FACTORS THAT INFLUENCE THE CAREERS OF WOMEN IN COMPUTER SCIENCE: A QUANTITATIVE AND QUALITATIVE ANALYSIS

by

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ABSTRACT

The current study examined the impact of parents, teachers and role models/mentors on the problem of under representation of women in the field of Computer Science. The current study investigated the problem from two complimentary perspectives. The first perspective investigated the opportunities available for women in Computer Science and the extent to which the three factors (parents, teachers, and role models/mentors) impact women in taking up these opportunities. The second perspective investigated the impact the three factors (parents, teachers, and role models/mentors) in retaining and increasing the number of women in Computer Science. The reason for conducting this study was to gain insight into this problem of inequity and to find possible ways to lessen, and hopefully eliminate it, over a period of time.The current study utilized survey research methodology to investigate the problem of under representation of women in Computer cience and also the impact of the three factors (parents, teachers, and role models/mentors) in addressing it. A combination of open and closed-ended questions and rank order statements on the survey questionnaire revealed that the three factors (parents, teachers, and role models/mentors) had a significant impact on taking women towards or away from Computer Science. Statistical analysis of the survey responses also indicated the relative order of importance of the three factors in their impact on women in the following order:

- Parents
- Role models/mentors
- Teachers

The study concludes that the impact of strong, supportive relationships will continue to have a significant impact on who takes on the field of Computer Science as a profession. This study leaves implications for further research in socio-psychological and educational research in the hope of breaking social barriers of gender biased values that influence the psychological and educational perspectives of the entire society.

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INTRODUCTION

Introduction

The Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (CAWMSET, 2001), stated that while the old economy hinged on supplies, factories, and transportation, the new economy relies mostly on brainpower. Nowhere is this more evident than in Information technology industry. The study notes that the Computer/Information Technology industry also has the most evident problem of under representation of women. Computer Technology is affected by a long history of male dominance. Technologies are not simply machines, but also social relations and communication systems, so computer technology continues pre-existing social and communication patterns. Women are underrepresented in Computer Science and this gap has increased in the present times. The number of women with earned degrees in Computer Science is so few that it has led to the under representation of women in the Computer Science industry as well. The CRA (Computing Research Association) Taulbee survey (1999-2000) revealed the following graduation data for women in Computer Science: 15% women graduated with a

Doctorate, 26% of women graduated with a Master's degree, and only 19% women graduated with a Bachelor's degree. According to the CRA Taulbee Survey, 2002 – 2003, only 19.9% women were enrolled in Computer Science and Computer Engineering Doctoral Programs and only 16.5% women were recipients of Doctoral degrees in Computer Science and Computer Engineering Doctoral Programs.

The current study made an attempt to investigate the reason why women were underrepresented in Computer Science and what could be done to possibly eliminate and lessen this problem.

Freeman and Aspray (1999) pointed out that if the number of women in the Computer Science workforce were increased to equal the number of men, even the tremendous shortage of workers noted by the ITAA (Information Technology Association of America) studies could be filled. A careful review of the past statistics shows that there are only a small number of women who have earned degrees in Computer Science; hence there are so few women in the Computer Science profession. According to U.S. Department of Education (1995-96) statistics, the percentage of women who earned a bachelor's degree in Computer Science (CS) was 27.5%, and the pipeline shrinks through the awarding of Master's degree (26.7%), and doctorate degrees (14.5%). Furthermore, according to the CRA Taulbee Survey (1997-98), a shrinking pipeline also exists in Computer Science academic positions, 16.4% assistant professors, 11.7% associate professors, and only 7.6% full professors are women (Kozen and Morris, 1999). Data analyzed by the Commission on Professionals in Science and Technology (Vetter, 1989, 1992), the National Science Foundation (1986, 1988, 1990, 1992), and the National

Research Council (CWSE, 1991) revealed and confirmed the dearth of women in sciences, including Computer Science.

The Association of American University Women (AAUW, 1990, 1992, 1994, 2003) also noted that there was a dramatic drop in the ratio of women to men involved in computing from high school to graduate school. According to these studies, there were many contributing factors to the gender gap problem including the lingering, false societal stereotype that girls are "not good" at math; the preponderance of computer games aimed at boys; and the many male-oriented on-line discussion groups that are often sexist. A recent study by AAUW (2000) noted that girls are still underrepresented in Computer science and are not 'technology literate.' The AAUW study suggested not only to make girls more tech-savvy but also the teachers more tech-savvy, so that it is possible to compute across the curriculum, where computers can no longer be treated as 'set aside,' lab-based activity.' A related problem is that only few women hold positions of power in the computer industry, a self-perpetuating situation because of the lack of role models and potential mentors. For example, less than 20% of the members of The World Wide Web Consortium staff, which sets the standards for HTML and other web protocols, are women (Acker, 1994).

In this new century, sophisticated technology is increasingly significant to the nation's economic, political, and social health. Almost every element of society – fields as diverse as music, sports, and agriculture – are being touched by technology. The AAUW study (1992), noted that to prepare for science and technology oriented jobs, it is necessary to present science, technology, engineering, and mathematics as unintimidating to every student, so that they will feel encouraged to gain the skills and knowledge necessary for a technical career. As part of the global economy, it is important to engage the intellectual potential of all young people equally. But data clearly points out the underrepresentation of women in computer science.

Social, Historic, and Intellectual Context

A part of the human condition is the temptation to imagine nostalgic past in which vexing problems of the present were more manageable. We look to the past for historical threads we want to weave today into a full tapestry of explanation. This is particularly powerful in education, where each generation creates mythical Edens against which, the present appears at best chaotic and at worst, simply wrongheaded.

In thinking historically about gender inequity in science and technology, it has always existed in terms of stereotyping and gender-role identity. Gender-role identities develop at a very early age. Children in their formative years learn what it means to be a male or a female because of the actions of parents in their first years of lives. Parents play more roughly and vigorously with sons than they do with their daughters (Jacklin, DiPietro, & Maccoby, 1984). When middle-class parents are asked about what they value in their children, they list achievement, competitiveness, and emotional control for their sons and warmth and 'ladylike' behavior for daughters (Block, 1983). According to a study conducted by the United States Department of Education (2000), there is a direct relationship between gender stereotyping and the entry and persistence of women into fields of science and technology.

DEDICATION

TO MY FAMILY AND FRIENDS WHO CONTINUE TO

STAND BY ME
AND
ABOVE ALL
TO
MY SON ROHAN
MY
CONSTANT SOURCE OF INSPIRATION

According to McGuire (1988), what starts at home as gender- role identity continues as gender-role stereotyping in school. According to this author, even in this era of great progress towards equal opportunity of the sexes, a preschool girl is more likely to say she wants to be a nurse or a secretary than to say she wants to be a doctor or an engineer. Most parents are not unhappy to hear this response. On the contrary, if a preschool boy said he wanted to be a fireman or a nurse, not a doctor or an engineer, his parents would have been very offended. Martin (1989) emphasized that preschoolers tend to have more stereotyped notions of sex roles than older children, and that all ages seem to have more rigid and traditional ideas about male-oriented occupations than about female-oriented ones.

According to Martin & Little (1990), children through their interactions with family, peers, teachers, and the environment in general, begin to form gender schemas, or organized networks of knowledge about what it means to be male or female. These schemas help children make sense of the world and guide their behavior. A young girl whose schema for 'girls' includes 'girls play with dolls and not with trucks' or 'girls can't be scientists' will pay attention to, remember, and interact more with dolls than trucks, and she may avoid science activities. Skolnick, Langbort, & Day, 1982, pointed out that young children learn important cognitive abilities through play. Boys and girls play with different kinds of toys and at different games and activities and parents contribute to the development of toy preferences long before anyone knows what the individual child prefers. Parents not only buy different toys for their sons and daughters, but also play with their children differently. Girls' games generally involve smaller, more intimate groups than boys' games and often concern social relationships. A study conducted by Block (1980) shows that parents playing the same game with sons and daughters stress achievement with sons (winning the game) and 'just being together' with daughters. Tobias (1978) termed boys' interaction with their environment and with one another in sports and games as 'street mathematics.' Batting averages, interception of a ball in the air, trajectories of balls, and scoring all involve calculations of numbers, time, speed or distance. Boys playing with balls, bikes, and billiards are actually doing experiments and learning the principles of physics. These concepts of physics become basic to boys' language of social interaction. Later many of the specific examples boys encounter in studying subjects like physics actually come from the world of 'boys' play'. Tobias further pointed out that spatial imagination or visualization are skills essential in sciences and math but sex-role socialization is the major deterrent to the development of girls' spatial abilities. Beginning with childhood toys and games, girls have limited practice in spatial visualization.

The problem of gender stereotyping is further augmented by gender bias in textbooks, which has existed for a long time. Research literature from as long ago as 1970 points towards gender bias in textbooks. Powell, Garcia, & Denton (1985), draw attention to it by pointing out that most of the textbooks produced for the early grades before 1970 portrayed both males and females in sexually stereotyped roles. Materials for the later grades often omitted women altogether from illustrations and text. These authors refer to a study conducted in 1975 of 2,760 stories in 134 books from 16 publishers, conducted by a group called *Women on Words and Images* who analyzed 62 elementary textbooks and found that the numbers of male and female characters were about equal, but it did not end the problem. Purcell & Stewart (1990) conducted a study and found that girls were shown in a wide range of activities in textbooks, but were still portrayed as more helpless than boys were. These authors found that books for older children were not free of sexual stereotypes and despite new publishers' guidelines, problems had not disappeared entirely.

Numerous studies (Bailey, 1993; Sadker & Sadker, 1985; Serbin & O'Leary, 1975; Wingate, 1986) draw attention to previous research on teachers' treatment of male and female students, which confirms that teachers interact more with boys than with girls. This is true from preschool to college. Teachers ask more questions of males, give males more feedback (praise, criticism, and correction), and give more specific and valuable comments to boys. By the time students reach college; men are twice as likely to initiate comments as women are. Baker (1996) suggested that the imbalances of teacher attention given to boys and girls are particularly dramatic in science classes and found that boys were questioned on the subject matter 80 percent more often than girls were. Another study by Rennie & Parker (1987) found that boys dominate the use of equipment in science labs, often dismantling the apparatus before the girls in the class have a chance to perform the experiments.

Stereotypes are perpetuated in many ways, some obvious, some subtle. Sadker & Sadker (1985) found that guidance counselors, parents, and teachers often do not protest at all when a bright girl says she doesn't want to take any more math or science courses, but when a boy of the same ability wants to forget about math or science, they will object. In these ways, students stereotyped expectations for themselves can be reinforced.

From infancy through preschool years, many studies found few differences between boys and girls in overall mental and motor development or in specific abilities. Numerous studies (Linn & Hyde, 1989; Newcombe & Baenninger, 1990), have confirmed that during the school years and beyond, psychologists find no differences in general intelligence on the standard measures – but these tests have been designed and standardized to minimize sex differences. The overall IQ scores of males and females are not significantly different on the average; however, scores on several subtests show gender differences. Studies conducted before 1974 showed that males performed significantly better than females on tests of spatial ability. Since 1974 the differences have virtually disappeared, except on tests that require mental rotation of a figure in space where males are faster, though not more accurate. This quickness in mental rotation of objects has been related to male participation in athletics. According to Woolfolk (1995), males' extensive experiences with video and arcade games may play a role in their creating an interest in technology. Mainly this difference is due to social conditioning of both the sexes, since females are not encouraged to play video games. Edward Lazowska (1999), Chair of the Board of Directors of the Computing Research Association, suggested that girls be encouraged to play computer games since computer games attract and maintain the interest of girls in computing.

Woolfolk (1995) raised the controversial question of whether boys are better in mathematics because they take more math courses than girls. Pallas & Alexander (1983) point out that there appear to be practically no differences between boys and girls in math achievement, although during high school girls take fewer math courses. As soon as mathematics courses become optional, many girls avoid them.

A government survey revealed the following data on the percentages of males and females who enrolled in and then completed high school courses in several areas pertinent to this study:

Table 1: Who Finishes What Courses?

COURSES	MALES COMPLETING	FEMALES COMPLETING
Algebra	81.6	76.8
Trigonometry or Geometry	60.1	50.3
Chemistry or Physics	54.2	42.3
English, 3 years or more	92.8	94.1
Foreign Language, 2 years or more	39.1	48.1

Source: National Center for Educational Statistics, Digest of Educational Statistics, 1990

Numerous studies show (Fennema & Sherman, 1977; Oaks, 1990; Pallas & Alexander, 1983), mounting evidence that the differences between boys and girls in math achievement decrease substantially or disappear altogether when the actual number of previous math courses taken by each student is considered. But other researchers point out that high ability boys are superior to high ability girls in mathematics reasoning, even when participation in previous math courses is taken into account (Benbow & Minor, 1986; Benbow & Stanley, 1980, & Kolata, 1980).

Oaks (1990) found that only 15 percent of the scientists, engineers, and mathematicians in the United States are women, and concluded that academically qualified girls choose not to take advanced science and math courses in high school. Thus they do not develop their abilities in this area. Ware & Lee (1988) suggested that the process of choosing a scientific major was examined in a nationally representative sample of male and female college students of above–average ability. Women attending a four-year college, who reported of being influenced by high school teachers and guidance counselors in making plans for college, and who placed a high priority upon aspects of their future family and personal lives were less likely to major in science than their female peers. High socioeconomic status, positive assessments of their high schools, and attending a four- year college predicted science majoring for men. According to a study conducted by the National Center for Education Statistics (NCES, 1997), more boys than girls are likely to take science, math and technology courses because boys do better in such courses as a result of social conditioning from family, teachers, mentors in early childhood years. In other words, students who do well in math, science and technology courses generally have more positive attitudes towards those subjects, and are more likely to take courses in those subjects and perform better.

A study conducted by Harvard University in 1986 confirmed that teachers play a vital role for the lower participation of girls in math and science studies. This study found that some teachers tend to accept wrong answers from girls, saying, in effect, "well, at least you tried." But when boys give the wrong answer, the teachers are more likely to say, "Try harder! You can figure this out." These messages repeated time and again can convince girls that they just are not cut out for mathematics and science.

A careful review of the research literature (NCES. 1997; Jacklin, DiPietro, & Maccoby, 1984; Block, 1983; McGuire, 1988; Martin & Little, 1990; Skolnick, Langbort,

& Day, 1982) indicated that the following three factors played a significant role in channeling and retaining women in the computer science field:

- Parents (including all family members)
- Teachers
- Mentors/Role Models

These three factors were analyzed in the current study to determine their role in channeling and retaining women in computer science.

Significance of the Subject to be Examined

This study has the potential to be of interest to two categories of professionals: the first category includes education professionals, education institutions, education researchers, and education policy makers. The second category includes corporate sector professionals.

This study was conducted with an expectation to facilitate education professionals to form a theoretical base of how to increase and retain the number of females in science and technology. This study is also an attempt to provide an impetus to education professionals to change the curricula to emphasize more female involvement in the field of Computer Science.

Research literature indicated that not much importance has been given to curriculum and pedagogical issues in terms of female retention and recruitment in computer science. A study by Matyas and Malcom (1991) of over 400 undergraduate institutions revealed that less than 10% of academic programs focused on women in computer science, and virtually none considered the impact of curricular and pedagogical issues in the classroom with respect to female recruitment and retention. In an attempt to increase and retain women in computer science, from kindergarten through faculty level, the National Science Foundation established the *Program for Women and Girls*. This program did not concentrate on pedagogy, curriculum or classroom climate, by applying the most broad, liberal definitions of those terms. Hands-on laboratory experiences, collaborative learning and group work were used as pedagogical techniques to improve the retention of girls in science. (National Science Foundation, 1994).

Based on a recent Information Technology Association of America (ITAA) study, there are nearly 346,000 unfilled IT (Information technology) positions in the United States. Camp (1997) emphasized that this situation was expected to get worse and based her statement on the report of the Bureau of Labor Statistics which predicted that the demand for workers in the IT field will grow to over one million additional workers between 1994 and 2005.

The current study, therefore has a two-fold significance for corporate sector professionals. The first is the start of making first steps towards equity in the workforce by increasing and retaining the number of women in science and technology. Second, increasing and retaining more women in science and technology will go a long way in decreasing the problem of insufficient technical workforce in the country. The most recent national debate regarding the insufficient technical workforce began in 1997 with reports prepared by the Information Technology Association of America (ITAA) and the United States Department of Commerce. Both of these reports point out that as a result of the supply-demand dynamics in the IT industry leading to a shortage of workers, the number of H-1B visas was increased to enable more foreign nationals to enter the IT labor pool.

The Washington metro area corporate sector is already realizing the shrinking pipeline of women in the workforce. One of the leading international firms based in Washington metro area called Deloitte & Touche has started a program called the 'Advancement and Retention of Women' in an effort to pump up the success, recruitment and retention of women. Sue Molina, a partner at Deloitte & Touche and national director for the company's program (Advancement and Retention of Women Initiative) was the main force for starting the women's initiative about seven years ago when the company found its rate of retaining and recruiting women was low compared with that of men. Molina (2000, 2001) emphasized the importance of the role of mentors and role models in encouraging women to be successful professionals. As a part of the Women's Initiative Program there are forums held for female employees where they (female employees) meet successful women professionals on a one on one basis. Molina described the positive influence in her own life of a mentor/role model. She described the Women's Initiative Program as a positive impact for female employees, since it prompted gender awareness and provided flexible schedules and career planning sessions for female employees.

Research Questions

The current study addressed the problem of underrepresentation of women in Computer Science as is strongly suggested by research literature. The current study investigated the problem from two complimentary perspectives. The first perspective investigated the opportunities available for women in Computer Science and the extent to which the three factors (parents, teachers, role models/mentors) impact women in taking up these opportunities. The second perspective investigated the impact the three factors (parents, teachers, role models/mentors) in retaining and increasing the number of women in Computer Science.

The research questions addressing these two perspectives were:

1. To what degree are the opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, and role models/mentors) impact women in taking up these opportunities?
2. To what extent are the three factors (parents, teachers, and role models/mentors) responsible for retaining and increasing the number of women in the Computer Science workforce?

Statement of the Hypothesis

The research literature suggests that the impact of the three factors (parents, teachers, and mentors/role models) is significant on the entry and retention of women in Computer Science. Therefore, it was hypothesized that females who were positively supported by these three factors in their lives, entered and successfully retained themselves in Computer Science than those who were not positively supported by the three factors. This study hypothesized that data derived from the study's research questions would demonstrate why the problem of underrepresenation of women in Computer Science existed and what could be done to lessen and eliminate this problem.

Purpose of the Study

The purpose of this study was to explore and describe the impact of the three factors (parents, teachers, role models/mentors) on the underrepresentation of women in Computer Science and also the perceived impact of these three factors towards the entry and retention of women in the workforce. The reason for conducting this study was to gain insight into this problem of inequity and to find possible ways to lessen, and hopefully eliminate it, over a period of time.

Methodology of this Study

This study utilized the same survey-questionnaire for data-collection in two ways: self-administered and web based. The current study utilized a cross -sectional research design only in part in using the self-administered survey where the survey information was collected at one point in time. The survey questionnaire was designed to incorporate quantitative, descriptive and qualitative methods with an intent to describe the problem of underrepresentation of women in Computer Science and also to study the impact of the three factors (parents, teachers, role models/mentors) in addressing it. The study is quantitative because a survey questionnaire was used for data collection. The advantages of using a survey design for this study was: economy of design, rapid turnaround in data collection, and the ability to identify attributes of a population from a small group of individuals. (Creswell, 1994). This study is descriptive since it presents a picture of specific details of the situation - underrepresentation of women in Computer Science, social setting, or relationship (three factors identified by research: parents and family, mentors and role models, teachers). This study is descriptive also because it fulfills the following goals:

- Gives a verbal and numeral picture
- Finds information to stimulate new explanations (Newman, 1997).

This study is qualitative because it includes open-ended questions (in addition to the closed-ended quantitative questions) in the survey instrument from which data was collected. The advantages of including open-ended questions was that they permit an unlimited number of possible responses, permit creativity, self-expression, and richness of detail and also permit adequate answers to complex issues (Newman, 1997; 2003). The reason for including a combination of closed and open questions on the survey instrument of the current study was to provide data to strengthen the dissertation findings by contributing to a broad database of knowledge.

Research Design and Instrument

The current study used survey research to collect data. Following a deductive approach, the study began with theoretical or applied research problem and ended with empirical measurement and data analysis. The survey instrument included a structured questionnaire (self-administered), with a combination of open and closed ended questions. It was anticipated that a combination of open and close questions on the survey instrument would reduce the disadvantages of any one type of question form and also offer a change of pace.

Population

The population under investigation was female Computer Science professionals (irrespective of whether they have an earned degree in the field or not) in the corporate sector in the Washington Metro area. The reason for choosing the Washington Metro area was because it is the fastest growing technology corridor of the USA. The sample population was not selected based on the ethnic background of the respondents because this study does not deal with ethnicity as a factor that affects the interest and persistence of women in Computer Science.

Anticipated Outcomes

The following were the anticipated outcomes of this study:

- To find out how important are the three factors (teachers, parents, mentoring,) to the interest of females in the computer science field.
- To find out how important are the three factors (teachers, parents, mentoring,) in the persistence of females in the computer science workforce.

Limitations

An anticipated limitation of this study was:

- Even though the response rate was hundred percent for the self-administered survey, the sample for this study was small (40 respondents) which restricts the generalizability and may skew any statistical significance that was found.

- The population sample for the self-administered survey included in this study was drawn only from businesses involved in Computer Science/Information Technology in the Washington Metro area.
- This study was confined only to looking at the success of women the Computer Science field, not at the ones who dropped out.
- The self-administered survey questionnaires were administered by the point of contact at the organizations chosen for this study. There is potential of bias because the point of contact could have had undue influence on the respondents (as a friend, co-worker or boss). However, the respondents were assured that the surveys would remain anonymous. The surveys were coded and the respondents were asked not to write their names on it. In this case, where anonymity was preserved the expectation would be to offset any potential for bias.
- The web-based survey was accessed by a total of 53 respondents out of which only 32 respondents completed the survey in its entirety.

Definitions

For the purpose of this study the following definitions apply:

- Email: Electronic mail.
- Gender-role Identity: the image each of us has of ourselves as masculine or feminine in characteristics – a part of our self-concept (Bem, 1974; Boldizar, 1991).
- Gender: usually refers to judgments about masculinity and femininity, judgments that are influenced by culture and context (Deaux, 1993).

- Gender-schemas: organized networks of knowledge about what it means to be male or female (Martin & Little, 1990).
- Information Technology: refers to computer systems (ranging from design and production of chips to the creation of complex, computer based systems for a particular application). It includes computer hardware and software, as well as the peripheral devices most closely associated with computer-based systems. The term information technology (IT) will be used interchangeably with Computer Science since Computer science is an IT related academic disciplines (Freeman & Aspray, 1999; Deming, 1998).
- Science & Technology: the use of this term will include Computer Science as a component whenever this term is used in this study.
- Scientists & Engineers: includes all people employed in a science or engineering occupation and who have received a bachelor's degree or higher in a science or engineering field, plus those people holding a non-science and non- engineering bachelor's or higher degree who are employed in a science or engineering occupation. (NSF's SESTAT (Scientists and Engineers Statistical Data, 2000).
- Computer Scientist: is a term used to designate a highly skilled worker in the Computer Science/Information Technology industry. A computer scientist has an earned Doctoral degree in the field and is engaged solely in research in hardware or software computer science. Computer scientists are expected to work only in research laboratories in Computer Science/Information Technology firms (Hewlett Packard, IBM, Siemens, Sharp, Hitachi, Mitsubishi, Panasonic, Ricoh, Philips, and Sony). The term computer scientist is not prevalent anymore. With the shortage of workers in the

Computer Science/Information Technology, companies designate the title of IT professionals to all workers in this profession including those engaged in research. Computer science skills being transferable, a researcher in this field may now be performing in addition to research functions, other IT related duties which include implementing, enhancing, and maintaining systems that rely on information technology (NSF's SESTAT (Scientists and Engineers Statistical Data, 2000; Statistical Profiles of Foreign Doctoral Recipients in Science & Engineering, NSF, 1999).

- IT worker/professional: any skilled worker who performs any function related to information technology, which itself is defined as the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware (Information Technology Association of America, 1997).
- Categorization of IT Jobs: IT jobs are categorized in four ways:

  Conceptualizes: Those who conceive of and sketch out the basic nature of a computer system artifact.

  Developers: those who work on specifying, designing, constructing and testing information technology artifact.

  Modifiers/Extenders: those who modify or add on to an information technology artifact.

  Support/Tenders: those who deliver, install, operate, maintain, or repair an information technology artifact (Computing Research Association, 1999).

CHAPTER 2

LITERATURE REVIEW

Introduction

Even though technology-based education is emerging as an increasingly important component of higher education, research indicates and confirms that women are significantly underrepresented in computer science (CAWMSET 2001; NSF 2000; AAUW 2000; 2003; Beyer, Rynes & Haller, 2004.). The facts are quite simple. In comparison with males, females do not take as many computer courses at school; they do not spend as many hours on computers at home, at computer camps, or in after-school computer centers. Girls do not select undergraduate or graduate computer majors as often as boys. Male success in technology enriched computer science classrooms is common. It is hard to understand why females are not investing as much time in computers as their male counterparts are. The average age when women decide to enter natural sciences and engineering majors is 20, for men it is 16 (Jagacinski, 1987; Mellwee & Robinson, 1992). By choice, high school girls do not take computer science advanced placement tests (Verbick, 2002). Majors leading to careers in technology continue to be dominated by men and young men are five times more likely than young women to choose computer science or computer engineering majors (Cohen, 2001). The National Center for Education Statistics, 2003, indicated that women who choose to major in and obtain bachelor's degrees in mathematics, natural and physical sciences and in other math-related disciplines such as engineering and computer science is only a fraction of that for men.

Camp (1997) stated that there is an incredible shrinking pipeline of women the field of computer science. The shrinking pipeline refers to the decreasing trend of women to enter and pursue careers in Computer Science. The author focused on a critical point in the pipeline and reviewed the number of degrees awarded to women at the bachelor's level and found a disturbing trend unique to Computer Science. The author found that the proportion of bachelor degrees awarded to women in all disciplines increased almost every year for decades, to a high of 55.2% in 1995-96. This increasing percentage of women earning college degrees had a positive effect on the percentage of women earning college degrees in all science and engineering fields, except computer science. The number of women entering computer science being so low at the academic level also leads to implications on the labor force. Beyer, Rhynes and Heller (2004) pointed out the labor force shortage of 835,000 IT professionals and especially of computer scientists, which provides impetus for increasing the representation of women in computer science.

The purpose of this literature review is to provide a research-based explanation to the question of the impact of the three factors (parents, teachers, and mentors/role models) on channeling and retaining women in Computer Science. Further, this literature review is an attempt to provide a synthesis of the research findings on gender differences in the field of computer science and also examined several popular theories of why the differences exist and what can be done to decrease them. This literature review is an attempt to provide a methodological database of the research sources cited for this study and provided readers with a broad knowledge base, and also facilitated the researcher of this study to select an appropriate instrument for data collection. This literature review includes scholarly references, which show the impact of the three factors (parents, teachers, and role models/mentors), on female Computer Science professionals, irrespective of their ethnicity. This is because this study did not deal with ethnicity as a factor that affected the interest and persistence of females in Computer Science.

This literature review also provides research findings on gender differences associated with recruitment and retention in the fields of Science, Mathematics and Engineering (SME) as a springboard for conducting this study. Numerous research studies (CAWMSET 2001; NSF 2000; NCES 2000; AAUW 2000; 2003; NCES 1997; Seymour & Hewitt, 1997; Verbick, 2002; Beyer, Rynes & Haller, 2004) have shown that science, mathematics and engineering are male dominated fields and much research was conducted in these areas to confirm that women were underrepresented in these areas as well. However, the number of women is steadily increasing in these areas, but the gender gap in Computer Science looms large. Recent research (NSF 2000; NCES 1997; Beyer, Rynes & Haller, 2004; Kohlstedt, 2004) has proven that student attitudes (both male and female) towards science and mathematics in the early years determines their persistence in these areas and related areas (technology, computers, engineering) in later years of life. Studies on SME will serve as a springboard for the current study because some of the same factors (parental support, teachers and role models) play an important role in determining the entry and persistence of females in this area as well. Studies on SME will facilitate an understanding of the logic and patterns of thought behind the decisions of females in making career choices (why or why not) in these fields of study and create a frame of reference for the current study.

(Faulkner, 2000) indicates that there exists an equation of 'power' between masculinity and technology, which significantly shapes the instructional approach in the classroom to be gender biased. Faulkner explains that 'power equation' refers to the dominance of masculinity over the feminine in the science and technology field, which also includes male speculation about speed and power of computers. Faulkner explores the issue of this 'power equation' between masculinity and technology being so durable that it leads to huge mismatches between image and practice. The study uses the survey methodology to indicate in clear terms that females in the same computer science class are treated differently than the males. Male students are encouraged to be more interactive and vocal. Surveys were administered to students and instructors. The population was sampled randomly to include students and instructors from two undergraduate computer science degree programs. The contribution of this research is that it confirms that a different teaching style is used for girls than boys in a science or technology classes. Teachers are an important factor in encouraging or discouraging girls from science and technology.

Clegg and Trayhurn (2000) conducted a study, which investigated the decline in the number of women in computing courses in higher education. The authors point out the gender gap and agree that female students in computer science are indeed treated differently than male students. The study reported that females are seen only as end-users, not a part of the academic mainstream in the computer science field. The authors adopted the case study methodology using taped interviews of undergraduate male and female computer science students. The interviews were based on allowing participants to construct a biography of their route into higher education, focused on previous educational experiences, hobbies and leisure interests, particularly experience with computers at home, significant others, parents, siblings, peers and teachers who had influenced their choices. Prompts were used but the interviewees were encouraged to construct their own story. Permission was asked for the interviews to be taped and none of the participants refused. The contribution of Clegg and Trayhurn's research to scholarly literature is that women are underrepresented in Computer Science, but there is hope that women will increase their number in this field. The authors found that female Computer Science professionals confidently spoke to them and expressed confidence in their own abilities. The reason that women are underrepresented in Computer Science is because of social conditioning. The really striking difference between men and women in this study was that there was a very high level of home computer use among men. These men have access to home computers from as young as 5 years, with a wide experience of playing computer games with their friends, taking things apart and messing with programming and so on.

Not only had the males greater access at home, it was apparent from their comments that they dominated at school; many of them recalled computer clubs or of a particular teacher being impressed and encouraging them. None of the women told these stories. These experiences are important because these are the reasons why men decide to go into the Computer Science profession. For the women in this study, their first experiences with computers were overwhelmingly associated with clerical and administrative tasks. This means that they bring different views of the capacity of computers derived from networked systems, rather than PC experience.

Crombie, Abarbanel & Trinneer, 2002, conducted a three – year study in which a questionnaire was used to compare female students from all female computer science (CS) classes to male and female students from mixed-gender CS classes. Females from all-female classes reported higher levels of perceived teacher support, confidence and future academic and occupational support than did females from mixed-gender classes. Females from all-female classes reported levels as high as those reported by males on perceived teacher support, whereas males reported higher levels than females from mixed-gender classes on perceived teacher support, confidence, intrinsic value, and future intentions.

Bowden, 2001: Crombie et al., 2001; Thorn, 2001, suggested the need of single-sex classes to encourage and uplift the confidence of young women majoring in traditionally male-dominated fields. Crombie et al. (2001) recommended that such courses be offered as early as high school, especially in computer science. Bowden (2001) also noted that one way to enroll more girls in computer science classes would be to offer single-sex classes, but suggested such a practice to be cost-prohibitive.

Statistics of Gender-Gap in Computer Science

Below are some statistics of gender gap in computer science:

1. According to the U.S. Department of Education (1995-96), the percentage of women who earned a bachelor's degree in CS was 27.5%, and the pipeline shrinks through the Master's degree (26.7%), and doctorate degrees (14.5%).

2. According to the CRA (Computing Research Association) Taulbee Survey (1997-98), a shrinking pipeline also exists in CS academic positions; 16.4% assistant professors, 11.7% associate professors, and only 7.6% full professors are women (Kozen and Morris, 1999).
3. According to the most recent statistics available from the CRA Taulbee Survey (1999-2000), only 16% women were hired in Computer Science faculty positions.
4. Nearly 75% of tomorrow's jobs will require use of computers; fewer than 33% of participants in computer courses and related activities are currently girls (US Labor Statistics, 2000).
5. Only 16% of scientists, 6% of engineers and 4% of computer scientists in the U.S. are women (Pearl, et al., ACM, 1990).
6. Girls consistently match or surpass boys' achievements in science and mathematics as measured by scholastic aptitude tests, achievement tests, and classroom grades (The National Science Foundation, 1994).
7. Only 34% of high school girls reported being advised by a faculty member not to take senior math (The National Science Foundation, 1994).
8. Women leave science and engineering careers at twice the rate as men do (Brodie, 1996).
9. Women's salaries in science and engineering lag behind men's by 12 to 15 percent (Hollenstead et al., 1995).
10. Only 16% fewer girls than boys reported ever talking to their parents about science and technology issues (The National Science Foundation, 1994).

11. By the year 2000, only 15% of the incoming workforce will consist of white men (Burge & Culver, 1994).
12. Only 6.4% girls/women were enrolled in graduate programs in science and engineering in 2001- 2002 academic year (The National Science Foundation, 2002).
13. Only 19.9% women were enrolled in Computer Science and Computer Engineering Doctoral Programs (CRA Taulbee Survey, 2002 – 2003).
14. Only 16.5% women were recipients of Doctoral degrees in Computer Science and Computer Engineering Doctoral Programs (CRA Taulbee Survey, 2002 – 2003).
15. The percentage of newly hired teaching faculty who are women dropped from 26% to 22%.
16. Only 25.6% of women were recipients of Bachelors and Master's degree in Computer Science and Computer Engineering Programs ((CRA Taulbee Survey, 2002 – 2003).
17. Only 8.6% of women comprise Full Professors, only 12.3% comprise Associate Professors, only 15.8% comprise Assistant professors in Computer Science and Computer Engineering Programs ((CRA Taulbee Survey, 2002 – 2003).

Past and present statistics clearly indicate the underrepresentation of women in Computer Science. Women are paid less than their male counterparts and leave the Computer Science at a much faster rate than men. The statistics also reveal the influence of parents, teachers, and role models/mentors on either taking women towards or away from Computer science. This literature review examined the impact of the three factors (parents, teachers, and role models/mentors) on the entry and retention of women in

Computer Science. This literature review has been separated by sections, each of which has been designed to shed light on the problem investigated in this study.

A Survey of Gender Gap in Computer Science

More sophisticated technology is increasingly significant to the nation's economic, political and social health. Almost every element of society including fields as diverse as music, sports and agriculture are being touched by technology. Science and technology should be presented to all students in an unintimidating manner to prepare them for jobs in these fields. Girls should not be shortchanged of the personal and economic fulfillment that arises from becoming more engaged in science and technology. Women have traditionally earned among the lowest incomes of workers. By directly or indirectly excluding women from significant educational opportunities, their chances are being jeopardized of attaining the professional careers that might lift them from the cycle of poverty (AAUW Report, 1992).

Trayhurn and Johnson (2000) conducted research on the issue of the gender-gap in computer science and indicated that women are avoiding the hard-end of computer studies on courses in higher education. Their findings are based on a study that they conducted of men and women in Information Technology/Computer Science courses in institutions of higher learning. The methodology involved case study approach with open-ended interviews, which found that women need to gain more self-confidence in order to be more interactive and visible in a computer science classroom.

McKenna (2000) refutes the assumption that teachers of computer programming assume 'male mastery' over the profession and that Computer Science is a masculine hacker's world. McKenna argues against the misconceived perception that males and females should be treated differently in the classroom. The author believes that women have as much to contribute in this field as any other. The author asserts that it is incorrect for teachers to teach or facilitate the development of a 'soft, hacking style' (this phrase has not been defined by the author) for the female students in the class. For the purpose of research, a psychoanalytic survey on college computer science teachers to see if they used different teaching styles for male and female students. Another psychoanalytic survey was administered to college computer science male and female students to see if they worked well with any particular teaching methodology. The contribution of McKenna 's study to the scholarly literature is that Computer Science is not a masculine culture and it is an act of absurdity to consider women as innately unsuited to the computing world. Clegg and Trayhurn (2000) conclude that a gender-stereotyping approach will not help to raise the declining number of female students in computer science. The authors express the need to recognize that both male and female students can make contributions to the field of computer science. The author poses the challenging question: 'what is wrong with computing?' rather than posing the question, 'what is wrong with women?'

Schmader, Johns and Barquissau (2004) conducted a study to trace the influence of gender stereotyping on women's experiences in the math domain. The chosen participants were female undergraduate students who were majoring in one of the several math related majors (i.e., math, engineering, physics, optical sciences, and astronomy and computer science). The participants were provided with an online survey. The study found that a high majority of women do enforce gender stereotyping to influence their career choices to believe that men have a superior ability than women in spatial-skills and math –related disciplines. Therefore, gender stereotyping does not help to raise the number of women in the above-mentioned math-related disciplines. This study also emphasizes the role of parents in either taking women towards or away from such math-related disciplines. This study suggests that parents' endorsement of gender stereotypes is predictive of their children's self-perceptions. In an earlier study conducted by Eccles et al. (1990) on school-age children and their parents, showed that parents tend to make stereotypic attributions for their sons' and daughters' math performance and these attributions are negatively related to their daughter's self-perceptions and decisions to engage in math-related activities. Jacobs and Weisz (1994) and Tiedemann (2000) also confirmed similar findings. These studies emphasize that girls are socialized to see themselves as being poor in math from an early age.

Beyer, Rynes and Haller (2004) conducted a study to address the problem of underrepresentation of women in computer science. Mail surveys were conducted on a random population of first-year college students (males and females). The study found that women were more influenced in their course-taking patterns by teachers and counselors than are men. This study also found that gender stereotyping negatively affected the career paths of women.

Parents and teachers play an important role in the lives of their children and their career paths. A study conducted by Steele, James and Barnett (2002) showed that women who had not encountered negative gender stereotyping from their parents and teachers while growing up pursued math-related career paths. However, such women still became affected by negative stereotyping in college, particularly in math –related fields, which resulted in their attrition from math-related fields of study.

The attrition of women from science is well documented (NSF, April, 1989; Siebert, 1992; NRC, 1991, NCES, 2003). Although both men and women leave the "pipeline" along the way, studies have repeatedly shown that a higher percentage of women leave, especially during the undergraduate years. This research originated in a Group Independent Study Project (GISP) on gender distinctions in science education at Brown University. The GISP, organized by students concerned about the under-representation of women in science, was designed to examine the role that science education plays in that under-representation. A common assumption is that students who leave the sciences are less able in the sciences than those who continue. However, this research shows that ability is not always the deciding factor in determining a college major, but it is more gender-based. This research reviews previous studies, which have looked at gender roles that inhibit or encourage technology use. Based on the information obtained from these previous studies and survey questionnaires conducted on graduate and undergraduate students, recommendations were made to encourage female representation in science (including computer science).

A number of factors contribute to the high attrition for women in science. Aspects of the structure and culture of SME [Science including Computer Science, Mathematics and Engineering] departments and engineering schools inadvertently encourage attrition and impede retention efforts, for the whole student population and for important subsets of it, including women (Seymour 1992). Seymour describes the aspects of culture that researchers believe contribute to attrition from SME majors, and gives concrete suggestions for addressing each of these issues. If implemented, these changes may prevent very capable students including women from leaving the sciences and may also attract students initially not involved in the sciences.

Communication Styles

Studies have shown that there are gender differences in communication styles in the classroom (NSF 1997; Hall, 1982). In general, men tend to respond to questions more confidently, aggressively, and quickly, regardless of the quality of their responses; they tend to speak more freely and spontaneously in class, formulating their answers as they speak. Women, on the other hand, tend to wait longer to respond to a question in class, choosing their words carefully, reflecting on the question and constructing an answer before they speak. The author also shows that women tend to be interrupted more frequently than men; when this happens; they get the message that their contributions are not as valuable, and they may hesitate to join discussions in the future. The author based this research on classroom observations and interviews both with the teachers and the students. The implications of this research are that science and technology classroom climate is not female friendly and teachers play an important role in taking women towards or away from science and technology.

Studies conducted by the Association of American Colleges (1982) and the American Association of Advancement in Science (2002), show that both male and female faculty members favor males in classroom settings by making more eye contact with men, nodding and gesturing in response to men's questions, assuming a posture of attentiveness when men speak, and locating themselves closer to men than to women.

Faculty members promote and reinforce visibility of women students by subtle practices such as calling directly on men but not on women.

Kirkpatrick & Cuban (1998), emphasize the importance of using teaching techniques that recognize a variety of learning styles in classrooms, which would not serve only women but would attract more students, including men, who are not learning under the standard lecture-style, large-class, science education system. Some faculty who have considered the challenge of teaching for a more diverse "audience" have claimed that more inclusive teaching is simply good teaching. The authors indicate this to be largely true, with two caveats: First, some suggestions (such as out-of-classroom strategies) have less to do with good classroom teaching and more to do with creating a welcoming climate; second, by concentrating on good teaching alone, gender-related differences disappear. The authors based their research on historical theories on why gender differences exist in computer science and provide a narrative on recommendations that practitioners, parents, and policy-makers need to address to encourage women in this area. This research contributes to scholarly literature in pointing out that when males and females have had same amounts and types of experiences on computers, females' achievement scores and attitudes are similar to those of males in computer classes and classes using computers (in primary through higher education levels).

Bridging the Gender Gap

Women pursue education and careers in computer science far less frequently than men do. In 1990, only 13% of PhDs in computer science went to women, and only 7.8% of computer science professors were female Additionally, the percentage of female computer science students decreasing. (Women's Educational Equity Act Programs, 1993). According to the CRA Taulbee Survey, in 1984-85 28.9% women graduated with a Master's degree in Computer Science and in 1996-1997 only 25.8%. This survey also indicated that 36.8% women graduated with a Bachelor's degree in Computer Science in 1984-85 and in 1996-97 only 28.4%. It is not only the concern at women's lack of participation in computer science, the demographics of the country are such that the United States will not have enough engineers and scientists unless underrepresented groups increase their participation.

This study examined the influences against a woman's pursuing a career in a technical field, particularly Computer Science. Such factors include the different way in which boys and girls are raised, the stereotypes of female engineers; subtle biases that female's face, problems resulting from working in predominantly male environments, and sexual biases in language. Finally, this study discusses effective ways to encourage women in the Computer Science field.

The ACM Committee on Women in Computing (ACM-W, 1998) announced that it would take steps to analyze and help reverse a disturbing gender gap problem. Recent studies by American Association of University Women (2000) and NSF (2000) show a dramatic drop in the ratio of women to men involved in computing from high school to graduate school. The ACM-W (1998), conducted a one-year study of the shrinking pipeline for women in computer science. It was financed by a grant by the National Science Foundation (NSF) and found that, "...the problem is rooted in our culture, and must be attacked ...by examining the societal factors that are keeping girls and women from entering the computing field." According to Simons (1998), there are many contributing factors to the gender gap problem, including the lingering, false societal stereotype that girls are "not good" at math; the preponderance of computer games aimed at boys and the many male-oriented on-line discussion groups that are often sexist.

According to Borg (2000) a related problem is that few women hold positions of power in the computer industry, a self-perpetuating situation because of the lack of role models and potential mentors. For example, less than 20% of the members of The World Wide Web Consortium staff, which sets the standard for HTML and other Web protocols, are women.

Mentors And Role Models

According to Borg, 2000, Freeman & Aspray, 1999; and Molina (2000), women need exposure to male and female mentors for encouragement and support. As Gilligan (1982) pointed out that women relate more with people than with machines. Many undergraduates and women in science cite the importance of their male and female role models or mentors in assisting them in their pursuit of a science career. While men have been important advocates, role models, and mentors for women scientists, women students also need exposure to women who are successful in computer science fields. According to Brunner, Bennett, & Honey, 1998, the 'old boy network' which draws promising male students into research projects and mentored relationships with faculty ... tends to exclude women. The authors used both psychological and sociological approach in investigating the problem of underrepresentation of women in science (including computer science). The authors conducted research in two phases. The Spencer Foundation funded the first phase of this research, which included interviews with users of technology and theirs opinions on gender issues. The second phase involved a fantasy study to explore men's and women's feelings about technology. A software program was made; assuming people might be less self-conscious about sharing their fantasies this way rather than with a human interviewer. The software program was designed to invite respondents to spin fantasies directly into the computer focusing on the role of technology in their lives. The results of this research indicated two distinct and highly gendered perspectives on technology: First, women fantasized about small, flexible objects that facilitate sharing ideas and staying in touch. In contrast men's fantasies were about bionic implants that allow their owners to create whole cities with a blink of an eye, or to have the greatest access to history. The implications that result are that women and girls are much more likely to be concerned with how new technologies can fit into the social and environmental surroundings, whereas men are much more likely to be preoccupied with doing things faster and more powerfully.

There are few female role models in computer science that have successfully balanced work and outside interests. Often college women and women in the corporate sector are thinking ahead to their hopes for children and a family, but cannot find many role models who are women and mothers, and who manage to balance the needs of both job and family life (Seymour, 1992).

According to Pearl et al, 1990, women faculty in Computer Science have a positive impact on students and actually influence and increase the retention rates of female students. The author points out that women hold only 6.5% of the faculty positions in Computer Science. A third of the Computer Science departments in the United States have no female faculty at all. The pattern of decreasing representation is generally consistent with that of other scientific and engineering fields (Pearl et al, 1990). The authors of this research project provide a thematic analysis based on review of previous studies, which have focused on the problem of the shrinking pipeline of women in computer science. This research also makes recommendations for increasing the number of women in computer science, which is also largely, based on previous research findings.

Pearl et al (1990) emphasizes the immense importance of female faculty mentors in computer Science. But considering the very small number of female faculty suggests inviting women Computer Scientists from other colleges/universities and even from the corporate sector to give a talk or for a longer period of time in a visiting faculty position. Camp (1997) observed that female students are immensely and positively influenced to see such successful female computer scientists. A positive role model lets the female students visualize a future for themselves in the field and gives a boost to their confidence and self-esteem. However, the author found that successful women Computer Scientists remained invisible to future female computer scientists. Such women were not invited to participate in activities of this type to the same degree as their male counterparts. Findings of this research were based on survey methodology. Surveys were administered to only Ph.D granting computer science departments.

Studies conducted by both Kohlstedt (2004) and Rosser (2002) emphasize the importance of female role models in the male dominated professions. Rosser (2002) describes her own experience of a lack of a networking and developing a mentor and collaborative type of relationship in the male dominated fields. Both of these author urge advocacy and promotion to celebrate women in science and engineering as a major tool to highlight and sustain the continuing trickle of women in male dominated fields. According to Thom (2001) many women abandon their plans to major in science during their first year of college because they experience science and engineering as 'male' field. Mentorship plays a key role in success as evidenced by the perseverance of women in the sciences mostly at women's colleges and of African Americans at historically black colleges and universities.

Influence Of School/Counseling/Teachers

Leveson's (1989), work found indirect ways that teachers guide students in a particular direction - such as when they spend more time with boys in math class and more with girls in reading classes. He also found that as time comes to choose higher-level classes, girls are often not given information about, or are steered away from, courses in the fields of science. Findings of this research were based on previous studies and interviews were conducted to both teachers and students at the high school level (Leveson, 1989). Numerous studies (NSF 2000; Woolfolk 1995; Lytton & Romney, 1991) found that girls are frequently tracked into low-ability math and science classes, even when girls have similar scores to boys who were assigned to the high-ability groups

When girls do succeed in high-level math and science courses, they are often still not encouraged to pursue scientific careers. In one study of high school students who had taken physics and calculus, 64% of the boys were planning to major in science and engineering, while only 18.6% of the girls had similar goals. Findings of this research were based on previous research conducted on the ratio of male and female attrition rate in science (Gilester, 1997).

Based upon participant observation, open-ended interviews, student-journals, and recorded class sessions, the Task Force on Women, (1988), found that it is the aspects of classroom activities (teaching styles, lack of interactive learning) negatively affect girls. For the most part, the choice of classroom activities appears to be slanted toward those that appeal to boys' interests. Even though considerable research has shown that girls work better when they work cooperatively on projects, competition and presentation formats that appeal to boys are still standard teaching applications. In addition, the Task Force found that girls participate in extracurricular science activities less frequently than boys do.

Horning (1984) examined the gender bias toward women in science has been illustrated in the content of textbooks. Men are pictured more often than women, and shown in more active roles. The accomplishments and contributions of women are usually omitted or mentioned only in a token manner. Webster (1994) agrees with the male dominance in science textbooks finding that most science textbooks reveal at least a subtle sexism. This research emphasizes the view that textbooks used in schools at all academic levels frequently reinforce the notion that science is a man's world. What is portrayed in the textbooks is then personified in the classroom - nearly all advanced science, including computer science and mathematics courses are taught by men. Both of these studies (Horning 1984; Webster 1994) used content analysis and previous research findings to reach their conclusions.

Pearl et al. (1990) quote a study known as the Illinois Valedictorian Project that followed 46 women and 34 men who had graduated at the top of their 1981 high school classes. At that time, students of both genders described their intelligence in a more or less equal manner: more than 40% of the men and women described their intelligence as "Above Average," and more than 20% of both genders said their intelligence was "Far Above Average." After four years of college, students of both sexes had continued their high academic performance. The women in the study had achieved a 3.6 Grade Point Average, and the men, a 3.5. Yet when asked to describe their level of intelligence at that point, 25% of the men perceived themselves as "Far Above Average," while 0% of the women did, even though their GPA was higher than the men's. Although the women had performed academically better than the men during those four years, the men's self-esteem increased in college while the women's decreased.

According to Pallas & Alexander, 1983, girls and boys begin elementary school with fairly equal abilities; girls actually demonstrate an advantage in language skills. In their middle school years, girls show a drop in math confidence and achievement. Tapscott (1998), described the girls' decline in confidence preceded their lowered achievement. By the end of high school, boys have progressed ahead of girls in higher level mathematics, biology, general science and physics, even though the girls have a higher overall academic achievement. Open--ended interviews and a survey of high school faculty and students were used by this study to reach its conclusions. A survey confirmed that even gifted and talented adolescent girls exhibit less confidence about their mathematical skills, which makes them less likely to take college-preparatory math and to follow through with college majors and careers in fields that require mathematics.

When faced with failure, male students tend to attribute their lack of ability to external forces, while women tend to blame themselves. The author points out that thirteen is the age at which girls' interest in higher education and non-traditional careers peaks. Men's esteem and ambitions continue to rise throughout their schooling, while girls' steadily decline. Wyman (1999) conducted a study at a Catholic girls' high school, which concludes that high school girls relate to typical low-wage jobs. Wyman sought to study the learning patterns of girls by using Modeling Instruction technique in his summer Physics class. Girls were given the task of developing at least one physics problem relating to their own interest. These questions were then typed without student names and passed back as a set of questions to all students. The students rated each question on a scale from one to five. Analysis of the questions and their relative rankings indicated that girls particularly liked questions directly related to their daily lives: weight of their book bags, being out of uniform, parking problems, faculty and friends.

The Support of Parents

The attitude of parents, and even the games they buy for their children, all have an influence on whether a son or a daughter becomes interested in science. Research shows (MIT 1993; Woolfolk 1995) that girls receive more dolls than any other toys and boys receive more toys related to math and science, thereby encouraging them into those fields.

A study conducted by National Science Foundation in 1988, based on observations and interviews as its methodology, noted that even educational games tend to be more male-oriented, like baseball math. Even when playing, males are often directed to activities involving spatial visualization, applicable to science, math and computer science. As a result, boys may come to class with more familiarity and experience with the subject matter. Another study by Sproull, Kiesler & Zubrow (1984), found that parents make more of an investment in their sons' college education, regardless of their abilities and achievements, than they invest in their daughters'. More women attend college than ever before, but everything from the G.I. Bill to expectations that a career in science will conflict with a woman's family life can discourage a female from a career in science.

Phases of Transformation at the Curriculum Level

Transformation at the curriculum level has to be done to encourage women. According to Freeman and Aspray (1999), it is because of the lack of equipment in high schools that women do not gain early experience with technology. Having more female representation will certainly change the way technology will be used in higher education. The use of technology will then be made more equitable. Based on the findings of research literature, the current use of technology is not based on equity. The most powerful use of technology is when it is challenging and equitable by encouraging both male and female students to be the power users of technology on equal footing (AAUW, 2000). According to Sharon Schuster (2000), the President of the AAUW Educational Foundation, it is of utmost importance to achieve equity in the use of technology. Instead of trying to make girls fit into the existing computer culture, the computer culture must become more inviting for the girls. The same reasoning applies to computer games.

Computer games don't have to be the virtual equivalent of GI Joes and Barbies. We have to think less about 'boys' games and 'girls'games and more about games that challenge our children's minds. The National Science Foundation (1998) funded a number of promising initiatives to increase the female representation in the sciences including computer science. These initiatives include making Computing, Algebra I and Geometry – the gatekeeper classes for college admissions.

According to Teo and Lim (2000), gender equity cannot be measured by how many girls send e-mail, use the Internet, or make PowerPoint presentations. Rather, gender equity means using technology proactively, being able to interpret the information that technology makes available, understanding the design concepts and being a lifelong learner of technology. These abilities should apply across the whole range of subjects and careers, not just computer science. This research reported that males and females view computers differently and that men have more interest and more positive attitude towards computers than women do. Data was collected through interviews and electronic survey. Respondents of the electronic survey were reported to be 89% male and 11% female. The unique contribution of this research to scholarly literature is that males and females perceive computers differently. Males are more comfortable with using computers because they have had more exposure to them in school, at home, with friends – a different social conditioning. Men who responded to the survey were more educated than the female respondents. This research does not mention the education major of the respondents. The study also concludes that in the future women are more likely to use real time audio or video than men.

Mayer-Smith, Pedretti, and Woodrow (2000) conducted a study on increasing the female representation in computer science. This study placed its focus on achieving equity as a result of increasing female representation in computer science. The authors emphasized that equity in computer access, knowledge, and use across all races, sexes, and classes cannot be solely measured by how many people use e-mail, surf the Net, or perform basic functions on the computer. The benchmark for gender equity should emphasize computer fluency: girls' mastery of analytical skills, computer concepts, and their ability to imagine innovative uses for technology across a range of problems and subjects. Empirical evidence was collected by using the methodology of classroom observations, student interviews and questionnaires, classroom achievement records, and journal entries. Findings from this research illustrate that sound pedagogical practices and social organization in technology enhanced secondary science classrooms can promote gender inclusive experience, where women and men participate and perform equally well. Methodologically, the study also illustrates how consideration of the complexity of classroom environments contributes to rich contextual understanding of the interplay of technology, teaching, and learning.

The AAUW (2000) report emphasizes that the increase in female representation in Computer Science will have its benefit even in the corporate sector where girls are an untapped source of talent to lead the high-tech economy and culture. Curriculum developers, teachers, technology experts, and schools need to cultivate girls' interest by infusing technology concepts and uses into subject areas ranging from music to history to the sciences in order to interest a broader array of learners.

McDonough (1999) encourages educators and parents to help girls imagine themselves early in life as designers and producers of new technology. The author of this study advises that girls should be engaged in 'tinkering' activities that can stimulate deeper interest in technology; provide opportunities for girls to express their technological imaginations. The author points out that equity in technology can be achieved only by granting a fair share of it to girls. The author used ethnographic research using field observations and interviews. Description is provided of the designer's actions affecting identity performance within graphical virtual environments and the manner in which those decisions interact with larger social contexts of dominance based on race, class, and gender. The author makes explicit the social consequences of designer's decisions, in order to further the dialogue between social scientists and technologists, and make suggestions regarding how designers may approach the construction of virtual environments without unwittingly contributing to patterns of dominance in society. Turkle (2000) culminated a two-year study analyzing previous research and emphasizes that girls should be educated to be the designers, not just consumers of technology. The author feels the strong need for getting women involved in making and shaping computer culture. This research uses survey responses, and focus groups of middle and high school students.

Borg (2000) conducted a study to understand why women are underrepresented in Computer Science. The author is convinced that 'equity' will be the hallmark of technology used in higher education, once there is an increase in the female representation in the field. The only way of achieving this goal is to change the negative stereotypes and assure that girls can have access to and experience with computers. Borg insists that if women's genius and brilliance are encouraged and used, if women are full partners in creating the future, then there is a possibility that the technology of the future can have a positive impact for all of us. The mission of this research was to increase the impact of women and technology in education and to increase the positive impact of technology on the world's women. These two goals are two sides of the same coin. Borg is guided by the belief that by tying them together we may be able to interest a much broader range of women to participate in the creation equitable instruction of technology in higher education. This research conducted workshops and brought together technology experts, business people, potential users, community members, students and social scientists. These workshops invited women and set up a forum for thinking and discussion of what it was that kept them away from computer science. The workshops helped to generate ideas grounded in the social, political, economic, and personal contexts of the participants. Short surveys were distributed in the workshops, which explored both the technical, and social science issues related to women and technology. Status hierarchies were avoided by deferring introductions until late in the workshop.

Phases Of Transformation At The Institutional Level

Mandated by law under the Science and Technology Equal Opportunities Act (1980), the National Science Foundation was charged to collect and analyze data and report to Congress on a biennial basis on the status of women in the science and engineering professions. The National Science Foundation supports programs for women to bring them into the scientific mainstream. One such program, the *Transformation of Science and Math Teaching to Reach Women (1993),* was conducted to design, implement, and evaluate a teaching model for helping teachers to better reach women in the classroom and retain them in science and technological careers. Of primary importance was increasing the understanding of faculty participants regarding women and science. Three plenary conferences formed the backbone of the project. Male and female faculty interacted with each other and the conference facilitators during these sessions. In the first conference, concepts were introduced to the participants about climate issues for women in the classroom, including pedagogical methods and curricular content that provide more female friendly courses in science and math. Participants then evaluated their teaching strategies in light of these concepts and considered how to improve their teaching strategies. Other factors that influence female recruitment and retention in science and technology were also discussed – family, role models, and guidance counselors. The objective of this conference was to reach women where they are most likely to be found and then retain them so they may be recruited to graduate research programs and finally make an addition to the Computer Science workforce (National Science Foundation, 1993).

To encourage women students to pursue careers in science and technology the National Science Foundation initiated another program to provide female role models. The National Science Foundation (1994) initiated the NSF Visiting Professorships (VPF) for women to address the problem of there not being enough female role models. In a similar vein, in 1992 the NSF established faculty awards for women scientists and engineers (FAW). This program attempted to recognize outstanding female faculty in institutions of higher education and enable them to advance to senior positions (tenured, full professor). This program was also initiated to encourage female recruitment and retention in science and technology.

The Other Side Of The Story – The Decreasing Gender Gap

Walker & Rodger (1996) conducted an evaluation of the PipeLINK program, which seeks to attract and retain women in computer science careers. Aimed at girls and women from high school through Ph.D. levels, the PipeLINK program suggests activities to aid participants at each level, connect students with role models and mentors, and provides an introduction to a wide variety of computer science topics. The authors conducted an evaluation of the program through questionnaires, which indicated that the participants are becoming visible female role models for future computer scientists. Also, for the high school participants, the responses to the questionnaires clearly indicated that the females were mentoring each other and electronic networking mentoring via email and the internet was most popular with this group. Based on questionnaire evaluations, this study indicates that the gender gap in science will decrease.

O'Sullivan (1995) conducted a study to analyze the problem of gender gap in science and technology (including computer science) and found that women were underrepresented in this area because they lacked self-confidence. It was found that even women who were interested in taking up careers in science and technology backed out to pursue something else primarily because they felt it was a male domain and lacked the confidence to work with men. However, research findings indicate that positive reinforcement in the form of role models and mentoring can lead to the female reentry in the Computer Science field. Data was collected from interviews and conferences with subjects.

Teo and Lim (2000) conducted a two-phase study to study the problem of gender gap in computer science. The first phase of the study using interviews and an electronic survey confirms the existence of a gender gap. The second phase of the study used Chi square tests along with the same methods of data collection as in the first phase and found that the gender gap may actually decrease. It was found that males and females may perceive and use the internet differently but the gender gap may decrease due to the introduction of formal technology training classes for females, which instills positive attitudes and self-confidence. This research concluded that in the future women are more likely to use real-time audio or video than men.

Webster (1995), studying the dynamics of the gender- technology relationship put forward an optimistic viewpoint that females would not be always underrepresented in technology. The author emphasizes that this gender gap is not static and the male domination and female subordination are always shifting over time and across cultures. The author has based this study on previous research and attributes the gender gap to stereotyping of social and cultural factors. The author uses the term 'gender-blindedness' to convey the lower number of women in science and technology. Analyzing the statistical data from previous studies the author actually finds the gender gap decreasing.

Clegg and Trayhurn (1999) study not only confirms that gender gap really exists in science and technology but also that this gap is may slowly decrease. The authors conducted a case study and taped interviews of undergraduate male and female students to examine why the number of women is so few in science and technology classes and why there are so few women in technology related jobs. The authors found that women are making more positive choices and developing a rigorous critique of the present state of computer education. It was found that women were becoming more assertive and confident in science/technology classrooms and workplaces. The authors also found that women were confident of their abilities and brought with them valuable administrative experience of using computer systems. The authors point out that one of the challenges is to conceptualize women's computer skills as real computing and to ask what is wrong with computing rather than what is wrong with women.

Summary of Research Literature Findings

Research literature indicated that women are indeed, underrepresented in Computer Science. Statistical evidence also proves the problem of underrepresentation of women in this field. Research literature pointed out the importance of the three factors (parents, teachers, and role models/mentors) in either taking women towards or away from computer Science. A small body of literature suggested that there is a possibility of the gender gap slowly decreasing.

Conclusions

In conclusion, the review of literature demonstrated that there existed a gender gap in the field of science and technology. The detailed quantitative and qualitative data analysis undertaken by numerous research studies suggested that there is some mechanism at work which continues to reassert dualistic gender categories and identities in gender-technology relations, despite what would otherwise be very convincing evidence of the potential for their demise. Research literature confirmed that it is predominately the social and cultural stereotyping that has led to the gender gap. Research and academic institutions (MIT, Stanford University, NSF, Brown University, The Spencer Foundation, AAUW, and ACM-W, UNITED STATES Department of Education, United States Labor Department, The National Science Foundation) are researching these problems to find ways to decrease and end this gap. The review of literature also confirmed that this gender gap is on the decrease. The results of the current study contribute to the existing research literature in confirming that the three factors (parents, teachers, and role models) have a significant impact on the entry and retention of women in computer science. The review of literature presented in this section provides a framework for the study's methodology, which is described in the next chapter.

CHAPTER 3

METHODOLOGY

Introduction

Based on the theoretical and empirical information presented in the previous chapter, a description of the methodology used in this study has been provided in this chapter that was used to answer the study's research questions with regard to the problem of underrepresentation of women in computer science. A review of research literature indicated that the following three factors play a significant role in recruiting and retaining women in the field computer science:

1. Parents
2. Teachers
3. Mentors/Role models

The intent of this study was to investigate the following research questions:

1. The degree to which there are the opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, and role models/mentors) impact women in taking up these opportunities?
2. The impact of the three factors (parents, teachers, and role models/mentors) on retaining and increasing the number of women in the Computer Science workforce?

This descriptive, cross-sectional study used quantitative and qualitative approaches for data collection and analysis. Survey research was used to collect data. The survey instrument consisted of a self-report questionnaire consisting of quantitative and qualitative components. Following the deductive approach as described by Newman (1997), the study began with a theoretical or applied research problem and ended with an empirical measurement and data analysis.

Research Design

As mentioned previously, this study utilized quantitative, qualitative and descriptive methods to answer the research questions of the study. The study was quantitative as the self-report survey collected information about demographic and used a likert scale to measure respondents reactions to the survey items. Survey was the preferred data collection procedure for the study with such advantages as the economy of the design, the rapid turn-around in data collection, and the ability to identify attributes of the sample population based on respondents own input (Creswell, 1994). This study was cross-sectional since the survey information was collected at one point in time. This study was descriptive as it presented a picture of specific details of the situation – under representation of women in computer science in relation to social setting, or relationship (three factors identified by research: parents, mentors/ role models, and teachers). The study fulfilled the following goals:

•Gave a verbal and numeral picture of the impact of the three factors on women in computer science

•Found information to stimulate new explanations (Newman, 1997).

This study included qualitative, open-ended questions in addition to the closed-ended quantitative questions in the survey instrument from which additional data was collected with regard to respondents experiences related to the three factors. The open-ended questions permitted an unlimited number of personal opinion responses from the respondents which proved to be very useful for the purpose of this study. The survey responses in these items provided the researcher with information about the first hand experiences of the respondents and the ways in which the three factors (parents, teachers, and role models/mentors) indeed had a significant impact on the entry and persistence of women in computer science. Open-ended questions permitted creativity, self-expression, richness of detail and permit adequate answers to complex issues (Newman, 1997). The intent of including a combination of closed and open questions on the survey instrument of the current study was to provide data to strengthen the dissertation findings by contributing to a broad database of knowledge.

Instrument

The survey instrument for the current study was based on:

- Knowledge about women in the Computer Science profession and an understanding of survey design based on the research literature.
- This survey was constructed and used by the researcher as there was no relevant preexisting survey that could suitably answer this study's research questions.

It is difficult to use and apply a general survey for new purposes to answer specific research questions. The survey used was based on the evaluation of preexisting surveys dealing with similar thematic issues as were being addressed by the present study. The following preexisting surveys were evaluated for similar essential survey conditions:

- Dr. Tracy Camp's survey for the Incredible Shrinking Pipeline. Communications of the ACM, 1997.
- Dr. Allen Fisher & Dr. Jane Margolis's survey on First Year Computer Science Students in Carnegie Mellon and University of California, Los Angeles, 2000.
- Dr. Thompson Teo's survey on Internet Users in Singapore, 2000.
- Prof. Sander's survey on Student Attitudes to Computer Science, 2000.
- AAUWU survey on Techsaavy: Educating Girls in the New Computer Age, 2000.

After carefully evaluating the above mentioned preexisting surveys, it was found that the format used was successful in obtaining the results for their administrators. All of these surveys mentioned did not use any negative language and began with general demographic questions. The questions in all of these surveys tended to become more specific after the general questions. Another common pattern used in these surveys was that when a general question was accompanied by a related specific question, the general question was asked first. None of the preexisting surveys contained any leading questions. All of these surveys ended with a note of gratitude from the author of the survey.

The format for the survey used in the present study followed the format used in the above mentioned surveys. The self-constructed survey for the present study followed all of the above mentioned format guidelines in the preexisting surveys as specified. As per the format used by the preexisting surveys, the self-constructed survey was made attractive by using different word processing fonts. The survey questions were organized in a logical sequence, which included brief and clear instructions for the respondents.

Gall, Borg and Gall (1996), pointed out that researchers tend to apply looser validity and reliability standards to questionnaires than tests because the researchers typically are collecting information that is highly structured and is likely to be valid. Also, the researchers are interested in the average response of the total group rather than the response of a single individual. A lower level of item reliability is acceptable when the data are to be analyzed and reported at the group level than at the level of the individual respondents. The survey instrument included a structured questionnaire (self-administered) in an attempt to answer the research questions of this study mentioned previously.

The survey questionnaire was limited to five pages of questions, with a response burden of 25 minutes per respondent. Long questionnaires are more cost effective, although the research literature indicated there is no absolute proper length for surveys. Responses drop significantly for longer questionnaires (Newman, 1997, Gall, Borg, and Gall, 1996). Following the pattern of the preexisting surveys the questionnaire for the present study included a combination of open (unstructured, free response) and close-ended (structured, fixed response) questions. Evidence on the relative merits of closed and open questions, suggested that a combination of the two formats offers a change of pace and reduces the disadvantages of any one question form (Bradburn, 1982; Yin, 1994; Newman, 1994; Gall, Borg, and Gall, 1996; Merriam, 1998).

The advantage of researcher administered questionnaires are that they are relatively inexpensive and can be conducted by a single researcher covering a wide geographical area. They are very effective and response rates may be high for a target population that is well educated or has a strong interest in the topic. Response rates for self-administrated questionnaires may be close to 100 percent (Newman, 1997, Martella, Nelson, & Martella, 1999). However, a researcher cannot control the conditions under which a mail questionnaire is completed. Different respondents can complete the questionnaire weeks apart or answer questions in a different order than that intended by researchers. Incomplete questionnaires can be a serious problem (Gall, Borg, and Gall, 1996; Newman, 1997).

After data collection was completed from the self-administered survey, the same survey instrument was posted on the World Wide Web to collect additional data. The survey was posted on the following listservs:

1. femptheoryqueer-aoir.org@listserv.aoir.org (www.aoir.org)
2. wcs@cs.usask.ca (www.cs.usask.ca)
3. ITempowermentlistserv.uic.edu
4. http://www.nsta.org/main/forum/showthread.php?p=1993#post1993
5. WebGuru@dslextreme.com

This was done to ensure that the self-constructed survey met with appropriate validity and reliability standards of data collection. According to Dillman (2000), web based surveys are the most significant advance in survey technology in the twentieth century. Dillman explained the advantages of web-based surveys as being cost efficient, reduced implementation time, easy transfer of collected data for importing into data analysis and access to a large sample population. Web based surveys also have their limitations since they have a high coverage error, which leads to a mismatch between the target population and the sampling frame (Newman, 2003). As many people still lack Internet access and among those with access, it is not possible to include and locate everyone and respondents are not equally computer literate (Dillman, 2000; Newman, 2003). According to Dillman (2000) the most crucial limitation of web-based surveys is the decision not to respond because everyone is one does not have the skill to respond the the instrument. Never the less, this study used web based survey as an instrument of data collection, in addition to the researcher administered paper survey not only for ensuring validity and reliability of data collection but also to open this research to a larger population. This study aimed to collect rich and unbiased data to answer its research questions.

Questionnaire Format

The preexisting surveys evaluated for this study confirmed that questionnaire format and layout was very important in receiving accurate reader response. Research studies also confirm that questionnaires that are neat, clear and easy to follow receive a higher response rate (Newman, 1997, Gall, Borg, & Gall, 1996). This questionnaire has been designed following those criteria as confirmed from the evaluation of the preexisting surveys and from the findings of the research literature. Respondents were provided instructions on the questionnaire in clear, jargon free language. Instructions were printed in a different style from the questions (different font-in bold letters) to distinguish them for easy reader responses. The questionnaire for this study consisted of four types of question formats:

1. Demographic questions

2. Likert type statements
3. Ranking statements
4. Open-ended questions

The questionnaire mainly consisted of Likert type statements (which typically asked for the extent of agreement with an attitude item) to assess the factors responsible for female interest, entry and retention in computer science. An option of 'uncertain' as one of the response alternatives was added as a method of dealing with respondents' possible lack of familiarity with the topic of a specific question. Allen, 1996, Gall, Borg, and Gall, 1996, and Newman, 1997, point out the advantage of using such an option for individuals with little or no information who might choose another response just to hide their ignorance, or because they feel social pressure to express a particular opinion.

Population

The sample population chosen for the researcher administered paper survey was female Computer Science professionals from the corporate sector of the Washington Metro area which was expanded to outside the region with the web-based instrument. The Washington Metro area is the fastest growing technology corridor of USA and the population involved is in the technology field. After establishing the strata of population, the sample was selected randomly to include female computer science professionals whether they had an earned degree in Computer Science or not. Stratified sampling produces samples that are more representative of the population (Gall, Borg, and Gall, 1996, Newman, 1997). The sampling frame for the companies selected was stratified by the kind of business they did, which for this study was Computer Science/IT (Information

Technology). Two organizations were chosen to include the sample population for this study. In each selected organization, a representative (point of contact) was identified to serve as the survey coordinator. A total of 40 questionnaires were administered to the sample population.

A total of 53 respondents accessed the web survey of which only t 32 respondents completed the survey in its entirety.

Data Analysis

Data analysis for the self – administered survey and for the web- based survey was conducted in the same manner. Data analysis was conducted on demographic questions by using frequency distributions Distributions – bar charts, histograms for age, ethnicity, highest degree earned, the number of science courses taken by the respondents in high school and college. Frequency distribution was also used to analyze and display the data collected on the parents' education and profession. For the Likert- type statements, a test of significance called Chi-square (χ^2) test was used to determine if all three factors (parents, teachers and role models/mentors) had equal impact on the entry and persistence of women in Computer Science. Chi-square (χ^2), a non-parametric test of statistical significance is used when the research data are in the form of frequency counts for two or more categories (Gall, Borg & Gall, 1996; Martella, Nelson, & Martella, 1999). The Chi-square test was conducted using the Excel spreadsheet.

For the rank order statements (questions 33 & 34), the respondents were asked to rank the three factors (parents, role models/mentors, and teachers) from the most important to the least important in its impact on the entry and persistence of women in computer science. Percentages were calculated from the survey responses to find which of the three factors (parents, role models/mentors, and teachers) ranked the highest. For the open-ended questions, content analysis was done to look for themes or concepts in the natural languages of the responses.

Internal Consistency

The reliability of the responses to the self – administered questionnaire were evaluated by using Cronbach's alpha (α), a parametric test. Of the several methods available to determine the internal consistency, Cronbach's method was chosen because it can be used when items on a measure are not scored dichotomously. Cronbach's alpha is one of the most widely used method for computing test score reliability (Gall, Borg & Gall, 1996). Gall. Borg & Gall (1996), describe the Cronbach's alpha as a measure of the internal consistency of a test, based on the extent to which test-takers who answer a test item one way respond to the other items in the same way. The reliability of the responses to the web based survey were evaluated by conducting the Pearson Correaltional test. The correlation matrix was conducted using the SPSS system. Correlation/alpha coefficient was calculated for each of the three factors (parents, role models/mentors, and teachers).

Null Hypothesis

Martella, Nelson & Martella (1999) defined null hypothesis as statement of valueless statistically significant relationships between variables being studied or differences between the values of a population parameter. According to Gall, Borg, and Gall (1996), researchers rarely want to confirm the null hypothesis, because studies are usually conducted to find differences, relationships, or effects. Gall, Borg, and Gall, 1996; Martella, Nelson & Martell, 1999, recommend the use of tests of statistical significance, to maximize the likelihood of rejecting the null hypothesis.

The null hypothesis for this study stated that if all of the three factors (parents, teachers, and mentors/role models) have equal influence, the mean ranks should be the same (at 0.05 level of significance).

Ho: Parents = Teachers = Mentors/Role Models

The Chi-square (χ^2) test of significance was used to test the null hypothesis of the current study (to investigate if all three factors (parents, teachers, role models/mentors) had equal influence on taking women towards or away from computer science. Chi-square (χ^2) test provides hypothesis tests where there are categories instead of numbers.

Role of the Researcher

The researcher attempted to provide general and specific information on the problem of underrepresentation of women in computer science and the impact of the three factors (parents, teachers, role models/mentors) on the entry and persistence of women in Computer Science. The researcher made an attempt to answer the study's research questions based on the findings of this study. Based on the theoretical and empirical information found during the course of this study, the researcher has provided information about the possible changes and interventions that may address the problem of underrepresentation of women in computer science.

The researcher strictly followed ethical issues. The researcher purposefully selected the informants and research documents, which were best to answer the research questions of the study. The researcher obtained permission from the Institutional Review Board for the protection of human rights. The researcher coded the survey instrument to preserve the anonymity of the respondents and that of their organizations. The researcher will in the future continue to maintain confidentiality of the data, preserve anonymity of informants.

Conclusions

This chapter outlines the complete design of the procedure that was used for this study. Approaches to the scope of this study, data collection and data analysis have been explained. The anticipated outcome of the study was fulfilled which was to determine the impact of the three factors (parents, teachers, and role models/mentors) on the entry and persistence of women in Computer Science. The study also successfully investigated the extent to which there are opportunities available for women in Computer Science and the extent of impact of the three factors (parents, teachers, and role models/mentors) on women taking up these opportunities.

CHAPTER 4

PRESENTATION OF RESULTS

Introduction

The purpose of this study was to explore and describe the impact of the three factors (parents, teachers, role models/mentors) on women in Computer Science and also the perceived impact of these three factors on the entry and persistence of women in the computer science workforce. The goal of this study was to gain insight into this problem of inequity and to suggest possible ways to lessen and to hopefully eliminate it over a period of time. To obtain meaningful information about the impact of parents, teachers and role model/mentors on women, a sample population of female Computer Science professionals was chosen from the corporate sector of the Washington Metro area as well as a self-selected sample of women who were members or participants in computer science organizations for women, collected via a web-based survey.

The results of this study have been generated from a self-constructed survey questionnaire which was administered in two different ways. The same survey questionnaire was distributed as a self-administered survey questionnaire and was also posted on the web. For the self administered questionnaire a total of 40 survey questionnaires were distributed to members of randomly selected female respondents from the chosen strata of sample population (Computer Science/Information

Technology organization in the Washington metro area). The self administered survey received a hundred percent response rate. The web posted survey was accessed by a total of 53 respondents out of which only about 32 respondents filled out the survey completely.

Research Questions of the Study

Both of the following research questions of the study were successfully answered by the survey responses generated by the self-administered and the web based survey:

1. To what degree are opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, role models/mentors) impact women in taking up these opportunities?

2. To what extent are the three factors (parents, teachers, role models/mentors) responsible for retaining and increasing the number of women in the Computer Science workforce?

The survey responses were consistent with the research literature in pointing out that there were opportunities available for women in computer science. Women choose not to take up these opportunities because computer science is regarded as a male profession. Women often do not get guidance and support from their parents, and teachers, and the lack of role models/mentors makes it hard for girls to enter or persist in this profession. Survey responses show that encouragement and guidance from parents, teachers and role models plays a monumental role in the entry and persistence of women in Computer Science.

This chapter has been designed to present results obtained from the two different methods of data collection: the self- administered survey and the web based survey. Administration and results from both methods will be presented in two separate sections (Section I and II) in this chapter.

SELF ADMINISTERED SURVEY

Profile of the Computer Science Firms

For the self-administered survey, the population sample was randomly chosen from the f Computer Science/Information Technology firms in the Washington metropolitan area. These firms had the following characteristics:

1. Hard-core Computer Science/Information Technology oriented companies.
2. Had programs for encouraging women to persist in the Computer Science/Information technology profession. These firms not only encouraged women to enter the profession, but also had initiatives for their retention.

The Computer Science/Information Technology (IT) firms chosen for the purpose of this study dealt with most aspects of this field including from programming, research, designing computer systems and IT related consulting. These firms were uniquely suitable for the current study because they were Computer Science/Information Technology firms and they had programs for encouraging and retaining women in this profession. These firms encouraged women in the profession by offering them free tuition for upgrading their skills or for getting a higher degree. Flexible work schedules were also included. Working from home was allowed, with each employee having been provided with a laptop and a pager. New mothers were encouraged to stay in the profession by giving them paid maternity leave according to legal guidelines and extended maternity leave for an additional time period (based on medical recommendation) on partial salary. New mothers were given the opportunity to ease back into work by having them work part time at first if they so desired. Women in these firms were promoted to supervisory positions who were providing role model/mentor activities by having one- on-one sessions with other women in the organization.

Administration of the Survey Questionnaire

The self - administrated survey questionnaire was administered to 40 female respondents from a randomly chosen sample population from these Computer Science/Information Technology firms in the Washington metro area. The survey questionnaire was coded with a separate code for each organization that it was administered to. The survey questionnaire was limited to five pages of open and close-ended questions, with a response burden of 25 minutes per respondent. The survey received a hundred percent response rate. The reason for a hundred percent response level was that it was self-administered. A point of contact was chosen at each of these firms who was given the survey to be administered. The respondents were given the option of either completing the survey on-line (via email) or on hard copy. Twenty-one surveys were completed via email and nineteen were completed on hard copies. The email were sent to the survey respondents by the point of contact and were returned to the point of contact. The emails and hard copies were then given to the researcher. The emails were returned to the researcher as an attachment so as to preserve the anonymity of the respondents. According to Newman 1997; Martella, Nelson, & Martella, 1999, self-administered surveys are very effective and response rates may be high for a target population that is well educated or has a strong interest in the topic. Response rates for self-administrated questionnaires are close to 100 percent (Newman, 1997, Martella, Nelson, & Martella, 1999).

The reasons for a hundred percent response rate on the study's survey is because the completed survey was returned to the point of contact on the same day that it was administered. Also, all subjects who were presented with it completed the survey. The problem of non-response and refusal to answer a survey was thereby eliminated. The respondents' reactions could change if they took the surveys home and discussed them with others. They may have chosen not to answer the survey. As Gall, Borg, and Gall, 1996; Newman, 1997 pointed out that a researcher cannot control the conditions under which a mail questionnaire is completed. Different respondents can complete the questionnaire weeks apart or answer questions in a different order than that intended by researchers which can seriously impede the results.

Data Analysis

The survey instrument was designed to make the participants comfortable following a funnel sequence (general questions before specific ones). The survey began with general demographic questions in the beginning, followed by specific queries to address the research questions of this study:

1. To what degree are opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, role models/mentors) impact women in taking up these opportunities?

2. To what extent are the three factors (parents, teachers, role models/mentors) responsible for retaining and increasing the number of women in the Computer Science workforce?

This chapter will be divided into sections following the sequence of questions on the survey instrument.

Demographic Information

The following demographic information was asked for on the survey instrument:

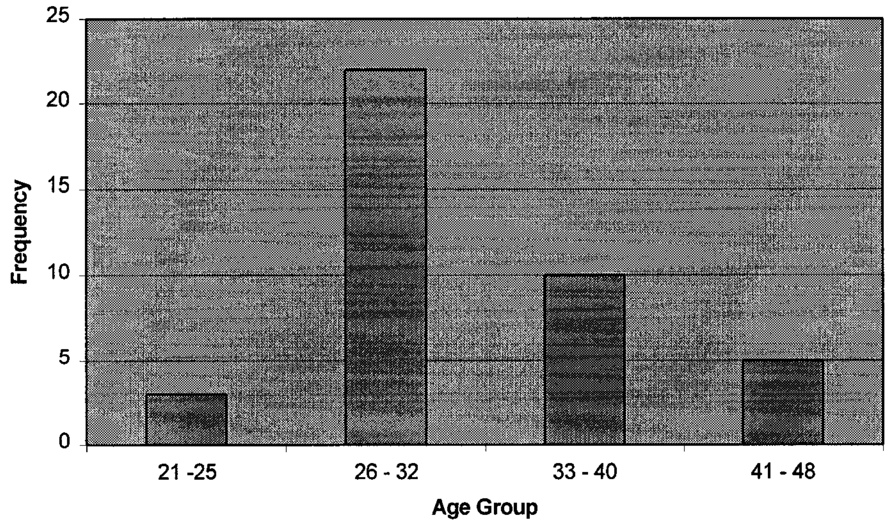
1. Age
2. Ethnic background
3. Occupation
4. Highest degree earned
5. Undergraduate institution attended
6. Highest degree earned by parents
7. Science degrees earned by family (parents & siblings)
8. Science courses taken by survey respondents in high school
9. Science courses taken by survey respondents in college

All demographic data has been analyzed using frequency distribution and has been displayed diagrammatically (histograms).

Age

All of the participants were between the ages of 21-48 with a major concentration between the ages of 26-32 (55%). The average was 32.4 years. The following chart shows the age distributions of the participants:

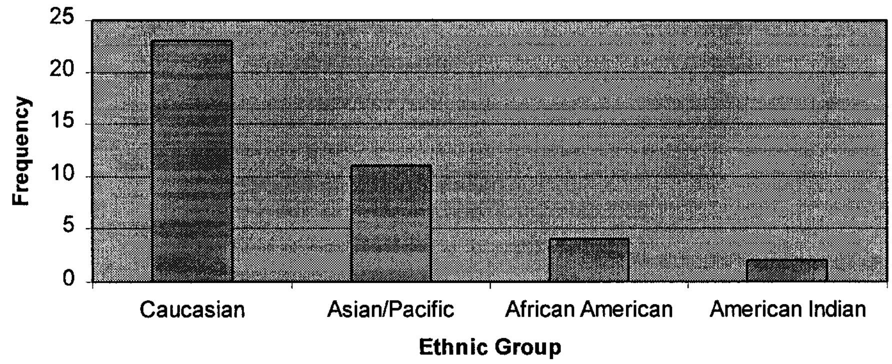
Figure 1. Age



Ethnic Information

Most of the survey respondents were Caucasian (58%). The survey instrument was administered to female Computer Science professionals, irrespective of their ethnicity.The following chart (figure 2)_shows the ethnic distribution of the sample population.

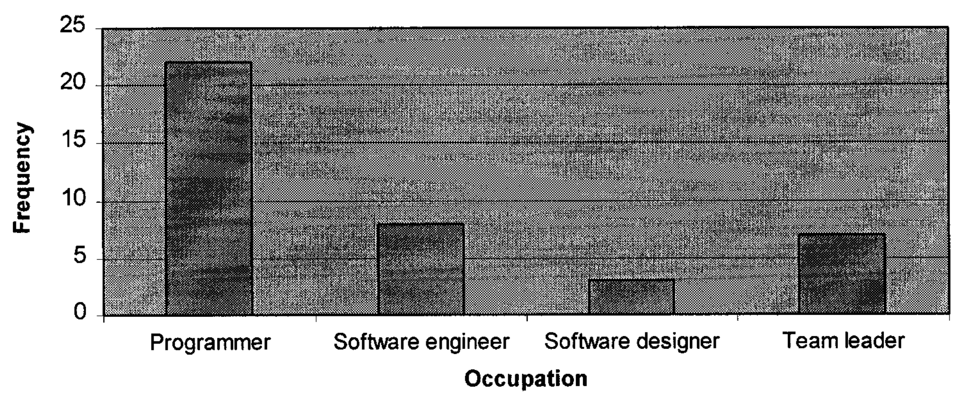
Figure 2. Ethnicity



Occupation

All of the respondents were Computer Science professionals. Most of the respondents were programmers (55%) and 18% were supervisory (team leaders). The following chart shows the occupational distribution of the sample.

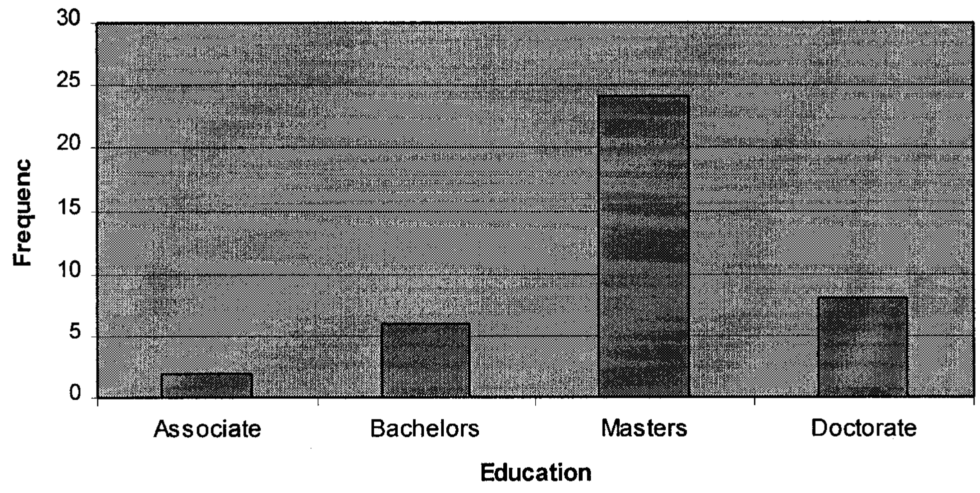
Figure 3. Occupation



Highest Degree Earned

The survey respondents had an earned Associate, Bachelor's, Master's and Doctoral degrees. A major concentration (60%) of the survey respondents had earned Master's degree. The distribution is shown in the following chart.

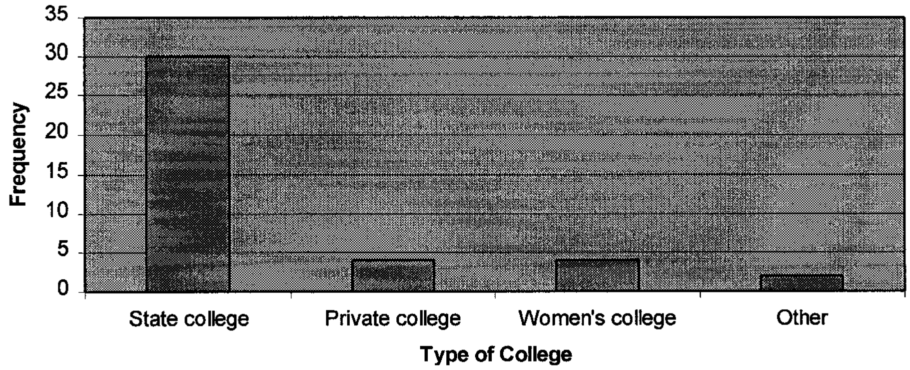
Figure 4. Highest degree earned



Undergraduate Institution Attended

Most of the survey respondents (75%) attended state universities. Only 10% attended women's college and 10% attended private college. The following chart (figure 5), shows the distribution.

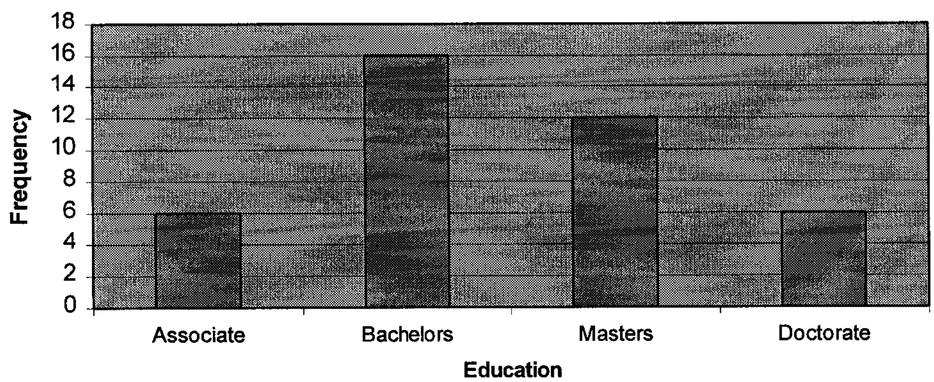
Figure 5. Undergraduate Degree source



Highest Degree Earned by Parents

40% the survey respondent's parents had an earned bachelor's degree. All were survey respondents' parents were educated with at least an Associate degree. The following chart shows the distribution.

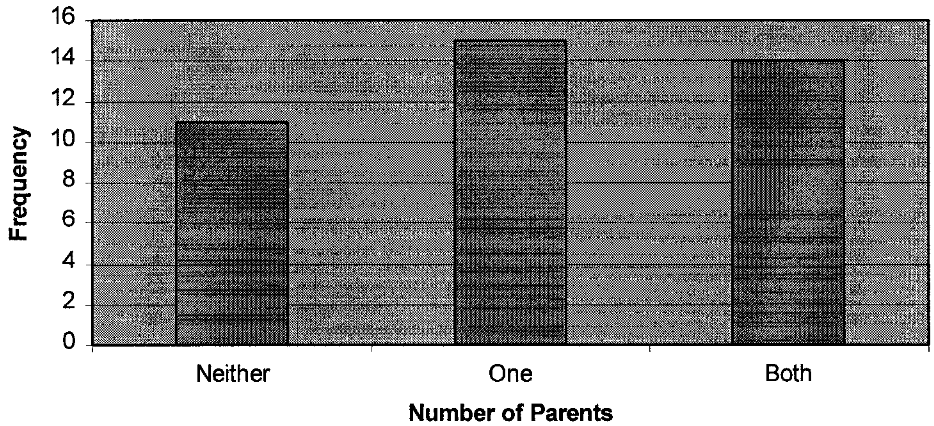
Figure 6. Parental Education Attainment



Parental Science Degrees

Although all of the respondent's parents held degrees, it was considered important whether the parents held degrees in science. 28% of the survey respondents' parents did not have an earned degree in science. The following chart shows the distribution of parental science degrees.

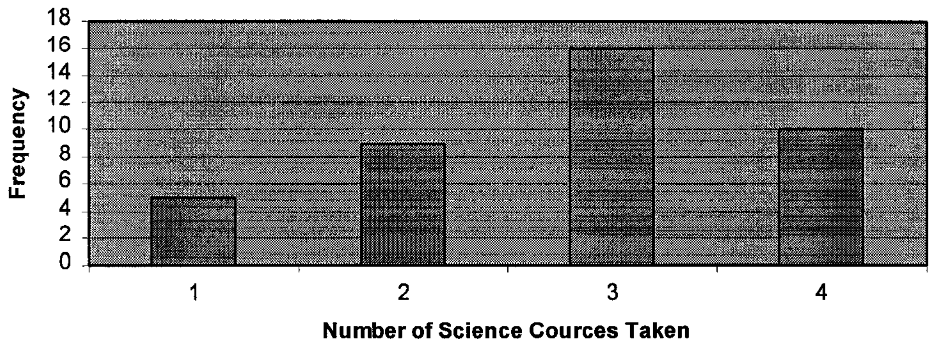
Figure 7. Parental Science Degrees



Science Courses Taken

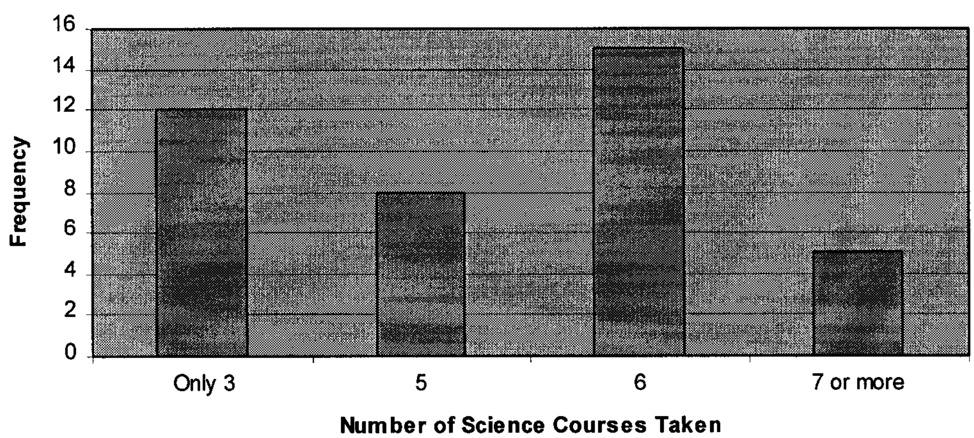
The survey instrument asked for science courses (Question 11) taken in high school and in college to gauge the pattern of interest in science and technology for the participants. The following two charts show that interest in science increased when the respondents went to college. On an average, the respondents took 2.8 sciences courses in high school and 5.1 science courses in college.

Figure 8. High School Science Education



38% of the respondents took six science courses in college and 13% of the respondents took more than seven science courses.

Figure 9. College Science Education



Overview of Demographic Data Collected

The survey respondents have the following demographics in common:

1. Between the ages of 26-40

2. Caucasian and Asian
3. Employed as Computer Programmers
4. Most (60%) have an earned Master's degree
5. Attended a State University
6. All parents are educated with a majority of them having an earned Master's degree
7. Only 28% of parents do not have a science degree
8. 40% took three science courses (including computer science) in high school
9. 38% took six science course (including computer science) in college.

Survey Format

The demographic questions on the survey were followed by the Likert type statements, rank order and open ended questions designed to answer the research questions of the study to investigate the impact of the three factors on women in Computer Science. Once the completed surveys were received, the first step was to test the reliability of the survey responses. Reliability of the survey responses was carefully considered since it is important to have high test score reliability. There are several procedures that can be used to test reliability. For the purpose of this study internal consistency was the approach used to estimate the test score reliability in which individual items of the test were examined. Cronbach's coefficient alpha(α), test was used to estimate the internal consistency of this study.

Internal Consistency

The reliability of the responses to the questionnaire was evaluated by using Cronbach's alpha (α), a parametric test. Of the several methods available to determine the internal consistency, Cronbach's method was chosen because it can be used when items on a measure are not scored dichotomously. Cronbach's alpha is one of the most widely used method for computing test score reliability (Gall, Borg & Gall, 1996). Gall. Borg & Gall (1996), describe the Cronbach's alpha as a measure of the internal consistency of a test, based on the extent to which test-takers who answer a test item one way respond to the other items in the same way. Correlation/alpha coefficient was calculated for each of the three factors (parents, role models/mentors, and teachers). A value between 0.6 and 1.0 generally indicates excellent reliability (Siegel, 1997). The completed questionnaires revealed a Cronbach's alpha values as follows:

Parents	0.83
Mentor/Role Model	0.78
Teachers	0.71

These values show a very high level of reliability. Each of the three factors showed a positive correlation thereby confirming that the survey questionnaire items measured the stated/anticipated intentions. Cronbach's alpha shows that there is consistency in the survey responses by showing a high correlation between the three factors (parents, teachers, role models/mentors) and their impact on women in leading them towards or away from Computer Science.

Determination of the Impact of Three Factors

(Parents, Teachers, Role Models/Mentors)

Once the study established a high level of reliability on the individual survey responses, a test of statistical significance called Chi-square (χ^2) was conducted to determine if all three factors (parents, teachers, role models/mentors) had equal impact on women or not.

Chi-square (χ^2) test

Chi-square (χ^2) is a non-parametric test of statistical significance that is used when the research data are in the form of frequency counts for two or more categories (Gall, Borg & Gall, 1996; Martella, Nelson, & Martella, 1999; and Siegal 1997). The chi-square (χ^2) test was used with the Likert type statements ((13-17, 19-32). The Likert type statements were coded as 5 (strongly agree), 4 (agree), 3(uncertain), 2 (disagree), 1 (strongly disagree). The scores for Likert type statements ((13-17, 19-32) which corresponded with the three factors (parents, teachers, role models/mentors), were totaled to create Chi square (χ^2) observed values contingency table (Table 2) as shown below. Correspondingly for each observed value an expected value was calculated and put below the observed values in the same table (Table 2).

Chi-square (χ^2) observed and expected values contingency table (Table 2) was used to evaluate the differences among parent, teacher, and role model/mentor scores. The Chi-square test was conducted using the Excel spreadsheet.

Table 2. Chi-square (χ^2) contingency table

	Strongly Agree	Agree	Uncert ain	Disagre e	Strongly Disagree	Total
Parents	159 125.36	111 120.34	19 26.44	29 41.02	2 6.84	320
Mentor s	52 94.02	106 90.25	27 19.82	42 30.77	13 5.13	240
Teache rs	64 55.63	47 53.41	12 11.73	19 18.21	0 3.03	142
Total	275	264	58	90	15	702

Note: expected values are shown below observed values

Chi-square statistic = 64.19,Degrees of freedom (df)= (3-1)(5-1)= 8, P - value =0.000
The value of chi-square statistic was calculated at 64.19.

Since the chi square value is larger than the critical value (at all three levels of significance -alpha .05, .01, .001; degree of freedom 8) and p value of 0.000 being highly significant, the null hypothesis is rejected indicating that all the three factors (parents, teachers, role models) do not have equal influence. Therefore (H_o) = rejected.

At .1% level, the critical value (with 8 degrees of freedom) is 26.124. The chi square statistic (64.19) is still much higher. Therefore the conclusion is:

That the three factors show very significant association and do not have equal influence

This indicates a very strong rejection of the null hypothesis.

The null hypothesis (H_o) for the Chi-square(χ^2) test had stated that : if all of the three factors (parents, teachers, role models) have equal influence, the mean ranks should be the same.

$H_0 = P = T = M = RM$ at the .05 level of significance

For the purpose of this study:

H_o stands for null hypothesis

P stands for parents

T stands for teachers

RM stands for role models

Alternate Hypothesis (H_a)= All three factors do not have the same influence.

Chi-square (χ^2) test provides hypothesis tests where there are categories instead of numbers. This test should be used to test for a statistically significant association between two or more variables or to determine whether an observed frequency distribution differs significantly from the distribution predicted by the null hypothesis (Siegal, 1997; Martella, Nelson, & Martella, 1999).

Chi-square (χ^2) Percentage Table

To determine which of the three factors (parents, teachers, role models/mentors) had the strongest impact on women, an overall percentage table was created from the chi-square test scores. From the overall percentages table (Table 3) it is clear that parents are the strongest influence followed by mentors/role models, and teachers in that order.

Table 3. Overall Percentages Contingency Table*

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree	Total (overall)
Parents	23%	16%	3%	4%	0%	46%
Mentors	7%	15%	4%	6%	2%	34%
Teachers	9%	7%	2%	3%	0%	20%
Total	39%	38%	8%	13%	2%	100%

Overall percentages contingency table indicates what percent fall into each categoryof each variable/factor and each combination of categories (one category of each variable/factor).

From the overall percentages table (Table 3), it is clear that parents have the most significant impact on women followed by role models/mentors and teachers (in that order).

Order of significance of the three factors (Parents, Teachers, Role Models/Mentors)

After the chi-square (χ^2) significance test was performed on the Likert type statements, attention was focused on the next set of survey questions which were the rank order questions (33 & 34). The rank order questions were analyzed carefully to determine if they confirmed the results derived from the overall percentages table derived from the chi-square (χ^2) test scores.

Rank Order Statements

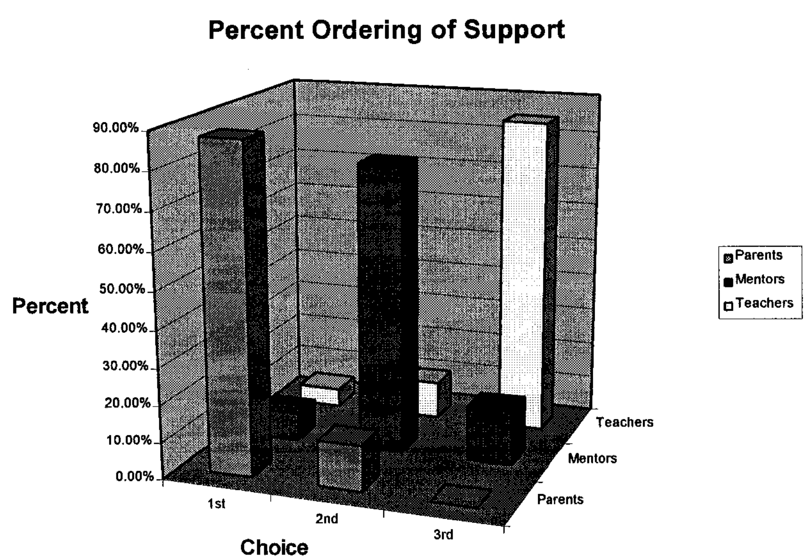
The respondents were asked to rank (questions 33 & 34) the three factors (parents, role models/mentors, and teachers) from the most important to the least important in impacting the entry and persistence of women in computer science. The rank order table (Figure 13) visually displays that parents are the most influential, followed by mentors/role models and teachers in that order.

Table 4 . Rank Order Table

Factors	1st	2nd	3rd
Parents	87.50%	13%	0%
Mentors	7.50%	78%	15%
Teachers	5.00%	10%	85%
Sums	100%	100%	100%

The following chart (Figure 14) also visually displays preference of the survey respondents that parents were the first choice of support, followed by role models/mentors and teachers.

Figure 10. Rank Order of the Three Factors (Parents, Role Models/Mentors and Teachers)



The choice of survey respondents for the impact of the three factors (parents, teachers, role models/mentors, and teachers) on women was confirmed twice. First, by the overall percentages table derived from chi square test scores and second, by the percentages calculated from the rank order questions. Therefore it was confirmed that parents had the strongest impact, followed by role models/mentors and teachers (in that order). These results were further confirmed by the three open-ended questions (18, 35, & 36) included on the survey. These three open ended questions gave an opportunity to the respondents to write about their experiences in reference to these three factors and to any other factors which may have proved to be a hindrance or sources of support to them.

Open ended Questions

There were three open ended questions (18, 35 & 36) on the survey which gave an opportunity to the survey respondents to write about what they felt were the factors (besides the three identified by this study) that were important for female recruitment and retention in Computer Science. Questions 35 and 36 asked the participants specifically to list any other factors beside the three factors that encourage them towards or turn them away from Computer Science. The data collected from these open ended question was qualitatively analyzed using content analysis. Qualitative content analysis has been included for exploratory purpose in this study and also to give greater confidence and validity to the quantitative measures used. Content analysis is nonreactive because the process of placing words, messages, or symbols in a text to communicate to readers occurs without influence from the researcher who analyzes its content (Newman, 1997).

Survey responses on these three questions recorded answers from the respondents were divided into the following two categories:

1. Factors that affect women positively towards Computer Science
2. Factors that negatively affect women towards Computer Science

For the first category the following factors were listed:

- Childhood support in learning Math and Science
- Exposure to mathematical puzzles
- Reading and watching science fiction/media
- Peer support
- Summer Science Camps/Courses

For the second category the following factors were listed:

- Unfair female competition with males
- Judgmental attitude in classroom and at workplace
- Child bearing and domestic responsibilities

The above mentioned categories were used to analyze the data as factors (other than parents, teachers, role models/mentors) that either take women towards or away from Computer Science. The way in which the respondents brought up these additional factors are in relation to the three factors (parents, role models/mentors and teachers) identified by this study thereby qualitatively confirming that parents, role models/mentors and teachers have a strong influence on the entry and persistence of females in computer science.

Some of the respondent open-ended responses have been included which clearly point out the strong influence of parents, role models/mentors, and teachers in the entry and persistence of women in computer science. Some of these responses are:

- My parents always supported my interest in science and math. When I chose
- computer science as a profession they were very happy to see I was happy with my choice.
- My parents are my role models. I was brought up to believe that I would be successful at whatever I chose to do.
- My favorite teacher was my music instructor in school. We meet for lunch even now. Both she and my mother are my role models. They are always there for me.
- More female teachers in sciences would help girls enter and stay in the science professions. The problem is we don't have many people to look up to.

ADMINISTRATION OF THE WEB SURVEY

The web survey was posted on the following listserves:

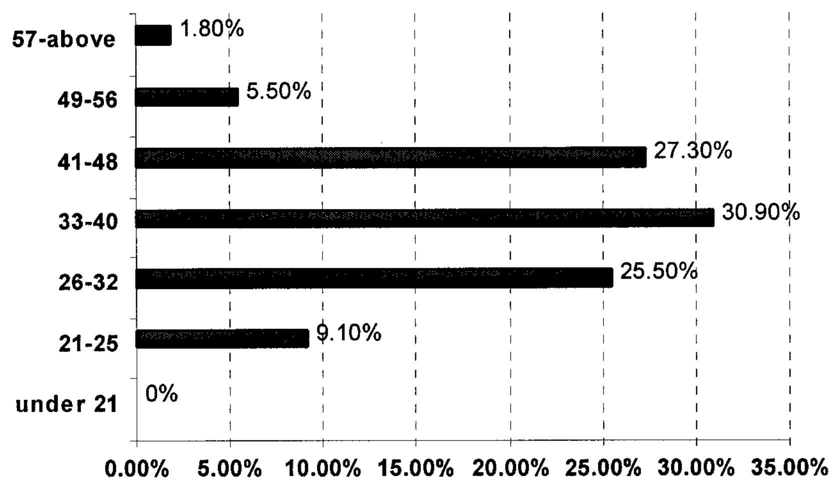
6. femptheoryqueer-aoir.org@listserv.aoir.org (www.aoir.org)
7. wcs@cs.usask.ca (www.cs.usask.ca)
8. ITempowerment @listserv.uic.edu
9. http://www.nsta.org/main/forum/showthread.php?p=1993#post1993
10. WebGuru@dslextreme.com

The purpose was to collect data from a random population of respondents from the math, engineering, technology and computer science field. A total of 53 respondents accessed the web survey but only about 32 respondents completed the survey in its entirety. This study used web based survey as an instrument of data collection, in addition to the researcher-administered paper survey not only for ensuring validity and reliability of data collection but also to open this research to a larger population. This study aimed to collect rich and unbiased data to answer its research questions.

Age

All of the participants were between the ages of 21-57 above with a major concentration between the ages of 33-40 (31%).. The following chart shows the age distributions of the participants:

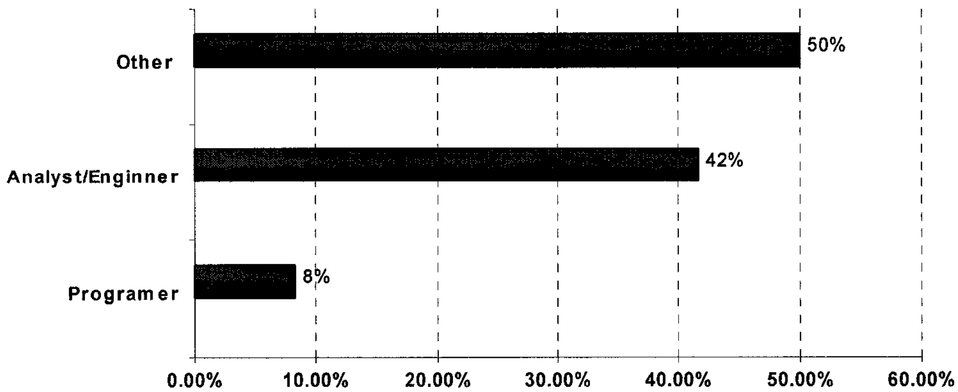
Figure 11. Age



Occupation

Respondents were from diverse backgrounds varying from business, computers, law, and arts to sciences. . Half of the respondents were from other occupations (50%) and half were computer professionals. The following chart (figure 12) shows the occupational distribution of the sample.

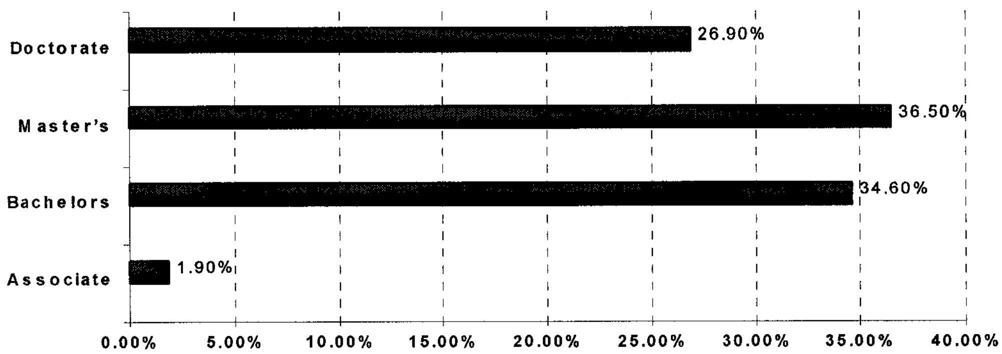
Figure 12. Occupation



Highest Degree Earned

The survey respondents had an earned Associate, Bachelor's, Master's and Doctoral degrees. A major concentration (37%) of the survey respondents had earned Master's degree. The distribution is shown in the following chart.

Figure 13. Highest Degree Earned



•79.59 % of the web – based survey respondents had taken science and technology courses (including computer science) in college.

•84.31 % of the web-based survey respondents had taken science and technology courses (including computer science) in high school.

Survey Format

The demographic questions on the survey were followed by the Likert type statements, rank order and open ended questions designed to answer the research questions of the study to investigate the impact of the three factors on women in Computer Science. Once the completed surveys were received, the first step was to test the reliability of the survey responses. Reliability of the survey responses was carefully considered since it is important to have high test score reliability. There are several procedures that can be used to test reliability. For the purpose of this study Pearson's Correlation test was the approach used to estimate the test score reliability.

Reliability of The Web Based Survey

The reliability of the responses to the web based questionnaire was evaluated by using Pearson Correlation Test. The correlation matrix was conducted using the SPSS system. Correlation/alpha coefficient was calculated for each of the three factors (parents, role models/mentors, and teachers). The completed questionnaires revealed correlation values as follows:

Correlations

		T	P	R
T	Pearson Correlation	1	.880 **	.855**
	Sig. (1 tailed)	.	.000	.000
	N	33	32	30
P	Pearson Correlation	.880**	1	.858**
	Sig. (1 tailed)	.000	.	.000
	N	32	34	30
R	Pearson Correlation	.855**	.858**	1
	Sig. (1 tailed)	.000	.000	.
	N	30	30	32

** Correlation is significant at the .01 level (1 tailed)

These values show a very high level of reliability. Each of the three factors showed a positive correlation thereby confirming that the survey questionnaire items measured the stated/anticipated intentions. The above table indicates that there is consistency in the survey responses by showing a high correlation between the three factors (parents, teachers, role models/mentors) and their impact on women.

Determination of the Impact of Three Factors (Parents, Teachers, Role Models/Mentors)

Once the study established a high level of reliability on the individual survey responses from the web based survey, the Chi-square (χ^2) was conducted to determine if all three factors (parents, teachers, role models/mentors) had equal impact on women or not.

Chi-Square ($\chi2$) Ttest

As stated earlier in Section I of this chapter, Chi-square (χ^2) is a non-parametric test of statistical significance that is used when the research data are in the form of frequency counts for two or more categories (Gall, Borg & Gall, 1996; Martella, Nelson, & Martella, 1999; and Siegal 1997; Neuman, 2003). The chi-square (χ^2) test was used with the Likert type statements ((13-17, 19-32). The Likert type statements were coded as 1 (strongly agree), 2 (agree), 3(uncertain), 4 (disagree), 5 (strongly disagree). The scores for Likert type statements ((13-17, 19-32) which corresponded with the three factors (parents, teachers, role models/mentors), were totaled to create Chi square (χ^2) observed values contingency table (Table 2) as shown below. Correspondingly for each observed value an expected value was calculated and put below the observed values in the same table (Table 2).

Chi-square (χ^2) observed and expected values contingency table (Table 2) was used to evaluate the differences among parent, teacher, and role model/mentor scores. The Chi-square test was conducted using the Excel spreadsheet.

Table 5. Chi-Square (χ^2) Contingency Table

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree	Total
Parents	129 118	43 46	26 30	26 25	8 13	232
Mentors	54 59	28 23	19 15	8 12	7 7	116
Teachers	82 88	33 35	22 22	22 19	15 10	174
Total	265	104	67	56	30	522

Note: expected values are shown below observed values

Chi-square statistic = 11.77

Degrees of freedom (df)= (3-1)(5-1)= 8

The value of chi-square statistic was calculated at 11.78. Since the chi square value is smaller than the critical value (at all three levels of significance -alpha .05, .01, .001; degree of freedom 8, the null hypothesis is accepted indicating that all the three factors (parents, teachers, role models) have equal influence. Therefore (H_o) = Accepted. At .1% level, the critical value (with 8 degrees of freedom) is 26.124. The chi square statistic (11.77) is much lower. Therefore the conclusion is: That the three factors have an equal influence

The null hypothesis (H_0) for the Chi-square(χ^2) test had stated that : if all of the three factors (parents, teachers, role models) have equal influence, the mean ranks should be the same.

$H_0 = P = T = M = RM$ at the .05 level of significance

For the purpose of this study:

H_o stands for null hypothesis

P stands for parents

T stands for teachers

RM stands for role models

Alternate Hypothesis (H_a)= All three factors do not have the same influence.

As stated earlier in Section I of this chapter, Chi-square (χ^2) test provides hypothesis tests where there are categories instead of numbers. This test should be used to test for a statistically significant association between two or more variables or to determine whether an observed frequency distribution differs significantly from the distribution predicted by the null hypothesis (Siegal, 1997; Martella, Nelson, & Martella, 1999; Neuman, 2003).

Order of Significance of the Three Factors
(Parents, Teachers, Role Models/ Mentors)

After the chi-square (χ^2) significance test was performed on the Likert type statements, attention was focussed on the next set of survey questions which were the rank order questions (33 & 34).

Rank Order Statements

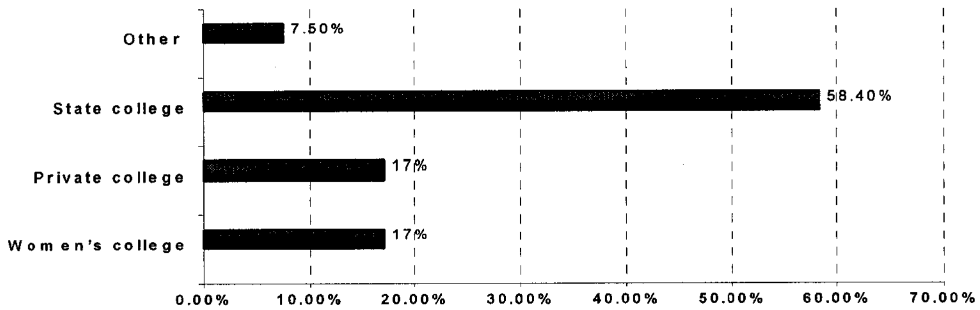
The respondents were asked to rank (questions 33 & 34) the three factors (parents, role models/mentors, and teachers) from the most important to the least important in impacting the entry and persistence of women in computer science. The rank order table (Figure 13) visually displays that parents are the most influential, followed by mentors/role models and teachers in that order.

The following chart (Figure 14) also visually displays preference of the survey respondents that parents were the first choice of support, followed by role models/mentors and teachers.

Undergraduate Institution Attended

Most of the survey respondents (59%) attended state universities. Only 17% attended women's college and 17% attended private college. The following chart shows the distribution.

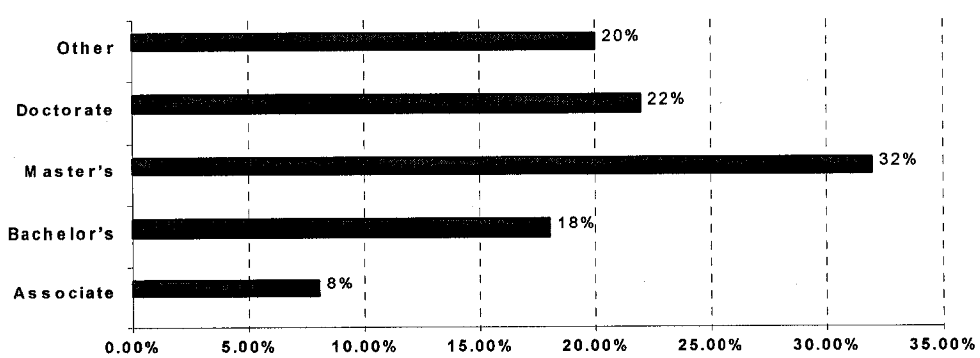
Figure 14. Undergraduate Degree source



Highest Degree Earned by Parents

32% of the survey respondent's parents had an earned master's degree. The following chart shows the distribution.

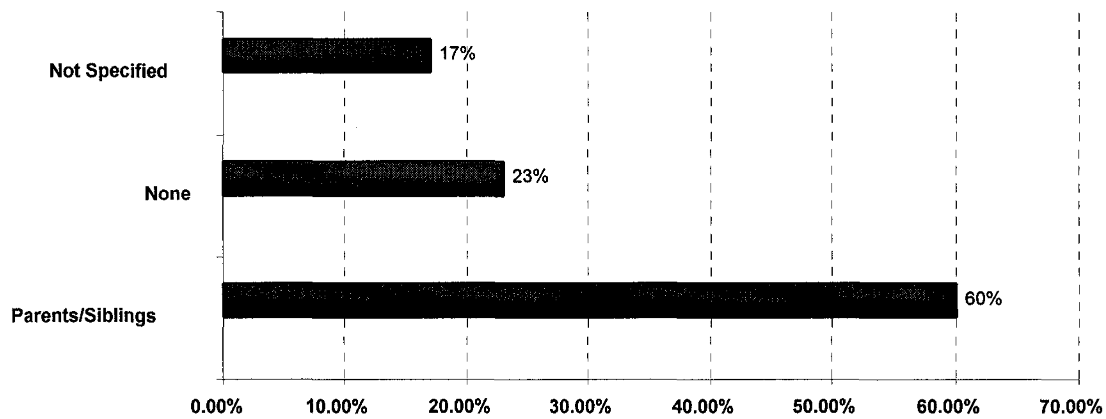
Figure 15. Parental Education Attainment



Parental Science Degrees

It was considered important whether the parents/siblings held degrees in science. 60% of the survey respondents' parents/siblings did have an earned degree in science. The following chart shows the distribution of parental science degrees.

Figure 16. Parental/Siblings Science Degrees



Overview of Demographic Data Collected

The survey respondents have the following demographics in common:

- Between the ages of 21- 57 and above
- Caucasian and Asian
- 50% employed as Computer Professionals

•Most (36.5%) have an earned Master's degree

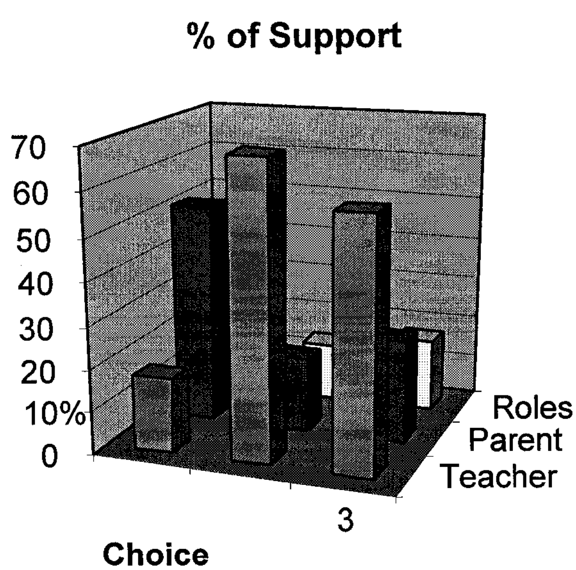
•Attended a State University (58.4%).

•Most parents educated with a majority of them having an earned Master's degree (60%).

Table 6 . Rank Order Table

Factors	1st	2nd	3rd
Parents	69%	17%	14%
Mentors	59%	24%	17%
Teachers	17%	52%	31%

Figure 17. Rank Order of the Three Factors (Parents, Role Models/Mentors and Teachers)



These percentages are quite staggered showing close choices. The choice of survey respondents for the impact of the three factors (parents, teachers, role models/mentors, and teachers) on women was confirmed twice. First, by the overall percentages table derived from chi square test scores and second, by the percentages calculated from the rank order questions.

Open ended Questions

There were three open ended questions (18, 35 & 36) on the survey which gave an opportunity to the survey respondents to write about what they felt were the factors (besides the three identified by this study) that were important for female recruitment and retention in Computer Science. Questions 35 and 36 asked the participants specifically to list any other factors beside the three factors that encourage them towards or turn them away from Computer Science. The data collected from these open ended question was qualitatively analyzed using content analysis. Qualitative content analysis has been included for exploratory purpose in this study and also to give greater confidence and validity to the quantitative measures used. Content analysis is nonreactive because the process of placing words, messages, or symbols in a text to communicate to readers occurs without influence from the researcher who analyzes its content (Newman, 1997). Survey responses on these three questions recorded answers from the respondents were divided into the following two categories:

3. Factors that affect women positively towards Computer Science
4. Factors that negatively affect women towards Computer Science

For the first category the following factors were listed:

- More computer use for girls
- More scientific toys for children

- More science and technology courses in schools
- More encouragement at young age
- More role models and better teachers
- Childhood support in learning Math and Science: by providing incentives to girls – extra credit for taking more computer science and math courses
- Allowing women to work from home
- Seminars in schools and colleges to encourage women
- Peer support

For the second category the following factors were listed:

- Judgmental attitude in classroom and at workplace - Unfair teachers, lack of respect from male peers
- Child bearing and domestic responsibilities: more maternity leave time
- The industry is male – centered. You wanna example? Games are how people get into the industry, and most of them are male-centered.

The above mentioned categories were used to analyze the data as factors (other than parents, teachers, role models/mentors) that either take women towards or away from Computer Science. The way in which the respondents brought up these additional factors are in relation to the three factors (parents, role models/mentors and teachers) identified by this study thereby qualitatively confirming that parents, role models/mentors and teachers have a strong influence on the entry and persistence of females in computer science.

Some of the respondent open-ended responses have been included which clearly point out the strong influence of parents, role models/mentors, and teachers in the entry and persistence of women in computer science. Some of these responses are:

- Yes, my parents encouraged me by encouraging my interest in science and nature.
- My Mother influenced me and she is a math teacher.
- My parents were supportive of my career choice. They are both in the medical field and would have liked me to pursue a career in that direction.
- Yes, I was encouraged to play computer games as my brother did. I played chess with my father which is typically considered a male game. My Mom taught me Math and helped with Physics as well.
- More role models other than parents.
- Fair and encouraging teachers.

Generalizability of Results

Extensive statistical analysis has proved that the results of this study are reliable and consistent. The data collection was conducted by using two separate means : self – administered and web based survey. Similar responses were generated by both methods of data collection. But a limitation of the study is that the sample size being small restricts the generalizability, which may skew any statistical significance that was found in the study.

Anticipated Outcome of the Study

The anticipated outcome of the study was to successfully answer the research questions of the study. Both of the following research questions of the study were successfully answered by the survey responses:

1.To what degree are opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, role models/mentors) impact women in taking up these opportunities?

2. To what extent are the three factors (parents, teachers, role models/mentors) responsible for retaining and increasing the number of women in the Computer Science workforce?

Survey responses were consistent with research literature in pointing out that the three factors (parents, teachers, and role models/mentors) had a significant impact on women.. Survey responses also indicated that opportunities were available for women in Computer Science. Women who choose not to take up these opportunities is because computer science is regarded as a male profession and due to lack of guidance and support from their parents, and teachers, and the lack of role models/mentors. The open-ended responses also indicated some more factors (media, peer support, summer science programs) that have an impact on the entry and persistence of women in computer science. Unfortunately the survey respondents did not discuss these additional factors in detail. However, these additional factors were discussed by the respondents in relation to the three factors (parents, teachers, and role models/mentors) identified by the study.

These additional factors mentioned by the respondents open a whole new avenue for research in this area. In addition to the extensive statistical analysis, these open ended responses helped to enrich this study by confirming that the three factors (parents, teachers, and role models/mentors) identified by this study have a significant impact on the entry and persistence of women in computer science.

Conclusions

The survey responses clearly point out that the three factors: parents, teachers, role models/mentors play an important role in either channeling women towards Computer Science or away from it. The study also found from the open ended questions that there were other factors beside the above mentioned three that also played a role in encouraging or discouraging women from computer Science.

CHAPTER 5

DISCUSSION

Introduction

Forty years ago Alice Rossi (1965) asked a question "Women in Science: Why so few?" The problem of underrepresentation of women has been known for so long and has remained substantially the same. According to the CRA Taulbee survey (1999-2000) 15% women graduated with a Doctorate in Computer Science, 26% of women graduated with a Master's degree in Computer Science, and 19% women graduated with a Bachelor's degree in Computer Science. Only 6.4% girls/women were enrolled in graduate programs in science and engineering in 2001- 2002 academic year (The National Science Foundation, 2002). The CRA Taulbee Survey, 2002 – 2003 provided the following information:

• Only 19.9% women were enrolled in Computer Science and Computer Engineering Doctoral Programs.

• Only 16.5% women were recipients of Doctoral degrees in Computer Science and Computer Engineering Doctoral Programs.

• The percentage of newly hired teaching faculty who are women dropped from 26% to 22%.

• Only 25.6% of women were recipients of Bachelors and Master's degree in Computer Science and Computer Engineering Programs.

• Only 8.6% of women comprise Full Professors, only 12.3% comprise Associate Professors, only 15.8% comprise Assistant professors in Computer Science and Computer Engineering Programs.

According to Rayman and Brett (1995) the problem of underrepresentation of women in sciences was discovered ever since the Sputnik era of cold war competition, when there was much concern that the United States was not meeting the challenge of producing talented scientists. It was clear that women were underrepresented in science, mathematics and engineering; they made up just over a quarter of all biologists and mathematicians, and only 9% of all chemists, 4% of all physicists, and only 0.8% of all engineers.

The purpose of this study was to explore and describe the impact of the three factors (parents, teachers, role models/mentors) on the underrepresenation of women in Computer Science and also the perceived impact of these factors towards the entry and persistence of women in the Computer Science workforce. This study was guided by the following research questions:

1. To what degree are opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, role models/mentors) impact women in taking up these opportunities?

2. To what extent are the three factors (parents, teachers, role models/mentors) responsible for retaining and increasing the number of women in the Computer Science workforce?

3. The results of this study indicate that the three factors (parents, teachers, role models/mentors) are indeed important in either taking women towards or away from Computer Science. Survey responses also indicate that there are opportunities available for women as there are for men. What women need is encouragement to break through the so called male domain of computer science.

The results from open ended questions (18, 35 and 36) indicate that several factors, (influence of media, summer science activities, peer influence, mathematical puzzles) which have not been highlighted in research literature previously, but are worth more attention which leads to implications for further research. Data for this study was this study was collected from utilizing two methods: self – administered surveys and web based survey. The same survey questionnaire was used for data collection utilizing two different methods. The 40 self-administered survey questionnaires survey received a 100% response rate. A total of 53 respondents accessed the web survey, of which only about 32 completed the survey in its entirety. This chapter is organized in six discussion sections, which deal with:

1. Demographic Survey Responses
2. Significant research findings in relation to the two research questions of the study
3. Implications
4. Limitations
5. Fulfillment of Anticipated Outcomes
6. Recommendations for Future Research

Demographic Survey Responses

Age

The demographic survey responses all of the participants from the self-administered survey were between the ages of 21-48 with a major concentration between the ages of 26-32 (55%). The average was 32.4 years. The data obtained on age is consistent with the research literature, which indicates that to a large extent Information Technology is an occupation for the younger workers. Ten years ago there was a higher concentration of IT workers in the age range of 40-50 years. But now there are more workers between the ages of 22 –35 (Computing Research Association of America, 1999). Most of the web based respondents were between the ages of 21 – 57 and above, with a major concentration between the ages of 33 – 40.

Ethnicity

Most of the survey respondents from the self – administered and web survey were Caucasian. The self – administered survey instrument was completed only by female Computer Science professionals, irrespective of their ethnic background. The data obtained on ethnicity is also consistent with the research literature, which indicates that a large number of students graduating in science and technology are Caucasian. The percentage of Native Americans and African Americans graduating in these disciplines is still low. The graduation rates based on ethnicity are consistent with Caucasian concentration in the IT workforce. With the temporary foreign work visa

(H-1B) there is an increasing influx of Asian IT workers in America (Computing Research Association, 1999; NSF, 2000; NCES, 2000). More research is required to address the issue of ethnicity and the entry and persistence of women in the Computer Science profession.

Occupation

All of the self – administered survey respondents were Computer Science professionals. Most of the respondents were programmers (55%) and 20% were software engineers, 8% were software designers and 18% supervisory (team leaders). Following are job descriptions of the respondents:

Programmers: are responsible for designing, coding, testing and debugging programs to implement new applications. Programmers also modify and make corrections in the existing programs. They use programming languages like COBOL, BASIC FORTRAN, and Pascal (Schultheis & Sumner, 1998).

Software engineer/Software designer: Both software engineer and software designer fall under the category of 'Developers.' Software designer works more with specifying and designing an information technology artifact. Software engineer works more with specifying, constructing and testing an information technology artifact (Computing Research Association, 1999).

Team leaders: manage a team of information technology workers. Team leaders are in the information technology field as well. They assign responsibilities, monitor progress and make sure the activities are covered within the specified deadlines (Schultheis & Sumner, 1998).

Only 58.4 % of the web- based surveys were computer professionals.

Highest Degree Earned and the Educational Institution Attended

The self –administered survey respondents had an earned Associate, Bachelor's, earned Associate, Bachelor's, Master's and Doctoral degrees. A major concentration (60%) of the survey respondents had earned Master's degree. Most of the survey respondents (75%) attended state universities. All the web based survey respondents had an earned Associate, Bachelor's, and Master's and Doctoral degrees. A major concentration (37%) of the respondents had earned Master's degree. Most of the respondents (59%) had attended state universities.

Parental Education and Science Degrees

All of the self – administered survey respondents' parents were educated with the highest being an earned Doctoral degree to the minimum of an Associate degree. For 28% of the respondents neither parent had a science degree. For 38% of the respondents' at least one parent had a science degree. 35% had both parents with a science degree. Further research can be conducted to determine the effect of parental education with the entry and persistence of women in Computer Science.

Most of the web- based survey respondent parents were educated with the highest being the doctoral degree. 32% of the survey respondent's parents had an earned master's degree.

High School and College Science Courses

All of the self – administered respondents had taken science and technology courses (including computer science) in high school and college. In high school 25% of the respondents had taken four science and technology courses. In college 13% had taken more than seven science and technology courses persistence of women in computer. 84.31 % of the web-based survey respondents had taken science and technology courses (including computer science) in high school. 79.59 % of the web – based survey respondents had taken science and technology courses (including computer science) in college. Further research can be conducted to determine the effect of taking more science and technology courses in the entry and persistence of women in computer science.

Significant Research Findings

Both of the study's questions were answered from the survey responses. The first research question will be addressed in the section to follow.

Research Question 1.

To what degree are opportunities available for women in Computer Science and to what extent do the three factors (parents, teachers, role models/mentors) impact women in taking up these opportunities?

The survey responses are supported by the research literature that opportunities exist for women in computer science and the three factors have a significant impact on women in taking up these opportunities.

Opportunities exist for Women

According to Turkle (1988) women stay away from computer related activities because computer culture has become linked to a characteristically masculine worldview, such that women too often feel they need to choose between the cultural associations of 'femininity' and those of 'computers.' The AAUW (2000) study revealed that it is the masculine and the feminine associations that do not let women come close to computer related programs, which is not to say that women do not have access to the opportunities available to them. Based on its research findings the AAUW study emphasizes that opportunities exist for women, but what needs to be done is to change the 'face of computing'- to remove gender associations so women can grab the opportunities as much as men. Some of the survey responses from the present study include:

- We girls are not denied the opportunity to go in the computer science profession. Most of us choose to stay away from it. I would not have been a programmer today but for the encouragement of my parents.
- My teachers did not tell me not to go for science or technology; they just were not helpful. I persisted in computer science because I always wanted to be in this profession like my mother.

•Girls are not denied entry in computer science. They just don't pursue this career path.

•When I was eight years old my, I asked my Math teacher for help in solving a problem. My teacher replied back and said 'you are girl – that part of your brain does not work.' I never forgot those words and I made up my mind to enter the science or math field. Today at 28 I am a successful software engineer. The opportunity was there. I just grabbed it!

According to Fisher & Margolis (2000), opportunities exist for women in Computer science but they choose to stay away and those who enter do not persist because of lack of self-confidence. When women experience a problem or do not understand something, they blame themselves. Men will experience a problem, not understand something and they will blame someone else. Women are far more likely to conclude that they just don't have what it takes, lose interest and disappear. Fisher and Margolis further concluded that this problem could be solved to a great extent if females had female role models (could be a family member, teacher, guidance counselor or a friend) but the reality is that female role models continue to be scarce. Rosser (1990) believes that opportunities are available for women in computer science and in related fields, but it is the gender stereotyping which keeps women away. There is need of women being provided direction as children that professions are not 'male' or 'female.' Barton (1998) agrees that opportunities exist for women in all aspects of sciences. But women do not enter or persist because science education has traditionally been a culture of exclusion for women. For more women to enter and persist in sciences any and all gender identity has to be deconstructed and girls need the support of family and of the educationists to assist them in making choices to enter the science programs.

Most of the survey responses from the open ended questions (18, 35, & 36) provide evidence that parents, role models/mentors and teachers were responsible for either taking them away or towards computer science.

The survey responses are consistent with research literature. Rosser (1997) attributes the leading cause of girls staying away from science and technology to differential treatment at home, gender stereotyped social experiences that boys and girls have in the society because of their underlying biological differences and the lack of female encouragement in most educational curriculums.

Osborne (1997) emphasizes that it is the difference in learning styles that keeps girls away from science and technology. Osborne demonstrates that parents present more visual objects or toys to baby boys and talk and interact verbally more with girls to comfort and quiet them when they are upset which partially explains the differing visio-spatial ability of boys and verbal ability of girls. Barton (1998) explains that parents and family members leave the most lasting impressions on children's minds. If both boys and girls are treated in a similar way at home, the educational setting may not. Teachers often do not provide the care that many students (particularly girls) need. There are very few women in sciences and there is a lack of role models to encourage more girls towards science. According to Hughes (1995) opportunities exist for women in all science majors and mathematics but they drop out because of differential responses of parents and teachers. Most parents tend to praise their daughter's hard work in attaining good grades, while attributing their sons' success to talent.

Survey responses have revealed yet another reason why women do not take up the opportunities in computer science – they need human touch. Women are comfortable interacting with other human beings not with machines.

Women Need Human Touch

Results of this study indicate that women associate themselves more with human beings than with machines – women need human touch. In the words of Gilligan (1982), women promote an inherently more sensitive, more related way of thinking. Gilligan also said that unlike males, females define themselves in relation to other people. Gilligan emphasized the feminine recognition of needs, relation, and response and their refusal to leave themselves, their loved ones, and connections out of their moral reasoning. They speak from and to a situation and their reasoning is contextual – human relationships. One of the survey participants wrote:

- I switched to the Information Technology (IT) industry from being a university faculty. I realize the lack of human touch in the IT industry. In a classroom full of students there was one human being interacting with the other. There were powerful exchange of ideas between people who had feelings and emotions. In the IT industry, I often feel I cannot breathe with just machines around me.
- It is hard to spend an entire day looking into a lifeless screen. It is a comfort is when I sit back to relax for a minute and see my children's photographs pop up on the screen saver.

According to AAUW (2000), girls do not have emotions about inanimate objects and stay away from information technology related careers not because of a phobia but because of disenchantment. The girls from the sample population of this AAUW study explained that building human relationships is an intellectually complex and valuable process. These girls questioned boys' absorption with computers as a substitute for social skills. These girls further said that women were into talking to each other and building relationships and boys were not as comfortable with themselves or with each other; therefore they just liked to build a relationship by putting it into a computer.

Freeman & Aspray (1999), point out that women are underrepresented in Computer Science because the perception of computing is that of a solitary occupation, not well integrated into social discourse or social institutions. Females feel abandoned when they are encouraged to develop skills and confidence to cope up with their environment. They need constant human nurturing. Beyer, Rynes and Haller (2004), confirm that women need human touch and conducted a study to find out that women are more interpersonally career and family – oriented and more likely than men to value careers that would allow them help others, work with people and provide opportunity to combine career and family. Further Beyer, Rynes and Haller found that although women aspired to generally higher levels of education, they showed interest in traditionally feminine subjects of psychology, nursing and English.

The survey responses consistent with the research literature answer the first research question of the study with clear evidence that there are opportunities available for women in computer science and women are aware of it. Women who choose to stay away from computer science have several reasons for doing so. Computer Science is typically regarded as a male profession and women often do not receive guidance and encouragement from parents and teachers. The lack of female role models also keeps them away.

Research Question # 2

To what extent are the three factors (parents, teachers, role models/mentors) responsible for retaining and increasing the number of women in the Computer Science workforce?

Based on the survey responses and available research literature, the study's second research question will be addressed in the following section. The survey responses are supported by the research literature that the three factors are responsible for retaining and increasing the number of women in the Computer Science workforce.

Feminine Importance of Relationships

The three factors (parents, teachers, role models/mentors) which lead women towards or away from computer science will be discussed in light of the emphasis placed in the research literature that females look for forming relationships to feel protected and secure (Gilligan 1982, 1989; Webster 1995; Freeman & Asprey 1999; AAUW 2000).

Parents

Results of this study correspond with the research literature in that parents are a strong influence in the life of children. Data collected for this study indicates that parents are the strongest and the most important influence in taking women towards Computer Science or away from it. The first relationship that a child forms is that with the parents (Woolfolk 1995). This study indicates that parents are the most important influence in taking women towards Computer Science or away from it. As Sadker & Sadker, (1985) point out that parents are the first and longest teachers in their child's life. One of the survey respondents wrote, 'I would not have been where I am today, but for my parents – my parents are my role models/mentors and teachers.' According to a study by Rayman and Brett (1995), women who persist in science are more likely to have received encouragement by their parents, especially their mothers. The authors also point out that informed support of parents in regard to their daughter's educational and career aspirations certainly encourages girls positively. The open ended question (question 18) from the survey instrument highlights the importance of parents as the most important factor in terms of support and instilling self confidence to make choices. A vast majority of the survey respondents wrote that had it not been for their parents, they would not have been in the IT profession. Some of the survey responses to question 18 were:

- One of the survey respondents wrote that her parents made her realize that, 'women were as capable of handling machines as men were,' and this instilled her with confidence to overcome the feminine resistance to cold machinery. This respondent wrote, “My father loved to repair his won car. He worked on his car on the weekends. I saw my mother help him when he was working on the car. In the end they both were covered with grease. I realized early in my life that working with metal was not a masculine job. It was job which could be done by both men and women.”

- My parents never differentiated between boys and girls. Being a girl, I was given as much freedom to choose my career path as my brother. My elder sister is medical doctor and I am in the IT profession. Being the girls we both took the science profession as our career path. My brother is a medical doctor as well. Close relationship with family helps to nurture growth in all children (boys and girls).
- My parents always said to me, ’go for it’ – choose what your heart desires. I chose computers. Being in this profession though, I feel I miss the human closeness – it is hard to be friends with a machine.
- Yes, my parents encouraged me by encouraging my interest in science and nature.
- Yes, I was encouraged to play computer games as my brother did. I played chess with my father which is typically considered a male game. My Mom taught me Math and helped with Physics as well.
- My parents encouraged me to pursue my dreams.
- My parents got me a lot of computer games.
- My parents encouraged the use of technology.
- My parents guided me and provided exposure to computers and internet.

Results of this study indicate that family characteristics, such as having parents in science and technology fields helps to push women towards Computer Science.

•One of the survey respondents wrote, "My father is a Physics professor and my mother is a software engineer. When I was child, I was never introduced only to science related toys – dealing more with physics. On my third birthday, my parents bought me a little plastic rocket. I was learning laws of gravitation before I learnt my ABCs. I was propelled into computer science because of my parents."

•"My parents including my siblings tremendously helped me by showing me that being a girl could not stop me from going close to machines. My father is a mechanical engineer. He brought back home models of cars and nut and bolt games. I have two brothers and we all played together. My parents wanted me to be a mechanical engineer but I became a software engineer. My family is happy with my success and so am I."

•Another of the survey respondents wrote, "My mother has a Doctorate degree in Biology. She always encouraged me towards the sciences. My father is an architect. He always left it for me to make my own choices. They are both happy that I am in the computer science field." This aspect of the survey responses from the study corresponds with the research literature in that family characteristics play an important role in shaping up children's future (Bailey 1993; Baker 1986; Newcombe & Baenninger, 1990; NCES 1997).

•Another survey respondent wrote, 'I thank my parents every morning, more so my mother who put me on this path.'

•My parents were supportive of my career choice. They are both in the medical field and would have liked me to pursue a career in that direction.

•My Mother influenced me and she is a math teacher.

•My father was a data-processing manager.

Survey responses also point out that it is relationships on the home front which keep women away from Computer Science. Responses to question 35 indicate that females bound by marriage and children find it hard to balance their lives. One of the respondents wrote, "Having a family – husband and children and career is impossible. I am working hard to get to the managerial level position before I have children." According to Lynn (1972), when a girl learns what it means to be female, she learns to be "like mother."

Another respondent wrote in response to question 36 on the survey that "lack of proper childcare arrangement and uncooperative behavior is the main deterrent from Computer Science." This respondent suggested an encouragement mechanism to encourage women – on site day care. The survey results confirm that a majority of women have to make a choice between career and family. According to Chodorow (1974), women are the primary caretakers of infants and young children and because of this, the earliest identification for both girl and boy babies is with the mother, a woman. As they mature physiologically, babies of both sexes begin a long process of separating themselves from the mother. For girls this separation process is never as complete as it is for boys, because mother is of the same sex. Women are unable to separate themselves from their relationships at home which does not leave them with an option to pursue Computer Science. In the words of Freeman and Aspray (1999), the image of computing as involving a lifestyle that is not well rounded or conducive to family life keeps women away from computer science. Freeman and Aspray (1999), point out that women also stay away from computer Science because the general perception is that software jobs are not family-friendly (e.g., long hours, lack of awareness of opportunities for telecommuting and other flexible schedules). Freeman & Aspray also point out concerns for safety and security felt by women and their friends and families about women working alone at night and on weekends also keeps women away from computer science.

In response to question 36, ten respondents wrote that the best encouragement mechanism was to have better and flexible work schedule for working mothers. Two of the respondents wrote that they were allowed flexible working hours but were given a laptop to complete the work assigned to them. This led them to hire childcare providers and did not allow them enough time with the family. Another survey response indicated "more maternity time for women." Turkle (1988) conducted a survey which pointed out that relationships are the main binding factor which becomes a personal and cultural symbol of what a woman is not and keeps women away from computer science. Therefore according to Turkle women's distance from computers is not computer phobia, but rather computer reticence, wanting to stay away from what does not belong to them. Some more of the survey responses on this issue were:

Role Models/Mentors

Survey responses also clearly show that role models/mentors are the second most important influencing factor for taking women towards or away from Computer Science. According to the Association for Women in Science (1993), female role models are particularly crucial for attracting and retaining women in science because women are socialized to a value connection. Three of the respondents wrote that without their role models they would have been lost. In the words of Lynn (1972), girls always need a female role model who is usually ever-present in the environment, to be imitated and to provide immediate feedback. Girls learning style is very different from the boys. Girls learn the lesson as presented and promotes a style based on personal relationship and imitation. All respondents placed strong emphasis on the importance of role models and mentors.

Freeman and Aspray (1999) point out that there are very few female role models in the Computer Science field which makes it hard for women to feel encouraged towards Computer Science. Some of the survey responses to questions 18 and 36 emphasize the importance of role models/mentors:

- "My mother was my role model, she still is. She is not in the science profession, but she is there for me. She raised me to believe in myself and told me that I was as capable of doing things as my brother. In our home there were no boy games and no girl games."
- "My older sister is my role model. She is a civil engineer. She is my hero. She taught me how to use a computer and encouraged me towards the computer science profession. She told me that I was not in a male profession and that I was in my own profession of liking. "
- More role models other than family members.

Noddings (1992) places emphasis on the positive role played by mentors/role models on the development of children. According to Noddings, "what is important is the aspect of caring which comes with being a role model. As role models we are not trying to teach problem solving through chains of mathematical reasoning, rather we show how to care in our own relations with cared-fors." Another survey respondent wrote as an answer to question 36, "I remember when I was a child and a teenager, I never dared to voice my likes and dislikes. My childhood best friend is still my role model. She encouraged me to speak for myself and encouraged me choose computer science as a profession. She felt it was a profession and did not label it as male or female." According to this respondent the most important encouragement mechanism is to 'have role model to look up to.'

Gilligan (1989) pointed out that if women and girls can stay with one another at the time when girls reach adolescence, girls' playfulness and irreverence may tap the wellsprings of women's resistance to culture of male domains and professions. Women in turn, taking girls' embodiment, their outspokenness and their courage, may encourage girls' desire for relationship and for knowledge and teach girls that they can say what they know and not be left all alone.

Teachers

Teachers were the third most important factor for taking women towards or away from Computer Science. One of the respondents wrote," I loved my kindergarten teacher. She told me nice stories about dolls and fighter planes. She is still my role model and always will be. When she passed away, I didn't know what to do." Another respondent wrote, "after my mother, my fifth grade teacher is my role model." Now my manager is added on to my list of role models. According to Skolnick, Langbort and Day (1982), children spend more time with their teachers than with any other adults except parents. They see themselves reflected in their teachers' eyes; what their teacher thinks counts heavily in their world. It is not surprising that teachers' expectations can affect children's achievement.

Survey responses indicate that the factors of teachers and role models/mentors are overlapping in some cases. For example, one survey respondent clearly said in response to question 36, "my art teacher was the best teacher I've ever had. She is my role model. She is a source of great encouragement to me " Another survey respondent said in response to question 36, " encouragement comes from someone who cares for you and someone whom you care for too. My role model is my college biology teacher. I felt her influence as a teacher and as a role model." Yet another respondent wrote in response to question 36 , "I could not stand taking on-line classes in college. I wanted a 'real' teacher – a teacher whom I could talk to and see in person. Someone who could encourage me and say 'you are a capable woman." A respondent to question 37 wrote, "more role models better teachers." According to Webster (1995), more female students feel the need of a 'human' teacher than learning over the Internet.

Some of the survey respondents wrote as an answer to Question 36, that teacher encouragement is an 'encouragement mechanism' for females to enter and retain themselves in computer science. These respondents complain that atmosphere in science classes is often cold which is not encouraging to anyone and particularly to females who are looking for warmth, support and care from the teacher. According to

Tobais (1990), a science classroom is perceived by most women, whether they succeed at and persist in science or not, as an 'unfriendly' place to be. More than their male classmates, women appear to be uncomfortable working in the intensely competitive environment that characterizes many introductory science classes. Tobias suggests that this 'unease' may contribute to the higher attrition rate among women considering a science major. Tobias also points out that women were likely to respond better to science if more cooperative and interactive modes of learning were part of the pedagogy and if scientific knowledge were more closely and explicitly linked to important societal issues. According to Kincheloe (1993),) teachers should not be simply transmitters of existing configurations of scientific knowledge. Teaching science cannot be reduced to the acquisition or mastery of skills or techniques, but must be defined within a discourse of human agency. Teachers should help to construct the dynamics of social power and relationship through the experiences that they organize and provoke in the classroom. It is the responsibility to make science education available for 'all.'

Masculine Traits of Successful Women

A common trait between four survey respondents is that women in science (including computer science) are authoritative, aggressive, masculine and competitive. These women are not nurturing role models to other women. The four survey responses that shed light on this aspect are:

• (Response to question 18) My mother is my role model. She is loving, caring and brilliant women. She is a successful wife, mother and a career woman. My mother stayed home with us (children) till we were 5 years old. I have a twin sister. I noticed that ever since she went to work (she is now Vice President of IT organization), she has become more authoritative at home. Her style of dressing has changed. She wore skirts all her life, but now she wears only pants!

- (Response to question 35) Both teachers and role models have helped me shape my career path. The most important aspect is forming a relationship based on trust. That is what helped me. 'All' my female science and math teachers were mean to me and other girls in my classes. I noticed that these female teachers were nice to boys.
- (Response to question 36) I have an undergraduate degree in computer science. I soon developed a close relationship with one of my computer science teachers. We are still on friendly terms. But I noticed she was so aggressive and masculine in her behavior. She could not stand if a student (male or female) challenged what she said – she got angry and very competitive. What would help as an instrument of encouragement for other women/girls would be to see more women in the computer science profession who are nurturing and willing to encourage more female to enter this so called 'male profession.' It does not help to see women in computer science take on 'male characteristics.'
- (Response to question 35) All these three factors played a crucial role in my life. Parents and role models played a positive role and my science teachers a negative role. I noticed my female computer science teacher (she taught me at 4 courses in the Master's program) was made of ice! A lot of female students dropped her class and ultimately the program because she was the instructor for most of the required

courses. What really helped me besides these three factors was reading inspirational books suggested to me by my parents.

Gilligan (1988) explains this phenomena of women in the sciences not being encouraging to other females entering this profession. Gilligan explains that it is like a film running backwards. Women teaching girls arrive at the moments of their own resistance and come up against their own solutions to problems which girls are facing in the present. These women remember obstacles in their own way and may encounter their own reluctance to know what they know. Women teaching girls may discover that they are harboring within themselves a girl who lives in her body, who is insistent on speaking, who intensely desires relationships and knowledge and who, perhaps at the time of adolescence went underground or was overwhelmed. It may be that girl students are looking for this girl in women and feel her absence or her hidden presence. If women become positive role models to other girls/women, it will break the old impasse in women's development.

Results from the survey responses indicate that women look for protective and supportive relationships which makes the three factors have an important affect either taking females towards or away from Computer Science.

Influence of media, summer science activities, and peer influence

Survey responses from questions 18, 35 and 36; indicate that media, summer science activities and peer influence also have an effect on the recruitment and persistence of women in science. Respondents mentioned that their parents would let them watch only discovery channel when they were young. When they grew up they watched science shows on television. Respondents mentioned, though not in detail that their parents took them to summer science camps sponsored by local county staff which were very helpful. Most of this staff was female which was a big help for females attending this camp.

Respondents have mentioned that seeing your female interested in science and determined about it was a big help. The respondents have described none of these factors in detail.

Implications

From the survey responses it is clear that all the three factors (parents, teachers, role models/mentors) are interrelated and have a significant impact on women. To encourage women towards Computer Science all of these three factors will have to work collaboratively. Based on the survey responses conducted for this study, a list of suggestions has been formulated:

- More frequent meetings between parents and teachers. It can help both parents and teachers to guide and direct children on their academic and career paths.
- More activities should be scheduled in schools for parents –teachers- female students' interaction. Activities, such as a female science club can be initiated where female science professionals can be invited as speakers. This can help provide encouragement to females to enter the science and technology (including computer science) profession.
- Seminars for parents to provide them with information on opportunities for girls in science and math.

•More gender equity workshops for teachers and employers.

Women need human touch and feeling protected and cared for. Therefore female Computer Science professionals are more likely to influence girls to enter the Computer Science profession and stay in it (Fisher and Margolis, 2000).

•Schools can encourage female students to enter science and technology, including Computer Science), by organizing activities as assigning a mentor to every students.

•Schools can host game shows (with science and mathematical background) for encouraging females to enter and stay in this profession.

For female persistence in computer science organizations, the following activities may help:

•Organizing a woman employee's forum which can meet twice a month. Speakers can be invited who are female and are successful in their Computer science careers.

•Having a mother-children day once a month where female employees can bring in their children with them to work.

Anticipated Outcomes Fulfilled

The following anticipated outcomes of this study were fulfilled:

•To find out how important are the three factors (teachers, parents, mentoring,) to the interest of females in the computer science field.

•To find out how important are the three factors (teachers, parents, mentoring,) in the persistence of females in the computer science workforce.

•The survey responses clearly demonstrate that all three factors (Parents, Teachers and Role models/Mentors are important in the recruitment and persistence of females in computer science.

Limitations

The following are the limitations of this study:

Even though the response rate for the self – administered survey was 100%; a limitation is that the population sample included in this study was drawn only from businesses involved in the Information Technology in the Washington Metro area. Another limitation of this study is that it is confined only to looking at the success of women the Computer Science field, not at the ones who dropped out. The results obtained from the self – administered survey cannot be generalized to all females since the sample population was drawn only from the Washington metro area. Moreover, the sample size of 40 being small, restricts the generalizability of the study and may skew statistical significance. The survey questionnaires were administered by the point of contact at the organizations chosen for this study. There is potential of bias because this point of contact could have had undue influence on the respondents (as a friend, co-worker or boss). However, the respondents were assured that the surveys would remain anonymous. The surveys were coded and the respondents were asked not to write their names on it. In this case, where anonymity was preserved the expectation would be to offset any potential for bias.

Most of the survey respondents were Caucasian and Asian and therefore the data collected should not be generalized to female population of other ethnicities.

Although, there is existing research in this area, more research is needed to study the effects of these and other factors (ethnicity, peer influence, summer science programs, and media) on the recruitment and retention of women in computer science.

This study also collected data from utilizing the same questionnaire on the web. The web survey was accessed by a total of 53 respondents of which only about 32 respondents completed the survey in its entirety. Even though the web survey eliminates the component of bias, it still holds the risk of high coverage error, which leads to a mismatch between the target population and the sampling frame (Newman, 2003). As many people still lack Internet access and among those with access, it is not possible to include and locate everyone and respondents are not equally computer literate (Dillman, 2000; Newman, 2003).

Recommendations for Future Research

This study provides rich opportunities for future research. This study leaves the field open for research on how would ethnicity affect the entry and retention of women in computer science. This study does not deal with ethnicity as factor. Further research is needed to look at the effect of media, peer influence and summer science courses on the entry and persistence of women in computer science. Further research is also needed to analyze why women in sciences become more masculine. Another issue for future research is how to provide more visibility to successful women in computer science so that more women can learn that there are women in this field who can prosper in this profession. A topic worth further research generated by this study is to find if more females enter and persist in Computer Science if both or at least one of their parents is in this field. Further research can also be conducted to determine the effect of male role models on the entry and persistence of females in computer science.

Recommendations for Types of Future Research Studies

Survey responses have clearly demonstrated that parents, role models/mentors and teachers have a significant impact on the entry and persistence of women in computer science. The additional factors (media, peer influence, summer science activities) that impact women in computer science have been discussed by the respondents in relation to parents, role models/mentors and teachers. This further confirms the significant impact of these factors (parents, role models/mentors and teachers) and on women. It also leads to the fact that these three factors (parents, role models/mentors and teachers) are the broad umbrella under which there could be several factors that could possibly affect the entry and persistence of women in science. This study leaves implications of further research in the following areas:

- Educational research
- Socio-Psychological research

Both of the above mentioned types of research are inter-related. The education system is based on social values, which in turn affect and shape the psychology of the whole society.

Educational Research

Survey responses consistent with the research literature point to the unfriendly climate in science and technology classes for female students. Teachers use different styles of teaching for girls than they do for the boys. Boys are encouraged and girls are left out (Henwood 2000; AAUW 2000). The curriculum is not conducive to female growth in science and technology. Men write most science and technology books. Most textbooks written for early grades before 1970 portrayed males and females in sexually stereotyped roles. Girls were portrayed helpless and boys were shown to be active. As Barton (1998) points out, 'by seventh grade I knew that teachers, textbooks and class lessons were telling me that women were not scientists. When I tried to express my interest in chemistry, I was punished by my teacher for not being realistic.' Future research can hopefully find interventions to lessen and finally eliminate the gender stereotyping in the curriculum. Hopefully, future research will be able to provide classrooms of science 'for all,' where females will be encouraged as much as males.

Socio-Psychological Research

Socio-psychological issues such as self-confidence, perceived ability have been linked to female persistence in science (Deaux 1976; Gilligan, Lyons & Hammer, 1990). The earliest memories of children are their parents (Sadker & Sadker, 1985). It is how children perceive their parents' treatment towards them that leads girls and boys to think they are suitable for doing certain things and not others. Gender-stereotyping usually begins at home and continues through the education system (Woolfolk, 1995). Parental expectations of their children influence children's educational and occupational aspirations. It is how girls and boys perceive their roles in society as a result of this psychological conditioning that they shape their career choice. Further research can find interventions to hopefully break this vicious circle of gender biased social values, which have led to psychological conditioning of the society at large. These research interventions may hopefully free both boys and girls from their preconceived notions, which will in time bring some change in the social values so that academic choices and professions are not labeled as male or female.

Conclusions

Women can certainly be as successful in the computer science profession as men. As Tobias (1990) said, "they (girls) are not dumb, they are different." There are opportunities available for women in computer science but women have a very different picture of the computing world then men do. Women who are so intricately involved in the power of relationships look are computers as 'cold machines.' Men who do not look for relationships on the same scale as women enjoy working with these machines. The underrepresentation of women in computer science is a matter of concern to the nation and research is being conducted to find out how to increase the number of women in computer science. Various research and academic institutions (MIT, Stanford University, NSF, Brown University, The Spencer Foundation, AAUW, and ACM-W, United States Department of Education, United States Labor Department, The National Science Foundation, Computing Research Association) are researching these problems to find a way to reduce this gender gap. The present study was an attempt to discover the impact of only three of the many factors that affect the entry and retention of women in computer science leaves rich opportunities for further research.

APPENDIX A

LETTER TO SURVEY RESPONDENTS

Rima S. Gulshan
School of Education, American University
Washington, D.C. 20016-8030

Oct 11, 2001

Dear Participants:

I am a Doctoral student at the American University, Washington, D.C., working on my dissertation titled 'Factors that influence the Careers of Women in Computer Science: A Quantitative and Qualitative Analysis.' The purpose of this study is to explore and describe the impact of the three factors (parents, teachers, and role models/mentors) on women in Computer Science and also the perceived impact of these three factors towards the recruitment and retention of women in the workforce. The reason for conducting this study is to gain insight into this problem of inequity and to find possible ways to lessen, and hopefully eliminate it, over a period of time. This survey is the main tool I am using in collecting information, and should take you approximately 20-25 minutes to complete. If you have any other insights into this issue that you are willing to share, please feel free to include them.

As successful women in this field, you can contribute immensely to my study with your knowledge and opinion of factors that prompted you to enter and persist in Computer Science. Your insights can help more women to enter and persist in this field. I appreciate your taking the time to fill out the survey, thereby making an important contribution not only to my study but also to the broad field of research dealing with similar issues.

Your identity and the identity of your organization will remain anonymous. I look forward to sharing the results of my study with you. If you need any more information about this research you can reach my committee chair Dr. Sarah Irvine at 202.885.3714 or via email at sirvine@american.edu. I can be reached at 703.978.0698 or via email at rgedu@aol.com.

Thank you.

Sincerely,

Rima S. Gulshan

APPENDIX B

SURVEY QUESTIONNAIRE

Factors That Influence the Careers of Women in Computer Science: A Quantitative and Qualitative Analysis

A1

SURVEY QUESTIONNAIRE

Thank you for taking the time to complete this survey. It will take approximately 20-25 minutes to complete. Please answer the questions below by checking the appropriate checkbox or writing in your response.

1. Age range:
   - ❐ under 21
   - ❐ 21-25
   - ❐ 26-32
   - ❐ 33-40
   - ❐ 41-48
   - ❐ 49-56
   - ❐ 57 and above

2. Ethic background:
   - ❐ Caucasian
   - ❐ Asian or Pacific Islander
   - ❐ American Indian
   - ❐ African American
   - ❐ Other

3. Occupation: ____

4. Highest education/degree earned is:

- ❐ Associate
- ❐ Bachelors
- ❐ Master's
- ❐ Doctorate
- ❐ Other

5. Undergraduate degree was earned at:
   - ❐ Women's college
   - ❐ Private college
   - ❐ State college
   - ❐ Other (please specify):

6. Undergraduate degree is in: ____

7. Master's degree is in: ____

8. Doctoral degree is in: ____

9. Highest educational level/degree earned by parents:
   - ❐ Associate
   - ❐ Bachelor's
   - ❐ Master's
   - ❐ Doctorate
   - ❐ Other (specify):

10. List family members (parents and siblings) with degree(s) in science (including computer science) and technology: ___________________________________
    ____

11. List all science (including computer science) and technology courses taken in high school: ____
    ____
    ____

12. List all science (including computer science) courses taken in college: ___________
    ____
    ____

Please circle only one response for questions 13-17, 19-32

13. The influence of parents and family members is a crucial factor for instilling female interest in computer science.

Strongly agreeAgree Uncertain Disagree Strongly disagree

14. Parents and family members were the most important factor in my decision to choose computer science as a profession.

Strongly agree Agree Uncertain Disagree Strongly disagree

15. My mother was the most important role model/mentor who instilled inspiration for me to pursue computer science as a major.

Strongly agree Agree Uncertain Disagree Strongly disagree

16. The absence of parental and family support at an early age to pursue computer science drives girls away from this field of study.

Strongly agree Agree Uncertain Disagree Strongly disagree

17. My parents owned a computer at home that encouraged me to develop my interest in computer science.

Strongly agree Agree Uncertain Disagree Strongly disagree

18. Do you feel your family/parents influenced you in pursuing a career in Computer Science in other ways as well? Please explain. ____________________

____
____
____
____

19. Boys and girls should be given the same kind of toys to play with at home and at school to give both sexes an opportunity to develop their abilities in any direction including humanities, science (including computer science) and technology.

Strongly agree Agree Uncertain Disagree Strongly disagree

20. Teachers in school played an important role in encouraging me to pursue a career in computer science.

Strongly agree Agree Uncertain Disagree Strongly disagree

21. My teachers strongly discouraged me from a computer science career.

Strongly agree Agree Uncertain Disagree Strongly disagree

22. I lost interest in science and technology courses following discouragement from my teachers.

Strongly agree Agree Uncertain Disagree Strongly disagree

23. Teacher encouragement is an important factor of female persistence and retention in computer science.

Strongly agree Agree Uncertain Disagree Strongly disagree

24. My female computer science teacher/teachers influenced me as a role model leading me to pursue a career in computer science.

Strongly agree Agree Uncertain Disagree Strongly disagree

25. I persisted in computer science because my computer science teacher(s) provided me mentoring.

Strongly agree Agree Uncertain Disagree Strongly disagree

26. A female role model/mentor is important to female retention in computer science.

Strongly agreeAgree Uncertain Disagree Strongly disagree

27. Female students are encouraged to stay and pursue a career in the computer science field when computer science teachers interact with male and female students on an equal basis.

Strongly agree Agree Uncertain Disagree Strongly disagree

28. As a female computer scientist, I actively participate in activities (role model/mentor) to encourage more females to enter this field of study.

Strongly agreeAgree Uncertain Disagree Strongly disagree

29. As a parent, I encourage my children (both male and female) to pursue a career of their choice.

Strongly agree Agree Uncertain Disagree Strongly disagree

30. As a parent, I do not portray computer science as a 'male' profession only.

Strongly agree Agree Uncertain Disagree Strongly disagree

31. As a parent, I volunteer at the local school system/colleges/universities to provide my services as a role model/ mentor to encourage female students to enter science (including computer science) and technology fields of study and profession.

Strongly agree Agree Uncertain Disagree Strongly disagree

32. As a female computer science professional, I volunteer at the local school system/colleges/universities to provide my services as a role model/mentor to encourage female students to enter science (including computer science) and technology fields of study and profession.

Strongly agreeAgree Uncertain Disagree Strongly disagree

For questions 33 and 34, please use the following scale:

A = most positive B = next most positive C = least positive

33. Of the following three factors, rank the most positive factor which fostered your interest in computer science.

_____ Teachers
_____ Parents
_____ Role model/mentor

34. Rank the following three factors in terms of their positive impact on female recruitment and retention on computer science.

_____ Teachers
_____ Parents
_____ Role model/mentor

35. In your opinion, are there any other factors besides these three (teachers, parents, role models/mentors) that play an important role in female recruitment and retention in computer science?

____
____
____
____
____
____

36. In your opinion are there any specific encouragement mechanisms that you would like to suggest that might play an important role in female recruitment and retention in computer science? Please list and explain:

Thank you again for taking the time to complete this survey!

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