer science program is too low, it will make them feel isolated from the beginning, unable to cooperate with each other. They will feel anxious, undervalue their capabilities and finally underperform. From the beginning the problem of gender representation is difficult. Why has the Computer Science Department failed to recruit female candidates? Some departments of computer science in North America such as Carnegie Mellon have special policies to attract female students. Considering the great disadvantages produced by itemization, the policy of recruiting a minimum number of female is required in the researcher's opinion.

The admission requirements for undergraduate computer science program were based exclusively on grades. Experience in programming did not count in the admission criteria. This was very strange, considering the fact that experience was the final requirement for hiring undergraduate students and programming is such a big part of the undergraduate program. On the other hand, researchers had pointed out that prior experiencing in computer science program does not mean 100% success (Margolis & Fisher, 2003). This research totally concurs with this view. In order to succeed in undergraduate school, good academic skills and social skills are also required. With all of these reservations, the prerequisites for programming skills are still highly recommended and probably remain the most important, even for Margolis and Fisher.

Another important idea inferred from this study was that greater success among current female students in the computer science program would increase the number of female candidates applying to the program. M3 mentioned that giving female students better technical skills is not the major problem:

> Give them better technical skills? I'm sure they are perfectly capable of learning the 'technical skills', they just have to decide to go into the field, which will take a slowly increasing number of females students, which will open up the minds of others to enter the field.

Combating Gender Stereotypes

The influence of negative stereotypes has been mentioned many times. A big problem is how we can fight against them. The most important are hacker's stereotype and the stereotype about gender. This is why combating gender stereotypes is crucial.

An important problem in social stereotypes is the overstated importance of "hackers" in the past. This research argues that this was more a mass-media invention before, transforming into an irrational feminist diatribe, or in a worse scenario, an ignorant opinion. These people, although they exist, are not as widespread as many novices might believe. Indeed, the subjects mentioned the myth of the pure "hacker" as a false image of what a computer scientist should be. This issue requires further reflection.

The IT industry incorporates people working together. Even though at the beginning of the CS undergraduate studies students are more individualistic and aloof, these attitudes gradually vanish. The subjects mentioned that the pressure to socialize and work in a team is high in IT careers.

Gender remains by far the most important stereotype. The images of boys who play with machines and girls who play with dolls are still widespread. Unfortunately, as Turkle (1984) mentioned, the different paths of boys and girls in education, their representations about themselves, increase the gender gap. These facts are valid in western culture and for this reason the stereotypes are difficult to fight against.

The rule about stereotypes should be replaced with WIINFM the rule "What's In It For Me". More exactly, both males and females should ask themselves individual questions about their personal relationship with computer science and not to consider their gender an obstacle or advantage in a computer science program. Their skills and passions are more important that their gender.

It is very difficult to fight against stereotypes since we cannot point to a specific person as guilty. These attitudes have become ubiquitous. Even females, who are victims of these stereotypes, actively participate in perpetuating them. These inequalities start from the preschool age when boys and girls do not receive the same opportunities to learn computers. In the beginning, due to socio-cultural traditions female students are not encouraged to learn computers and to achieve hands-on experience. In this way the gaps between genders in confidence and experiences start to increase very early. Due to these gaps at the end of high school for many girls it is already too late to consider themselves selecting a computer science program. They go to traditional female jobs such as nursing or education.

As Charles and Bradley (2006) found, if people emphasize self-esteem as a career goal, girls will select stereotypical jobs, about what their gender is in general good at. Even when these traditional jobs are paid less, they will prefer these jobs instead of constantly feeling anxious and unfit in a well paid IT position. This tendency is widespread in almost all well industrialized societies, in particular Canada and the US.

A complete solution to this deep-seated problem may be beyond the power of the Department of Computer Science. However, the university has a huge role and a consistent power in spreading its ideas about computer education in local community. This fight against negative stereotypes should be widely targeted by faculty and administrative officials together. Charles and Bradley (2006) noticed that countries with the best female representation in computer science seem to have in common a strong requirement in curriculum for substantial coursework in mathematics and science.

Improving Teaching

Two of the first year observed courses were supposed to build the basics of student knowledge, but professors failed to link the concrete significance with the specified outlines. For this reason the courses required a serious daily effort by students to accommodate the new concepts. Although the courses claimed to build the core experience, these instructors required students to have a considerable level of prior competence in order to understand them.

The instructors should be more sensitive to and aware of how computer science literacy is constructed. Since females generally had less previous computer experience it is obvious that they would expect to assimilate less during these courses. Even though a consistent self learning process at this level is required, there are serious limitations with respect to the pace that a beginner student can learn and become literate in programming. For this reason the researcher noticed that the Department of Computer Science suffered from a lack of experience in computer science pedagogy. Instructors and TAs did not consider enough the starting point of beginning students with respect to programming and computer literacy. In addition, they were not aware of different approaches to social interactions in education such as constructivism and cooperative learning. Instructors should also play a more active role in mentoring or counseling undergraduate students.

Communication should be improved

In this category about communication the following two themes emerged: the level of English itself and the communication between students. In classes and labs, the absence of defensive communication atmosphere would not automatically build the supportive communication. The instructors and the TAs should also be consciousness about working with less self-confident students and to deal with valuing all students' opinions. Mentoring among students should be encouraged.

Be Sure the Basics Are Taught First

An important question was what instructors and TAs should teach. It was supposed that in higher education the level of difficulty in undergraduate courses be at least at be medium level. Many details and even important concepts were left unexplained. On the other hand, the increase in the percentage of students registered in

Canada and the US has contributed to lower the standards in universities (Bauer, 1997). A recurrent sentiment among students with different levels of experience in programming is that attention should be paid to the basics first. As F1 and M3 mentioned, mastering the basics in computer science courses takes more time than other disciplines. Although the theoretical notions can be explained in a couple of minutes, the theory is not enough. Students need to see more samples and work on some projects in order to achieve the necessary skills for mastering programming. This means that a hands-on practical approach is important. Students should be given opportunities to apply and practice theoretical concepts. Also, it is important to not learn only a specific tool just because it is a state of the art software industry. These observations were confirmed by subjects. M5 felt that the teaching methods should "put more emphasis on basics rather than being tool specific."

A Curriculum Better Adapted for Learners

An important question was the level of details that instructors and TAs should teach. It was not clear whether students should be taught from scratch or not. What should be the pace of the course? Other universities clearly take into account previous experience in computer science of candidates and establish courses based on the associated level of difficulty. For instance, the University of Waterloo requires that entry-level students be registered in courses corresponding to one of the three levels of difficulty: beginners, intermediate and advanced. The majority of North American universities are not concerned with the initial level of student preparations and this presents difficulties for learners.

Because a large number of the students did their previous studies in other countries, the initial level of experience could be different. On the one hand, there are students who did not have the opportunity to use computers until they graduated from high school or even from a postsecondary program. For them, taking computer courses is something totally new. They need time to learn simultaneously about how to use a computer, how to master programming and to understand what an IT career is.

On the other hand, there are countries where students could have special programs in computers. Let's take the example of Romania, where students could be taught the first notions of computer programming from the fifth grade. The "typical" student in a special high school computer science profile could have eight or nine hours per week and already have learned programming languages such as Visual Basic, Pascal, C++, Java and SQL. In addition, they might acquire fairly complex notions related to data structures, algorithms, web-design, databases and theoretical foundations of computer science. In consequence, at a time when these students graduate from high school classes with a computer science profile, they might know almost all the requirements for the first two years of study in an undergraduate program at a North-American university.

There are many other countries in Asia and Europe where the implementation of curriculum in computer science is also advanced. This is why it is important to take into consideration the initial level of knowledge when the Department of Computer Science design courses for admitted candidates. This is why the level of difficulty at which a course is taught is important. Also, computer science applicants are accepted with different levels of experience in programming and computer literacy in general. This reality should be reflected in the curriculum of the Department of Computer Science.

With respect to the recommendations about curricula for programming, attitudes differed contrastingly. Subjects had different opinions abut what should be taught. F3 and F6 wanted to learn state of the art programming. In this way they believed students will adapt without effort to the IT job market. In contrast, M1 and M6 wanted the basics to be taught and learned properly. With respect to the adaptation for different products required for the IT market they suggested that these targets be pursued independently. This researcher mentioned before the necessity for teaching in detail, especially for the majority of female students. Hence, it can be inferred that universities should help female students adapt to state of the art software like .Net products (C#, Visual C, ASP .NET, VB .NET), Biztalk, Java Enterprise, Services Oriented Architecture (SOA), Extensive Markup Language (XML). Universities tend to avoid teaching commercial software owned by powerful companies but these are common place in the IT industry. A suggestion is to include courses about these software products even as non-mandatory, in the curriculum.

Improving the Conditions for Learning

Asked about the modalities to improve the underperformances of female students, M7 answered that there should be a greater effort to link theoretical concepts with practical approaches and projects. FT1 suggested that:

> The biggest mistake is to put things off. Once the students are under pressure, they become too stressed out to perform. Students, who keep up with their work and ask question when something bother them, usually do well in the class.

First, a proper environment for adjustment in the program is required. It is strongly recommended that a richer image of computer science be presented; that is not so rule oriented through programming. It could be argued that constructivist learning environments come closer to fitting women's ways of knowing (Ben-Ari, 1998).

Roulet (1997) mentioned that "Girls' and women's achievement in mathematics is tied to the way females develop and maintain their self-concept, how they deal with success and failure, and how they handle competition.

Another possibility is to extend the diversification of courses. More online courses are helpful for students, especially for those with family obligation or from those who have already a job. Women would find this appealing as online courses are popular among them.

Preparation for the Real world

Female students often brought textbooks to labs and classes and were more industrious in their work during the labs. Asked about what aspects they did not enjoy in computer science program, F3 mentioned that "most CS programming courses don't offer enough actual projects that prepare us enough for programming jobs of the real world." While studying at the university, female students did not focus on the practical values that IT employees desired.

This research argues that an important step is to offer the opportunity to achieve hands-on experience to entry-level students. In this way, female students will have the opportunity to exercise and master the fundamentals of programming. Co-op placement is also very important to provide more practice in teaching. As we know, co-op practice provides experience for students. Giving an opportunity to take co-op placement to all students would help all students to have industrial experience before finishing the school. This is especially helpful for female students.

The Time Dedicated to Practice Should Be Considered

Students recommended to other students to take the time to practice. Asked what she would recommend to new student, F1 answered: "to learn to dedicate time to practice. There is a consistent difference between learning a lesson from book or courses and practicing that content in programming." This recommendation was reiterated by other subjects.

Linking the Current Research with Feminist Ideas

The original interest about the topic of gender inequity was instilled by feminist researchers' sources. They revealed the subtle discrimination that many female students feel despite outward appearances of openness. Linked with practical activity, some feminist researchers in this area such as Margolis and Fisher are renewed. Reflecting on their actions implemented by them in Carnegie Mellon College, some courageous ideas and strategies were revolutionary. For instance, affording a special number of females each year even with lower level of experience was a good method to protect them from the devastating effects produced by tokenization. Also, the counseling support for female candidates and female registered students was very successful. A real success was their course for teachers in computer science when they not only explained about teaching but also presented the difficulties that female students have. Also their efforts to build network of peers for female students were very effective.

What was found to be excessive was the exclusivist feminist point of views about males. For them, spending long hours in front of computers was considered anti-social behavior. For ideological reasons, leadership qualities of all male students were dismissed. Hacker experience was easily universalized as a typical characteristic of male computer science students. Harassment, aggressiveness, ironies and other male negative behaviors were also over generalized. Because some female students fail in computer science, the entire spectrum of programming was at fault and inutile.

Unfortunately, they did not realize that the radical feminism they practiced, itself represents a problem in creating and perpetuating negative stereotypes in profiling computer science programs and the students in these programs. Based on their different background, radical feminists portrayed the entire specter of programming as hostile for females. They refused or ignored counseling and programs for male students because they are assumed to have no need for these.

Males were treated ideologically with hostility. It is easy to see what would happen if male students fought back in the same way. In fact, in the current research, some male students and professors felt that some advantages received by female students were not fair. The issue is not new. Also, the research of Margolis and Fisher (2003) mentioned some profound reticence from male students. This is not surprising. Reversing the bias is not the solution, but trying to annihilate it is. This is why liberal feminism and trying to improve the existing situation and not destroying everything, are the only means to improve in computer science programs as in any domain from STEM.

Concluding Statement

The influence of computer science technology is pervasive in all advanced countries. It is impossible to talk about progress without considering aspects of the Information Technology industry. For this reason it is necessary to have both genders involved not only in using computers, but also in programming them.

Eliminating this gap represents one of the biggest challenges in computer science education (Solvberg, 2003; Young 2000). The goal of this study was to assess learning practices in undergraduate computer science courses, in order to identify factors that contribute to creating and perpetuating gender gaps and suggest classroom strategies for eliminating or reducing these gaps. Although the study has provided useful insights into the issue, it needs to be extended by further research.

Future Research

The recommendations for future research include:

- A study in high school computer science classes from the same district to see what are the difficulties and differences at the high school level.
- A study exploring in detail how the ethnicities of undergraduate students in computer science interact with anxieties, performances, and attitudes.
- A quantitative research with a greater number of students, at least 100, extending the measure of different skills (algorithms, data structures, C++, Java, web-design knowledge).
- Experimental research using different learning strategies based on constructivism principles for example, cooperative, experiential and active learning.

REFERENCES

American Association of University Women (AAUW) (2000). *Tech savvy: Educating girls in the new computer age*. Washington, DC: AAUW.

Anderson, R. E., Welch, W. W. & Harris, L. J. (1983). Computer inequities in opportunities for computer literacy. Unpublished manuscript. Minneapolis: University of Minnesota.

Ayersman, D.J. (1996). Effects of computer instruction, learning style, gender, and experience on computer anxiety. *Computers in the Schools*, 12(4), 15-30.

Bandalos, D. B., & Benson, J. (1990). Testing the factor structure invariance of a computer attitude scale over two grouping conditions. *Educational and Psychological Measurement*, 50, 49–60.

Bauer, H. H. (1997). The new generations: Students who don't study. Retrieved January 24, 2006 from http://www.bus.lsu.edu/accounting/faculty/lcrumbley/study.htm

Ben-Ari, M. (1998). Constructivism in computer science education: Technical Symposium on Computer Science Education archive. Proceedings of the 29th SIGCSE Technical Symposium on Computer Science Education, 257 – 261.

Bernstein, D. (1991). Comfort and experience with computing: Are they the same for women and men? *SIGCSE Bulletin*, 23(3), 57-60.

Beynon, J. (1993). Dominant boys and invisible girls: or, Hanna it's not a toaster, It's a computer!" In J. Beynon, J. & H. Mackay H. (Eds.) Computers into classrooms: More questions than answers (pp. 1-18). London: Falmer.

Bhargava, A. (2002). Gender bias in computer software programs: a checklist for teachers. *Information Technology in Childhood Education*, 22, 205-218.

Bravo M. J., Gilbert L. A. & Kearney L. K. (2003). Interventions for Promoting Gender Equitable Technology Use in Classrooms, *Teacher Education Quarterly*, 30(4) 95-109.

Broos, A. (2005). Gender and Information and Communication Technologies (ICT) Anxiety: Male Self-Assurance and Female Hesitation; *CyberPsychology and Behavior*, 8(1), 21-31.

Bunderson, E.D. & Christensen, M.E. (1995). An analysis of retention problems for female students in university computer science programs; *Journal of Research on Computing in Education*, 28(1), 1-15.

Bush, T. (1996). Gender, group composition, cooperation, and self-efficacy in computer studies. *Journal of Educational Computing Research*, 15(2), 125-135.

Butler, C. (2002). Success in introductory computer science courses: A survey of assessment studies and predictive factors; Retrieved August 22, 2005

Bunderson, E.D., & Christensen, M.E. (1995). An analysis of retention problems for female students in university computer science programs. *Journal of Research on Computing in Education*, 28(1), 1-15.

Campbell, K. (2000). Gender and educational technologies: Relational frameworks for learning design. *Journal of Educational Multimedia and Hypermedia*, 9(2), 131-149.

Campbell, P. B. & Gulardo, S. (1984). Computers in education: A question of access. *Computers in the Schools*, 1(1), 57-65.

Campbell, P. B. & Sanders, J. (2002). Challenging the system: Assumptions and data behind the push for single-sex schooling. In A. Datnow A. & L. Hubbard (Eds.), *Gender in Policy and Practice: Perspectives on Single-Sex and Coeducational Schooling* (pp. 31-46). NY: Rutledge Flamer.

Carter, J. & Jenkins, T. (2001). What they think: Students' preconceptions of computing. Paper presented at the International Conference on Engineering Education, Oslo, Norway.

Charles, M. & Bradley, K. (2006). A matter of degrees: Female underrepresentation in computer science programs cross-nationally. In J. McGrath-Cohoon & W. C. Aspray (Eds.), Women and Information Technology: Research on the Reasons for Underrepresentation (pp. 183-204). Cambridge, MA: MIT Press.

Cohon, J. M. (2001). Toward improving female retention in the computer science major. *Communications of the ACM*, 44(5), 108-114.

Collaborative Research Experience for Women (CREW) (2001). Project from Xavier University granted by the Computing Research Association (CRA). Retrieved August 12. 2005 from http://cerebro.cs.xu.edu/crew2001

Compeau, D., Higgins, C.A. & Huff S. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study, *MIS Quarterly*, 23(2) 145-158.

Cook, J., Leathwood, C. & Oriogun, P. (2001). Online conferencing with multimedia students: Monitoring gender participation and promoting critical debate. Paper presented at the *Higher Education Academy, Center for Information and Computer Sciences*, London.

Cooper, J. & Weaver, K.D. (2003). *Gender and computers: Understanding the digital divide*. Mahwah, New Jersey: Erlbaum.

Corston, R. & Colman, A. M. (1996). Gender and social facilitation effects on computer competence and attitudes toward computers. *Journal of Educational Computing Research*, 14(2), 171-183.

Crombie, G., Abarbanel, T. & Anderson, C. (2000). Bridging the gender gap in high-technology education. *NASSP Bulletin*, 84(618).

Creswell J. W. (2003). *Research Design, Qualitative, Quantitative and Mixed Approaches* (2nd edition). London: Sage.

Damarin, S. (1989). Rethinking equity: an imperative for educational computing. *The Computing Teacher*, 16(7), 16-18.

Davies, S., & Guppy, N. (1998). Race and Canadian Education. In V. Satzewich (Ed.), *Racism and Social Inequality in Canada: Concepts, Controversies and Strategies of Resistance* (pp. 131-156). Toronto: Thompson Educational Publishing.

DeClue, T.H. (1997). Academic computer science and gender: A naturalistic study investigating the causes of attrition; Doctoral Dissertation; Southern Illinois University at Carbondale (UMI No. 9801057).

Deboer, G.E. (1984). Factors related to the decision of men and women to continue taking science courses in college. *Journal of Research in Science Teaching*, 21(3), 325-329.

Dickhauser, O. & Stiensmeier-Pelster, J. (2002). Gender differences in computer work: evidence for the model of achievement-related choices. *Journal of Contemporary Educational Psychology*, 27(3), 486-496.

Dryburgh, H. (2000). Under representation of girls and women in computer science: Classification of 1990s research. *Journal of Educational Computing Research*, 23(2), 181-202.

Durndell, A. & Haag, Z. (2002). Computer self-efficacy, computer anxiety, attitudes towards the Internet and reported experience with the Internet by gender in an East European sample. *Computers in Human Behavior*, 18, 521-535.

Ebo, B. (1998) *Cyberghetto or Cybertopia? Race, Class and Gender on the Internet.* Westport, CT: Praeger.

Gilligan, C. (1982). In a different voice: Psychological theory and women's development. Cambridge, MA : Harvard University Press.

Galpin, V. (2002). Women in computing around the world: An initial comparison of international statistics. Retrieved August 2, 2005 from http://citeseer.ist.psu.edu/703908.html

Garvin-Doxas, K & Barker, L.J. (2004). Communication in computer science classrooms: Understanding Defensive climates as a means of creating supportive behaviors. *ACM Journal of Educational Resources in Computing*, 4(1), 1-18;

Gee, J.P. (2005) What Games Have to Teach Us: An interview with James Paul Gee, by Brandon Sheffield, *Game Developer Magazine*, 2005(11), 58-61.

Gibb, J.R. (1961). Defensive communication. *Journal of Communication*, 11-12, 141-148.

Gorski, P. (2005). Education Equity and digital divide. *Association for Advancement in Computer Education Journal* 13(1), 3-45.

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

Greening, T. (1999). Gender stereotyping in a computer science course. *ACM SIGCSE Bulletin*, 31(1), 203-207.

Gregory, M. Y. (1997) 'Gender Differences: An Examination of Computer-Mediated Communication'. Paper presented at the Annual Meeting of the Southern States Communication Association. Savannah, April, GA.

Grignon, J. R. (1993). Computer experience of Menominee Indian students: Gender differences in coursework and use of software. *Journal of American Indian Education* 32(3), 1-15.

Grundy, A.F. (1998). Mathematics in computing: A help or hindrance for women? Retrieved August 24, 2005 from http://www.cs.keele.ac.uk/content/people/a.f.grundy/maths.htm

Grundy, A. F. (2003). Women, Power and Progress, Retrieved August 20, 2005 from http://www.cs.keele.ac.uk/content/people/a.f.grundy/power.htm

Gunn, C. (2003). Dominant or different? Gender issues in computer supported learning. *Journal of Asynchronous Learning Networks*, 7(1), 14-30.

Hancock M. S., Davies, R. & McGrenere, J. (2002). Focus on women in computer science. Retrieved February 3, 2005 from http://www.cs.ubc.ca/wccce/program04/Papers/mark.html.

Harrell, W.J. (1998). Gender and equity issues affecting educational computer use. *Equity and Excellence in Education*, 31(3), 46-53.

von Hellens, L. & Nielsen, S. (2001). Australian women in IT; *Communications of the ACM*, 44(7), 46-52.

Howell, K. (1993). The experience of women in undergraduate computer science: What does the research say? *SIGCSE Bulletin*, 25(2), 1-8.

Jennings, S.E. & Onwuegbuzie, A. J. (2001). Computer attitudes as a function of age, gender, math attitude, and developmental status. *Journal of Educational Computing Research*, 25(4), 367-384

Jenson, J., de Castell, S., & Bryson, M. (2003). “Girl talk”: Gender, equity, and identity discourses in a school-based computer culture. *Women’s Studies International Forum*, 26(6), 561-573.

Johnson, R.B. and Onwuegbuzie A. J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational Researcher.* Vol. 33 (7) 14-26.

Johnson, R. B. & Turner, L. A. (2003). Data collection strategies in mixed-methods research. In Tashakkori & Teddlie (Eds.) *Handbook of Mixed Methods in Social and Behavioral Research* (pp. 297-319). Thousand Oaks, CA: Sage Publications.

Kersteen, Z.A., Linn, M.C., Clancey, M., & Hardyck, C. (1988). Previous experience and the learning of computer programming: The computer helps those who help themselves. *Journal of Educational Computing Research*, 4(3).

Kheng, L. G. (1990). WIT: The Singaporean way. *The Computer Bulletin*, 2(1), 18–20.

King, J. (1993). Getting anxious about electronic learning. *Australian Educational Computing*, 8, 16-20.

Knuth, D. (1974). *The art of computer programming*, MA: Addison Wesley.

Kramer, P. & Lehman, S. (1990). Mismeasuring women: A critique of research on computer ability and avoidance. *Signs: Journal of women in culture and society*, 16(1), 158-172.

Linn, M. C. (2005). Technology and gender equity: What works? In N. F. Russo, C. Chan, M.B. Kenkel, C .B. Travis & M. Vasquez.(Eds.), *Women in Science and Technology*. NY: American Psychological Association.

Margolis J., Fisher, A. (2003). *Unlocking the Clubhouse: Women in Computing*. Cambridge, MA: MIT Press.

Martin, S. (1998). Internet use in the classroom: The impact of gender. *Social Science Computer Review*, 16(4), 411- 418.

McKenna, P. (1999). Transparent and opaque boxes: Do women and men have different computer programming psychologies and styles? *Computers & Education*, 35(1), 37-49.

Morse, J. M. (2003). Principles of mixed methods and multimethod research design. In A. Tashakkori & C. Teddlie (Eds.) *Handbook of Mixed Methods in Social and Behavioral Research*, (pp. 189-208). Thousand Oaks, CA: Sage.

Moses, L.E. (1993). Our computer science classrooms: Are they "friendly" to female students? SIGCSE, 25(3), 3-12.

Myers, W., Bennett, S. & Lysaght, P. (2004). Asynchronous communication: Strategies for equitable e-learning. Paper presented at the Australian Society for Computers in Learning in Tertiary Education, Perth.

Onwuegbuzie, A. J. & Teddlie C. (2003). A framework for analyzing data in mixed methods research. In A. Tashakkori& C. Teddlie (Eds.), *Handbook of mixed* *methods in social and behavioral research* (351-383), Thousands Oaks, CA: Sage.

Pearl, A., Pollack, M.E., Riskin, E., Thomas, B., Wolf, E., & Wu, A. (1990). Becoming a computer scientist. *Communications of the ACM*, 33(11), 47-57.

Pickett, P. (2005). Young males continue to dominate tech world- Research suggests IT world still holds old views about what is 'women's' work; *ComputerWorld Canada* (Jan, 2005). Retrieved August 12, 2005 from http://www.itworldcanada.com/a/ComputerWorld/924b7d01-e5d1-4053-bb7b-7d7adf35c7c8.html

Pieterse, V. & Sonnekus, I. P. (2003). *Rising to challenges of combining qualitative and quantitative research. 6th World Congress on Action Learning, Action Research and Process Management in Conjunction with the 10th Congress on Participatory Action Research.* Retrieved August 12, 2005 from (www.education.up.ac.za/alarpm/PRP_pdf/ Pieterse&Sonnekus.pdf)

Rajagopal, I. & Bojin, N (2003). A gendered world: Students and instructional technologies; *First Monday*, 8(1). Retrieved Jan 3, 2006 from http://www.firstmonday.org/issues/issue8_1/rajagopal/

Ramalingam, V. & Wiedenbeck, S. (1998). Development and validation of scores on a computer programming self-efficacy scale and group analysis programmer self efficacy. *Journal of Education Computer Research*, 19(4), 367-381.

Rosen, L.D., Sears, D.C., & Weil, M.M. (1987). Computerphobia Behaviour. *Research Methods, Instruments, & Computers*, 19, 167-179.

Roulet, G. (1997). Mathematics curriculum for Ontario secondary schools: Issues, choices and opinions. A background research paper commissioned by the Ontario Ministry of Education and Training in support of secondary school curriculum renewal. Queens' University. Retrieved July 12, 2005 from: http://educ.queensu.ca/~rouletg/WEB-PPR.htm#top

Rowell, H. G., Perhac D.G., Hankins, J. A., Parker B.C., Pettey C.C. & Iriarte–Gross J.M. (2003). Computer related gender differences; Conference at SIGCSE, 54–58

Sadker. M & Sadker, D. (1992). Fairing at fairness. NBC Dateline. Broadcast April 7, 1992. Burlington, VT: New Video.

Sanders, J. S. (1985). Here's how you can help girls take greater advantage of school computers. *American School Board Journal*, 172(4), 37-38.

Sanders, J. S. (1986). Closing the computer gender gap. *The Education Digest*, 52, 20-23.

Sanders, J. S. (1994). *Lifting the barriers: 600 strategies that really work to increase girls' participation in science, mathematics, and computers*. Seattle: Jo Sanders Publications.

Sanders, J. S. (2000). Fairness at the source: Assessing gender equity in teacher education for colleges and universities. Retrieved Januay 7, 2006 from http://www.josanders.com/pdf/Fairness_122702.pdf

Sanders, J.S. (2005). Gender and technology: A research Review. Retrieved at Dec 20, 2005 from http://www.josanders.com/pdf/gendertech0705.pdf

Savard M., Mitchell S.N., Abrami, P. C. &. Corso, M. (1995). Learning together at distance; *Canadian Journal of Educational Communication*, 24(2), 117-131.

Schumacher, P., Morahan-Martin, J. & Olinski, (1993). Computer experiences, attitudes, computer and mathematical anxiety, and grades of MBA students. *Collegiate Microcomputer*, 9(3), 183-192.

Scott-Dixon, K. (2004) *Doing IT: Women working in information technology.* Toronto: Sumach.

Scragg G. & Smith, J. (2001). A Study of barriers to women in undergraduate computer science, Department of Computer Science, State University of New York, Geneseo, Retrieved August 12, 2005 from http://www.cs.geneseo.edu/~scragg/Papers/ barriers %20to% 20women.shtml

Selwyn, N. (1997). Students' Attitudes toward Computers: Validation of a Computer Attitude Scale for 16-19 Education. *Computers & Education*, 281(1), 35-41.

Shen, C. H. (1997). The effects of gender and cooperative learning with CAI on college students' computer science achievement and attitudes toward computers, (Doctoral dissertation, Florida Institute of Technology, 1997). Dissertation Abstracts International, 55, 1 IA.

Shih T.C. (2001). Redesigning an introductory Java course to bridge the gender gap in computer science education. School of Computer Science, Carnegie Mellon University. Retrieved August 12, 2005 from http://www.contrib.andrew.cmu.edu/~tshih/THESIS/thesisFinal.doc

Silcox P.E. (1998). A comparison of women pursuing traditional and nontraditional science majors; Master in Education (Counselling) thesis, The University of Western Ontario: Ontario.

Simonson, M. R., Maurer, M., Montag-Torardi, A., & Whitaker, M. (1987). Development of a standardised test of computer literacy and a computer anxiety index. *Journal of Educational Computing Research*, 3(2), 231–247.

Solvberg A. M. (2003). Computer-Related Control Beliefs and Motivation: A Panel Study, *Journal of Research on Technology in Education*, 35(4), 473-487.

Stoilescu, D. (2004). Difficulties encountered by women in Computer Science. Paper presented at the 1st Graduate Women's Studies Symposium, York University, April, Toronto.

Stoilescu, D. (2005). Equity Strategies Required in Computer Science Curriculum. AACE - SITE, Phoenix, Arizona.

Sturm, D. & Moroh, M. (1994). Encouraging enrolment and retention of women in computer science classes. *15th National Educational Computing Conference.*

Tannen, D. (1991). *You Just Don't Understand: Men and Women in Conversation.* NY: Harper-Collins Publisher.

Tannen, D. (1994). *Gender and discourse.* NY: Oxford University Press.

Todman, J. (2000). Gender differences in computer anxiety among university entrants since 1992. *Computers & Education*, 34 (1), 27-35.

Turkle, S. (1984). *The second self: Computers and the human spirit.* NY: Simon and Schuster.

Turkle, S. (1997). Seeing through computers: Education in a culture of simulation, *American Prospect,* 31(3-4) 76-82.

Turkle & Papert, (1992). Epistemological pluralism and the revaluation of the concrete. *Journal of Mathematical Behavior*, 11, 3-33.

Vegso, J. (2005). Interest in computer science as a major drops among incoming freshmen. *Computing Research News*, 17(3), Retrieved September 2, 2005 from http://www.cra.org/CRN/articles/may05/vegso

Venkatesh, V. (1999). Creation of favorable user perception: Exploring the role of intrinsic motivation. *MIS Quarterly*, 23(2), 239-260.

Vygotsky, L. S. (1978). *Mind in Society*. Cambridge, MA: Harvard University Press.

Wasburn, M. H. & Miller, S. G. (2005). Still a chilly climate for women students in technology: A case study. In V. S. Rosser & M. F. Fox (Eds.) *Women, Gender and Technology*. Urbana-Champaign: University of Illinois Press.

Williams L., Wiebe E., Yang K., Ferzli M., & Miller C. (2002). In support of pair programming in the introductory computer science course. *Computer Science Education*, 12(3) , 197- 212.

Wilson, B.C. (2000). *Contributing factors to success in computer science: A study of gender differences*; Ph. D. Dissertation, Southern Illinois University, Carbondale-Illinois. (UMI No. 9982125)

Wilson, B. C. (2002). A study of factors promoting success in computer science including gender differences. *Computer Science Education*, 12(1&2), 141-164.

Wilson, B. C. (2004). A study of learning environments associated with computer courses: Can we teach them better? *Journal of Computing Sciences in Colleges*, 267-273

Wilson, B.C., Shrock, S. (2001). Contributing to success in an introductory computer science course: A study of twelve factors, ACM – SIGCSE, 184-188, 2001.

Wilson, B. G. (1997). Reflections on constructivism and instructional design. In C. R. Dills & A. A. Romiszowski (Eds.), Instructional development paradigms. (pp. 63-80). Englewood Cliffs, NJ: Educational Technology Publications.

Wilson, K.R., Wallin, J.S. & Reiser C. (2003). Social stratification and the digital divide. *Social Science Computer Review*, 21(2), 133 - 143.

Wright, R. (1997). *Women computer professionals: Progress and resistance*. Lewiston, NY: Edwin Mellen.

Young, B.J. (2000). Gender differences in student attitudes toward computers. *Journal of Research on Computing in Education*, 33(2), 204-216.

Yuen, A. H. K., & Ma W. W. K. (2002). Gender differences in teacher computer acceptance. *Journal of Technology and Teacher Education*, 10(3), 365-382.

APPENDIXES

APPENDIX A

Consent to Participate in Research

UNIVERSITY OF
WINDSOR

Title of Study: ***Classroom Practices and Teaching Methods as Factors in Gender Inequity in Undergraduate Computer Science Programs.*** You are asked to participate in a research study conducted by **Dorian Stoilescu**, from the Faculty **of Education, University of Windsor** for his Master's thesis project. If you have any questions or concerns about the research, please feel to contact **Dorian Stoilescu** at **(519)253-3000 Ext 3808** or **stoiles@uwindsor.ca or his supervisor, Dr. Clinton Beckford at Clinton@uwindsor.ca** or **(519)253-3000 #3815.**

PURPOSE OF THE STUDY

The study will investigate classroom practices and teaching methods in selected computer science undergraduate courses. It seeks to elucidate issues related to attitudes and performances among the genders in computer science and suggests methods for both genders in instruction in undergraduate computer science classes.

PROCEDURES

If you volunteer to participate in this study, the researcher would ask you to do the following things:
- Sign the consent form
- Allow your activity to be observed during the class(es).
- Allow researcher to do a document analysis from your notes, assignments, web course outlines, textbooks, courseware, web based materials, and performance tasks.
- Participate in an interview 45-60 minutes (or fill an electronic survey at your own pace) with the researcher to discuss about ways to cope with gender differences in class.

The document analysis and observation of volunteer will be done as discreet as possible. Transcripts from observation and document analysis will be provided. The researcher will tape the interviews and transcribe them. The transcripts will be also given to each interviewee for verification.

POTENTIAL RISKS AND DISCOMFORTS

There are no known risks involved in this study.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

The University of Windsor will benefit from this study by:

- Recommendations regarding improvement of gender relations in computer science classes;
- Experiencing the benefit of the research process and evidence based practice that will promote a decrease in undesirable attitudes and performances between genders.

The research will be conducted among students and professors at the University of Windsor.

PAYMENT FOR PARTICIPATION

The participants will not be paid for attending this research. Knowledge and experience are the only benefits for your involvement.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. **All the interviews, observations and document analysis transcripts will be held only in digital format, on CDs, for a maximum of five years. All the digital records will be archived and encrypted onto CDs. These data will be used only for the purpose of educational research. The researcher is the only person who have access at these CDs and is the only who knows the passwords required to extract the records from archive.**

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE SUBJECTS

The results of the study will be posted on Research Ethics Board, University of Windsor webpage, (www.uwindsor.ca/reb under Study Results). All participants have open access to this webpage.

SUBSEQUENT USE OF DATA

Data collected from this research may be used in subsequent studies.

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. This study has been reviewed and received ethics clearance through the University of Windsor Research Ethics Board. If you have questions regarding your rights as a research subject, contact:

Research Ethics Coordinator
University of Windsor
Windsor, Ontario N9B 3P4

Telephone: 519-253-3000, ext. 3916
E-mail: lbunn@uwindsor.ca

SIGNATURE OF RESEARCH SUBJECT

I understand the information provided for the study ***Learning Practices and Teaching Methods as Factors in Gender Inequity in Undergraduate Computer Science Programs*** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____
Name of Subject

____________________________________ __________________
Signature of Subject Date

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

____________________________________ __________________
Signature of Investigator Date

APPENDIX B

Letter of Information to Participate in Research

UNIVERSITY OF
WINDSOR

September 1, 2005

Dear Student,

Title of Study: ***Classroom Practices and Teaching Methods as Factors in Gender Inequity in Undergraduate Computer Science Programs***
You are asked to participate in a research study conducted by **Dorian Stoilescu**, from the Faculty of Education at the University of Windsor for his Master's thesis project. If you have any questions or concerns about the research, please feel free to contact **Dorian Stoilescu** at stoiles@uwindsor.ca or **(519) 253-3000 #3808 or his supervisor, Dr. Clinton Beckford at Clinton@uwindsor.ca** or **(519)253-3000 #3815.**

PURPOSE OF THE STUDY

The study will investigate classroom practices and teaching methods in selected computer science undergraduate courses. It sets to elucidate issues related to attitudes and performances among the genders in computer science and suggests methods to improve both genders' instruction in undergraduate computer science classes.

PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

- Sign the consent form
- **Allow your activity to be observed during the class (es).**
- **Allow researcher to do a document analysis from your notes, assignments, web course outlines, textbooks, courseware, web based materials, and performance tasks.**
- **Participate in an interview 45-60 minutes (or fill an electronic survey at your own pace) with the researcher to discuss about ways to cope with gender differences in class.**

The document analysis and observation of volunteer will be done as discreet as possible. Transcripts from observation and document analysis will be provided. The researcher will tape the interviews and transcribe them. The transcripts will be also given to each interviewee for verification.

POTENTIAL RISKS AND DISCOMFORTS

There are no known risks involved in this study.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Participants could learn how to better adjust and address some of the challenges that exists between genders, in order to **make personal and class the academic and professional activities more enjoyable for both genders.**

The University of Windsor will benefit from this study by:

- **Recommendations regarding improvement of gender relations in computer science classes;**

- **Experiencing the benefit of the research process and evidence based practice that will promote a decrease in undesirable attitudes and performances between genders.**

The research will be conducted among students and professors at the University of Windsor.

PAYMENT FOR PARTICIPATION

The participants will not be paid for attending this research. Knowledge and experience are the only benefits for your involvement.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. All the interviews, observations and document analysis transcripts will be held only in digital format. All the digital records will be stored into an encrypted archive and used only for the purpose of doing educational research. The researcher is the only person who knows the password to extract personal records.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE SUBJECTS

The results of the study will be posted on Research Ethics Board, University of Windsor webpage, (www.uwindsor.ca/reb under Study Results). All participants have open access to this webpage.

SUBSEQUENT USE OF DATA

Data collected from this research may be used in subsequent studies.

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. This study has been reviewed and received ethics clearance through the University of Windsor Research Ethics Board. If you have questions regarding your rights as a research subject, contact:

Research Ethics Coordinator
University of Windsor
Windsor, Ontario N9B 3P4

Telephone: 519-253-3000, ext. 3916
E-mail: lbunn@uwindsor.ca

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_______________________________ Signature of Investigator

_______________ Date

APPENDIX C

Consent for Audio Taping

UNIVERSITY OF
WINDSOR

Research Subject Name:

Title of the Project: ***Classroom Practices and Teaching Methods as Factors in Gender Inequity in Undergraduate Computer Science Programs***

I consent to the audio/video-taping of interviews, procedures, or treatment.

I understand these are voluntary procedures and that I am free to withdraw at any time by requesting that either the taping be stopped or the viewing be discontinued. I also understand that my name will not be revealed to anyone and that taping and viewing will be kept confidential. Records are digitized, stored in mp3 format only in the personal laptop of researcher, and tracked by number. During the time when researcher does not use the record, these data will be stored in an encrypted archive. The researcher is the only person one who knows the password.

I understand that confidentiality will be respected and the viewing of materials will be for professional use only.

Research Subject Date:

APPENDIX D

Questionnaire for Students

The research will be focused on these courses (abbreviated as 7C):

- 60-100 Key Concepts in Computer Science;
- 60-140 - Introduction to Algorithms and Programming I;
- 60-141 - Introduction to Algorithms and Programming II;
- 60-212; Object-Oriented Programming using Java;
- 60-254 - Data Structures and Algorithms
- 60-270; Advanced Website Design;
- 60-322; Object-Oriented Software Analysis and Design

Provide hints from these course(s). When asked to grade, please try to provide the reason.

Example: Learning by examples;

7 - Although an example could approach something new, students cannot learn by examples only.

Answer to the following questions:

1. Introduction and learning preferences

a) Gender, Age, Status in Canada, Ethnicity, Other languages (if speak) excepting English
b) Are you taking computer science as a minor or major?
c) On a 1 to 10 scale, (1 being the least significant, 10 being the most significant) what helps you learn? Consider each of the following items:
   i. Class size;
   ii. Being in all males/females class/teams;
   iii. Being in mixed class/teams;
   iv. Experiencing by yourself;
   v. Finding a role model;
   vi. Having a counselor able to help;
   vii. Having a mentor;
   viii. Having peers able to learn from them and learn them;
   ix. Contacts with teachers;
   x. Contacts with TAs;
   xi. Learning by examples;
   xii. Trial and error tests;
   xiii. Online discussions groups;
   xiv. Internet research;
   xv. Intranet research;
   xvi. Programming and research books/journals;

xvii. Finding a real project to participate;
xviii. Finding employment in IT industry;
xix. Assignments that are more practical and specific;
xx. Assignments considered integrating my work in a team;
xxi. Assignment flexible that offer more choices;

d) What works for you (from a 1 to 10 scale, 1 being the least significant and 10 being the most significant):
   i. Do you understand directly from class?
   ii. Do you understand directly from textbooks?
   iii. Do you like to ask your peers?
   iv. Do you need regularly assistance from others in labs?
   v. Do you avoid asking help when you can's deal with a situation?
   vi. Are you considering yourself having good communication skills?
   vii. How you evaluate your team skills?

e) Types of interactions preferred (on a 1 to 10 scale, 1 being the least significant, 10 being the most significant):
   i. Individual study
   ii. Team projects and group study
   iii. Questions/tasks that emulate competition among your peers

f) On a 1 to 10 scale, (1 being the least significant and 10 being the most significant) what do you believe is your level of the followings skills:
   i. Math,
   ii. Algorithms,
   iii. C++ Programming,
   iv. Java Programming,
   v. Data Structures,
   vi. Web-design,
   vii. Knowledge in networks;
   viii. Information system skills?

g) (Confidence, from a 1 to 10 scale, 1 being the least significant and 10 being the most significant) what was your confidence level in computer science:
   i. Before starting the program
   ii. In the first year
   iii. Second year(if it's the case);
   iv. third year (if it's the case);

2. Premises for selecting computer science program:

a) Describe your schooling experiences in computer science before selecting the program (elementary, middle, high school, summer programs, occasional schools, work)
b) Did/Do you have a mentor in computers?
c) Friends: Did/ Do you have friends with experience in computers? How were/are these reports?
d) Who was the expert in your home?

3. About your interest in computer science:

a) If you were going to describe computer science, what would you say?
b) Peers and culture: If you were to describe characteristics of students in CS what/how would they be? Is this you? Do you fit in/ Not fit in?
c) Time spent in CS per week?
d) What interests you the most about CS?
e) What interests you the least about CS?
f) What are the projects you are drawn to?
g) What do you regard as your academic strengths and weaknesses?
h) What do you like and dislike about programming? (Finish these sentences:• I like (or do not like) programming because... •I did found interesting(or do not agree with) these aspects….)
i) Does playing skills help a future IT specialist? Are computer games gender biased? How much time per week do you play computer games?
j) Does Internet help a future IT specialist? Is it the Internet gender biased? How much time per week do you spend on the Internet?
k) Do you use other language (excepting English) to communicate in actual academic program or in extra CS activities? Did this language(s) have a role in building your CS personality?
l) Do you have already experiences with IT job market, job recruiters, finding employment?

* 4. Being a woman/man in the program:

a) Ideas of why are so few women in field?
b) What have to be different in order to motivate them and give them better technical skills?
c) (Same questions for male students)
d) Is class participation correlated more with one gender than the other?
e) What are the interactions between students from different genders in class/labs?
f) Do you believe specific teacher strategies are required to accommodate gender differences?
g) How are you experiencing being a woman/man in this CS program?
    i) Do you think that your gender did impact on the way you were treated in computer science classes?
    ii) Which facts (positive or negative) come to mind that are related to being a woman/man in CS classes (i.e. experience, interactions, confidence, was encouraged/discouraged, teasing/teased, avoiding/avoided, discriminating/ (discriminated by) colleagues, professors or TAs, gender overgeneralization)?
    iii) How do you find the environment from this point of view?
h) Being woman in IT industry is an advantage or not? Why?
i) Same questions about men

j) How did your family encourage you as women/men in using computers and in pursuing a CS program?
k) What was the following interactions:
    i) women student and women professor
    ii) women student and male professor
    iii) male student and female professor
    iv) male student and male professor
    Were all the same for you?
l) Are there challenges experienced disproportionately by one gender?

5. About your current CS student status:

a) How often are you attending classes and labs?(7C)
b) Expectations: What were/are your expectations (towards you, peers, professors and TAs)? Finish these sentences: • I like (or do not like) .... because... •I did (or not) agree with these aspects....)
c) Describe what you like and dislike about computer science program in the Univ. of Windsor?
d) Atmosphere: How would you describe the general atmosphere?
e) Describe how did you perform in these 7C? Where your grades according to your expectations?
f) Classes: What is your favorite CS class? Why?
g) What is your least favorite? Why?
h) Professors, teachers assistant Experiences good/bad with Profs and TAs?
i) Peers: Experiences good/bad with your colleagues?
j) Fit: Do you feel that you and CS are a good fit? Thoughts about switching out of CS? Why? Why not?
k) What would you change about your current CS academic program if you could?
l) Do you have already plans about CS career after graduation?
m) What factors are most influential when you want to join into a CS team/project/company?
n) Looking back on your experience of four years in CS, what are some lasting impressions: What helped the most? What hurt the most?
o) What advices do you have for new students?

APPENDIX E

Questionnaires for Instructors

The research will be focused on these courses (abbreviated as 7C):

- 60-100 Key Concepts in Computer Science;
- 60-140 - Introduction to Algorithms and Programming I;
- 60-141 - Introduction to Algorithms and Programming II;
- 60-212; Object-Oriented Programming using Java;
- 60-254 - Data Structures and Algorithms
- 60-270; Advanced Website Design;
- 60-322; Object-Oriented Software Analysis and Design

Provide hints from these course(s). When asked to grade, please try to provide the reason.

Example: Learning by examples;

7 - Although an example could approach something new, students cannot learn by examples only.

Answer to the following questions:

1. On a 1 to 10 scale, (1 being the least significant and 10 being the most significant) what do you believe helps students learn? Consider each of the followings:
    i. Class size;
    ii. Being in all males/females class/teams;
    iii. Being in mixed class/teams;
    iv. Experiencing by themselves;
    v. Having a mentor able to help;
    vi. Having a counselor able to help;
    vii. Having peers able to learn from them and learn them;
    viii. Contacts with teachers;
    ix. Contacts with TAs;
    x. Learning by examples;
    xi. Trial and error tests;
    xii. Online discussions groups;
    xiii. Internet research;
    xiv. Intranet research;
    xv. Programming and research Books/Journals;
    xvi. Finding a real project to participate;
    xvii. Finding employment in IT industry;
    xviii. Assignments that are more practical and specific;
    xix. Assignments considered integrating my work in a team;
    xx. Assignment flexible that offer more choices;

2. **Types of students learning styles that you noticed during teaching.** From a 1 to 10 scale, answer to the followings:
    a. Do students understand directly from textbooks/ class?
    b. Do they find easily examples and documentation from the Internet and integrate in assignments?
    c. Do they like ask their peers?
    d. Do they like ask you?
    e. Do they like ask theirs TAs?
    f. Do students need regularly assistance from others in labs?
    g. Do students avoid asking help when they can't deal with a situation?
    h. Are you considering your students having good communication skills?
3. Types of interactions preferred that works for you (from a 1 to 10 scale):
    a. Individual study
    b. Team projects
    c. Questions/tasks that emulate competition among your peers
4. What interests your students the most about CS?
5. What interests your students the least about CS?
6. What mistakes and good practices in students' activities were observed during the class and labs?
7. What are the most usual software projects, students are drawn to?
8. If you were to describe characteristics of students in CS what/how would they be?
9. What do students like and dislike about programming? Do they put an equal between programming and computer science?
10. Experiences good/bad with TAs/ students/ professors?
11. What would you change about your current CS academic program if you could?
12. Ideas of why are so few women in field?
13. Which facts (positive or negative) come to mind that are related to being a woman/man in this program (i.e. experience, interactions, confidence, was encouraged/discouraged, teasing/teased, avoiding/avoided, discriminating/(discriminated by) colleagues, professors or TAs, gender overgeneralization)?
14. How are you experiencing being a woman/man in this CS program?
15. Being woman/men in IT industry is an advantage or not? Why?
16. Is class participation correlated more with one gender than the other?
17. What have to be different in order to motivate female students and give them better technical skills? (the same questions for male students)
18. Do you believe teacher strategies are required to accommodate to gender differences?
19. Are there challenges experienced disproportionately by one gender?
20. Do you find often students that are switching out of CS? Why? How often?(males vs. females)
21. How often are your students attending classes and labs? (males vs. females)
22. What was the interaction between:
    a. women students and you,

  b. male students and you

23. How do you comment your students' experiences with IT job market, job recruiters, finding employment?
24. What do you like and dislike about CS teaching? (Finish these sentences: • I like (or do not like) currently practice teaching because... •I did (or not) agree with these aspects....)
25. Looking back on your experience in CS, what are some lasting impressions: What helped the most? What hurt the most?
26. What advices do you have for new students?
27. Is there anything you haven't discussed that you would like us to know about your CS experiences?

VITA AUCTORIS

Dorian Stoilescu was born in June 11, 1967 in Galati, Romania. He has been involved in computer science teaching and in software development since 1991. He graduated from University of Bucharest where he received his Honors Bachelor of Science in Computer Science and Mathematics. He received his teacher certifications in 1994 ("Definitivat") and 1998 ("Gradul 2") and awards in teaching in 1995, 1996, and 1997.

In Romania, he wrote three textbooks for high schools: "C/C++ Manual" (1997, 1998), "C/C++ textbook" (1998) and Pascal for Beginners (1998). He was a member of the National Committee of Romanian Teachers in Computer Science and participated in elaboration of national computer science curricula in Romanian high schools.

In Canada, he is currently a member of Canadian Society for the Study of Education (CSSE), Canadian Association of Curriculum Studies (CACS), the Association for Computing Machinery (ACM), Institute of Electrical and Electronics Engineer (IEEE), and the Association for the Advancement of Computing in Education (AACE). He has presented posters and papers in conferences in Canada and in the US in subjects related to technological education (e-learning, multimedia, computer based instruction, technology and equity) and equity issues. He enrolled in the Master of Education Program at the University of Windsor's Faculty of Education.