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Young Women's Decision to Pursue Non-Traditional Science: Intrapersonal, Interpersonal and Contextual Influences

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Abstract

Much research has been conducted on the issue of the under-representation of women in math, science and engineering careers. This research has largely focused on a single factor and has usually taken the form of survey research. Little research has taken a holistic approach, nor has it looked exclusively at young women who have recently begun a program in math, science or engineering. The present study was qualitative in nature and it took a holistic approach to the study of the under-representation of women in math, science and engineering in order to gain a better understanding of the influences involved in this decision.

This study focused on three factors which are involved in the decision to continue in math and science and they include Interpersonal Influences, Contextual Influences and Intrapersonal Influences. Thirteen in-depth interviews were conducted with young women who were in their first or second year of a math, science or engineering program. Interviews focused on these three factors.

The interview data revealed that these young women were most significantly influenced by Intrapersonal factors. The decision to enrol in a math, science or engineering program is most directly affected by the fact that these young women had a passion for math and science throughout their school years. They talked enthusiastically about what attracts them to these subjects; why they enjoyed them; and how they were an integral part of their lives. The fact that the participants loved math and science was the main factor that kept them involved despite the obstacles they encountered. These young women were also strongly influenced by Interpersonal factors such as teachers, peers/friends, parents and others who supported, encouraged and provided them with information. Thirdly, the participants were influenced by

Contextual factors such as group work and labs, special programs and course selection where they had opportunities for exploring math/science careers, participating actively, collaborating within groups and interacting with role models.

Implications of this study suggest that educators and parents need to become more aware of what can be done to foster a passion for math and science in girls at a young age. It is important for girls to made aware of their career opportunities and to continue taking math and science in order to keep their options open. Intervention programs involving role models have proven successful in fostering an interest in math and science and providing information about what is involved in a math/science or engineering career. Teachers, peers/friends, and parents need to be aware of the importance of their influence in girls' decision to pursue a given career.

Chapter One - Introduction

Although some progress has been made over the past twenty years, women remain considerably under-represented in engineering and math and science related occupations. It is true that opportunities have improved steadily with almost 25% of scientists and engineers in the United States and Canada being women (Schiebinger, 1999), however, it is also important to note that of the 61 000 members of the professional engineers of Ontario, only 2000 are women (Frize, 1997). In the 1994/95 school year, in Canadian Universities females accounted for 57% of the total undergraduates enrolled but only 24% of the undergraduates in engineering, applied science, math and physical science were women (Datillo, 1997). And finally, only nine women have won Nobel prizes in science compared to more than three hundred men (McGrayne, 1993).

Starting as early as elementary school girls are excluding themselves from science related occupations (AAUW, 1992). In high school, many young women already have a clear idea of the occupations they do not plan to pursue. Even girls with excellent math and science preparation in high school are choosing to pursue math and science related careers at disproportionately low levels. An important American study found that 64% of senior high school males who had taken physics and calculus were planning to major in science or engineering in college compared to only 18.6% of the females who were equally prepared (Dick & Rallis, 1991).

The low representation of women in science and engineering fields may have serious productivity implications. We are currently excluding half of the world's brain power and productivity and wasting a great deal of technological talent (Peltz, 1990). In an economy based on technology and information, we must use all of our resources in order to remain competitive in this technologically sophisticated world (Oakes, 1989).

There are also serious implications for women at a more personal level. According to Dick and Rallis (1991), with the increasing emphasis on science and technology in our society, women are putting themselves at a great disadvantage if they opt out of math and science. Choosing a scientific career is likely to increase women's standard of living and put them at an advantage both socially and politically. Women who choose non-traditional careers can expect to have lifetime earnings that are 150% of women who choose traditional careers (Women and Work, 1997). However, it is also important to remain sensitive to the fact that many traditional female careers are under paid. The societal value attached to traditional female work is a separate issue that needs to be addressed. Similarly, it is important to remember that nontraditional careers are not appropriate for all females just as they are not appropriate for all males.

Although much research has been conducted on the issue of the low representation of women in engineering and math and science related careers, we actually know very little about young women who have recently entered these areas in university. These individuals have rarely been given the chance to explain why they believe they chose a science career. It is necessary to understand why some women choose science careers in order to know how to effectively encourage more women to enter these fields (Fabrikant, Svitak & Kenschaft, 1990).

The present study represents an attempt to gain a better understanding of why some women enter math, science, and engineering programs. It is a qualitative study and data were collected through in depth interviews. The purpose of the study was to gain a better understanding of why some young women enter non-traditional science related programs in order to better ascertain how we can encourage more young women to do so. The study focuses on math, science and engineering together as these subjects have often been studied together in past research. As well, there is a strong connection between these subjects, and math has often been considered the "critical filter" to the study of science and engineering (Kahle, Parker & Rennie, 1993).

The study focused on school influences and examined the following three contributing factors in young women's decision to pursue a science, math, or engineering program in university: 1) Interpersonal Influences; 2) Contextual Influences; and 3) Intrapersonal Influences.

These three factors were chosen because they show up most frequently in the data as important in career and course choice decisions. What is more, they cover a broad range of the home and school influences in people's lives and they are specific to childhood and adolescence which was the focus of this study. The research shows that children as young as four years old already have strong ideas about which occupations are appropriate for their sex and which ones are not, and by early adolescence, many girls have excluded themselves from a large number of occupations (Steinke & Long, 1996). In order to get a clearer picture of the impact of these influences it is important to ask young women who plan to pursue a science program why they made this choice based on their recollections of their school years. These three factors have also been the focus of research on why girls drop out of math and science as well as in studies of women who do pursue science careers.

By focusing on these three factors we will be able to develop stronger educational programs geared at retaining women in math and science. With a stronger understanding of why young women continue to take math and science courses, schools will be better able to develop more effective curriculum materials, instructional processes and special programs that promote involvement in math and science. This type of information would also be helpful in order to better equip counselling services with the resources and information needed to ensure that students are encouraged to keep their doors open as well as to consider a wide range of careers.

A retrospective study is important because it involves women who have recently graduated from high school and can likely remember their adolescence clearly. Young women who have recently finished high school and are planning to pursue a science program are likely to be able to articulate why they chose this program and remember what influences were involved. According to Dick and Rallis (1991), "Given the inherent limitations of surveys and the rarity of women choosing careers in science and engineering, interviews with these women might be the best step toward gaining a more detailed picture of the forces forming their career choices (p.283)".

Qualitative studies in this area are important because we lack detailed information about the factors young women believe led them to pursue math, science or engineering programs. The available research in this area has been limited to one or two factors and generally focuses on factors that influence girls to opt out of math and science. Some studies have focused on the reasons why adult women have entered a science career, but there is a lack of information on why young women choose to pursue these programs. This type of information is essential if we hope to gain insights into the reasons women opt into or out of science. It is also integral for informing educational initiatives designed to encourage science participation. It is important to know what young women think and believe in order to develop responsive programs.

This study represents an attempt to gain a more holistic understanding of why some young women choose to pursue careers in math, science and engineering. A criticism of many of the studies in this area has been that they only focus on a single aspect of the problem. Hanson (1992) noted: "A good example of the lack of attention to complexity in past research is the tendency of many analysts to focus on single dimensions of the science experience" (p. 84). Mau, Domnick and Ellsworth (1995) also commented on the lack of attention to the complexity of the problem in the following statement: "The studies provide information about variables associated with women's aspirations to nontraditional careers, but give no information about the significance of each variable in comparison with the others and do not indicate how these variables interrelate and contribute to the choices that women make when choosing nontraditional occupations" (p. 324). This study was an attempt to better grasp the complexity of the factors that shape the decision to pursue a math, science or engineering program.

The focus on Interpersonal, Contextual and Intrapersonal Influences was taken based on the social psychological perspective. This perspective rests on the belief that people bring various personality factors, attitudes and beliefs to their social situation, which is also influenced by a variety of socialization factors. The factors focused upon in this study all fit within the social psychological framework. From this perspective, decisions are based on interpersonal, contextual and intrapersonal factors.

This study is guided by two social-psychological theories: cognitive social learning theory and gender schema theory/sex-role stereotyping. Bandura (1978) explains that in social learning theory, causal processes are conceptualized in terms of reciprocal determinism. From this perspective, psychological functioning involves interactions between interpersonal, contextual and intrapersonal influences. Farmer, Wardrop, Anderson and Risinger (1995) highlight how the interaction among these factors influences science participation: "over time a broad range of interacting factors in the self and in the environment influences the strength of interest in careers and the selection and persistence in a science, math, or technology career" (p. 155). Cognitive social learning theory emphasizes modeling and reinforcement.

Sex-role stereotyping and gender schema theory is also relevant for this study. The stereotyping of math and science as male domains is often considered a contributing factor to the under-representation of women in engineering and math or science related careers. According to Inkpen (1996), "no where is the cost of sex bias, sex role stereotyping and sex discrimination more compelling, concrete or clear than in the area of occupational aspiration, vocational education and the resulting employment, economic self-sufficiency and job satisfaction of females and males" (p.33).

A schema is a general knowledge framework that a person holds about a topic; it organizes and guides perception. Schemas help us to process and remember information, but they also act to filter and interpret information and can therefore cause errors in memory. Each of us have gender schemas which represent a basic predisposition to process information on the basis of gender. Hyde (1991) explains that "the developmental process of gender-typing or gender-role acquisition in children is a result of the child's gradual learning of the content of society's gender schema" (p. 57).

Sex-role stereotypes can be seen as resulting from gender schemas. People tend to hold certain stereotyped beliefs because of the frameworks we gradually develop based on gender. Gender schema theory is a more recent way of explaining how we each develop sex-role stereotyped beliefs. The factors which will be discussed in this paper are all influenced by sex-role stereotyping and gender schemas. For example, interpersonal influences can be affected by stereotypes if teachers, parents, and peers have stereotyped beliefs which could lead to differential treatment of boys and girls (Evans, Whigam & Wang, 1995). Contextual influences are also likely to be influenced by stereotyped beliefs. According to Koballa (1988) "the disproportionate enrollment of the sexes in science courses has received attention as a prominent example of the effect of sex stereotyping" (p. 480). Stereotyped beliefs could also affect participation in lab activities if a girl believes that her role is to take notes rather than to engage in hands-on experiences. Intrapersonal factors can be affected if girls develop attitudes and beliefs about the appropriateness of girls engaging in math and science courses and careers.

This study represents an attempt to gain a stronger understanding of why some young women enter math, science or engineering programs in university. It is a qualitative study which used in depth interviews to gain insights into how Interpersonal, Contextual and Intrapersonal factors affect the decision to continue math and science participation. Previous studies in this area have focused on one aspect of the issue. This study took a more holistic approach, taking into account a wide array of the influences upon this decision.

The following chapter presents a review of the literature related to Interpersonal Influences, Contextual Influences and, Intrapersonal Influences. Chapter three includes an explanation of the methodology involved in this study and chapter four presents the results of the interviews. Finally, chapter five is a discussion of the results, implications for practice, research limitations and the final conclusions.

Chapter Two - Literature Review

The following section will include a review of the literature related to the three factors which are the focus of this study. First, Interpersonal Influences will be discussed in terms of student-teacher interactions, peer/friend influences and parental influences. Contextual Influences will include a discussion of group work and labs, course selection and the lack of information about math/science careers. Finally, the literature review will include a look at the role of Intrapersonal Influences. The literature review will include studies which look at both math and science as well as ones that look at math alone. I believe that these studies are relevant because math has often been considered the "critical filter" to the study of science and engineering. Students who continue to take math courses in high school are more likely to pursue engineering and science careers.

Interpersonal Influences

Much of the research in this area has focused on the role of Interpersonal Influences on the decision to pursue or not pursue a math, science or engineering program. The following section will look at the role of teachers, peers/friends and parents, and how they are involved in either discouraging or encouraging girls to pursue a math, science or engineering program.

Teachers

Many studies have focused on the role of teachers as a factor leading to different course and career choices between boys and girls. It is well-documented that girls and boys have very different experiences in math and science classrooms both at the elementary and secondary school levels (Scantlebury & Kahle, 1993).

Teacher-student interactions in science and math classrooms have been the focus of considerable research. Scantlebury and Kahle (1993) suggest that "teachers can perpetuate stereotypic cultural beliefs regarding girls' ability in, aptitude for, and suitability for science by their teaching practices and behaviours " (p. 537). Jones and Wheatley's (1989) research produced similar results. In their study of high school physical science and chemistry classes, they found that boys spoke more often and in louder, more confident tones, while girls were praised less and appeared to be more quiet and self-conscious.

A study by Barba and Cardinale (1991) looked specifically at teacher/student questioning interactions in high school science classes in order to determine the quality of these interactions with regards to gender. The interactions which were explored included: a) on-task vs. off-task student responses; b) teacher designated vs. non-designated methods of attraction such as raising hands vs. calling out; and c) low level vs. high level questions asked by the teacher. The results indicated that female students had fewer interactions with their science teachers and received less attention. Teachers asked female students more low-level questions and male students more high-level questions and females were also less likely to be identified as "target students". The female students were more likely to remain on task and to raise their hand when they had an answer. According to the authors, "as students move from one science class to another over the course of time, female students may attribute their successes to luck and a sense of failure in the sciences to low-ability and ultimately produce less effort. In this way, the lack of any interaction between science teachers and female students instigates a vicious cycle that terminates in avoidance of science classes by females" (Barba & Cardinale, 1991, p. 309).

Often, the types of questions asked and the questioning techniques used by teachers differ depending on the sex of the student (Scantlebury & Kahle, 1993). Teachers have been observed asking a question of the class then looking at a male student, as if a female would not be expected to know the answer. Boys in both elementary and secondary school are often called on more frequently, are asked more higher order questions and receive more feedback (Peltz, 1990). Similarly, Jones and Wheatley (1990) found that males were more likely to call out answers and male students were more likely to be praised by teachers. These results are consistent with those found in other studies of gender differences in classroom interactions with teachers (AAUW, 1992; Sadker & Sadker, 1994; Scantlebury & Kahle, 1993).

Gender differences in science classrooms are not limited to questioning activities. For example, Jones and Wheatley (1988) looked at the kinds of criticism teachers directed toward males and females. They found that science teachers criticized males more often; however this criticism may not be perceived negatively by students but rather may serve as a form of positive reinforcement. They also suggested that girls are criticized for intellectual inadequacy, whereas boys are criticized for lack of effort or failure to be neat. The researchers concluded that this type of criticism may not threaten a boy's view of his ability but the types of criticism directed towards girls may be more likely to have an impact on their self-esteem.

Hanson (1992) suggested that there may be long term consequences of differential treatment in classrooms. He maintained that white males receive the most positive attention in science and math classrooms and that they are pushed to think, to expand on ideas and to defend their positions, thus preparing them better for the adult world. Girls on the other hand receive less praise, less negative behaviour feedback and less nonacademic feedback. Sadker and Sadker (1994) indicated that at all grade levels and in all subjects, females have fewer opportunities to interact with teachers.

Research studies have suggested that teachers may not be aware of their influence with regards to young women's involvement in math and science courses. For example, Plucker (1996) found that teachers showed a low level of awareness with respect to how their actions may affect the performance of girls in math and science. Some intervention studies have been conducted to sensitize teachers to how they can positively affect their students' attitudes and behaviours.

In 1989, Mason and Kahle conducted a study in which teachers were involved in an intervention program aimed at encouraging the full and fair participation of girls in their science classrooms. The Teacher Intervention Program was designed to sensitize teachers to the importance of a stimulating, equal learning environment, through workshops and personal communications. The experimental group, compared to a control group composed of teachers who did not attend the intervention program, had students who scored significantly higher on measures for attitudes and perceptions toward science and scientists, experiences in extracurricular activities, and interest in a science related career.

Teachers can act as positive role models for girls by providing them with encouragement and the opportunity to see women with positive attitudes toward science and engaging in science activities (Oakes, 1990). In one study of first year students at Stanford University, it was found that women with female math teachers in high school had higher SAT math scores. This effect was not simply the result of superior teaching because the effect was not found for male students. Furthermore, nearly three times more women who had had one or more female role models in high school received A's in their college math courses in comparison to those who had all male math teachers in high school (Boli et al.,1985, cited in Oakes).

Most of the research concerning teachers is concerned with what types of interactions between teachers and girls leads girls to eventually drop out of these courses and not pursue a career in one of these areas. We have little information about how teachers contribute to young women's decisions to pursue science, math and engineering programs. Further research is needed which takes into account how teachers enhance or inhibit young women's decisions to pursue post-secondary studies in math, science and engineering.

Peers/Friends

The effect of peers and friends on the decision to pursue a science related program is not clear. Moffat (1992) found that peers/friends did not appear to have an effect on career choice. About 50% of the students in grades two, five, eight and eleven who were interviewed in this study said that their friends would think a science career was a positive career choice, while 50% did not.

There is some evidence to suggest that the influence of peers/friends may shift over time. Baker and Leary (1995) conducted a qualitative study in which they interviewed girls in grades two, five, eight and eleven about their science experiences and what influenced them to choose science. The students in grade two indicated that their friends would be supportive if they chose a science career, but by grades five and eight they felt that their friends would not be supportive. However, by grade eleven the girls again believed that their friends would be supportive.

Leslie, McClure and Oaxaca (1998) suggest that peer influence is the "missing link" that explains the transformation of adolescent girls from being equal participants in math and science. They suggest that because adolescence is a time when some girls value popularity over academics they may lack the self-confidence to pursue their own goals regardless of what their peers believe they should do.

These studies highlight the importance of considering the influence of peers/friends on girls' decision to pursue math/science programs. The research that has touched on this area is inconclusive. It appears that friends may have an influence, especially for girls. However, little research has looked at how females respond to the support or lack of support of their peers and how they perceive peers/friends' responses as influencing their decisions. Further research is needed to ascertain how peers and friends influence young women who are pursuing math, science and engineering careers. This kind of research could help reveal the intricacies of peer influence and the subtle ways in which peers affect each others' decisions.

Parents

Another Interpersonal Influence that has received attention is parents. The influence of parents has been found to be important for females in their decision to pursue math and science related careers (Fabrikant, Svitak and Kenschaft, 1990). Campbell and Connolly (1987) found parents were the strongest negative social influence on girls' science career choices when they held different expectations for daughters than for sons and when they treated their children in ways that reinforce gender stereotypes. Parents often expect math to be more difficult for their daughters, discount the importance of math and science and provide fewer opportunities for out-of-school math and science opportunities (Oakes, 1990).

Clewell, Anderson and Thorpe (1992), suggest that "parents who value and have confidence in their children's ability to do well in math and science have a positive influence on their children's attitude and performance" (p. 87). Parents can help their daughters by acting as teachers, role-models and support people. They can also help to counteract the stereotyping they encounter in school and in society.

A 1995 study examined the factors which influence the course choices of gifted adolescent students who participated in a summer academic program. The focus was on the factors which influence the choice between math, science and verbal oriented courses. Students were required to fill out a questionnaire with their parents prior to the summer program. The results indicated that parental attitudes were very influential in their children's decision to pursue math and science courses. The more importance a parent attributed to a subject for his or her child, the more likely a child was to choose that subject. Parents of boys were more likely than parents of girls to believe that their children were interested in and good at math and science. Parents of sons also believed that math was more important to their sons' than to their daughters' future (Olszewski-Kubilius &Yasumoto, 1995).

Leslie, McClure and Oaxaca (1998) suggested that women who enter math/science careers tend to come from intact families, have mothers who work, have parents who are well educated and consider education to be important. These authors believe that parents have an effect on course and career choices through "demonstrating the feasibility of science and engineering careers, that becoming a scientist or an engineer is a reasonable expectation, in a word, that it is efficacious" (p. 260).

The differential role of mothers and fathers has been the focus of some research. Montgomery (1990) studied the career aspirations and the factors influencing career decisions of a group of 15 gifted females in grade eight through a multiple case study approach. The women who pursued math/science careers differed from the other women in several ways related to family. They were more likely to have fathers with careers in math or science, they were more likely to receive both their mother's and father's encouragement for career choice in math and science and they were more likely to choose a career related to their father's field of study.

These studies support the results of previous studies which suggest the importance of parental influence. Haworth, Povey and Clift (1986), found that fathers were an important influence for female engineers and more of the mothers of non-engineers expressed positive attitudes towards their daughters' chosen careers than did mothers of engineers. Similarly, Eccles and Jacobs (1986) found that parents' stereotyped beliefs were a key cause of sex differences in students' attitudes toward math. Parents with strong stereotyped beliefs about the difficulty of math for girls and boys appeared to pass these beliefs on to their children.

The research indicates that parents play an important role in their daughters' attitudes toward math and science, in their decisions to continue to enrol in math and science courses in high school and in their career choices. However, we have few detailed accounts of how young women perceive parents influencing their career decisions. Further research is needed that focuses on how parents influence course and career decisions and how this influence is perceived by their daughters.

In sum, the literature indicates that Interpersonal Influences play an important role in the choice of whether or not to continue in math and science courses. The literature on teachers has been based mainly on direct observations in classrooms and has indicated that boys and girls have very different classroom experiences. The literature however, does not provide a clear picture of how teachers positively influence their students. The role of peers/friends in course and career choice decisions is one that has not been studied extensively, and the results thus far, are inconclusive. Most of the studies which have touched on this area have not probed very deeply into the more subtle aspects of the influence of peers/friends. Nor does the research provide information about how young women perceive the influence of their peers and friends. Parents also appear to play an important role in course choice decisions. Parents who are involved in science careers themselves as well as parents who stress the importance of math and science to their children are found to be more likely to have daughters who pursue these courses. However, as is the case with peers and friends, it is unclear how young women perceive the influence of their parents on their decision to pursue a science career. The research on Interpersonal Influences leaves us with few detailed accounts of how young women see these interpersonal factors influencing career decisions.

Contextual Influences

The second main factor that has emerged from the literature as important in career and course choice decisions among adolescent females is that of Contextual Influences. This section will include a discussion of group work and labs, course selection, special programs and the lack of career information provided in high schools.

Group Work and Labs

Interactions between male and female students in math and science classrooms have been found to influence attitudes toward these subjects. During science labs, girls are often relegated to the position of note-taker and consequently get less hands-on experience in science (Peltz, 1990). Other researchers have noted that males often monopolize equipment

(Scantlebury & Kahle, 1993), are more aggressive, and as a result, get more hands-on time with computers and other science equipment (Sadker & Sadker, 1994). Jones and Wheatley (1989) suggested that male students are more interested in participating in science activities, and female students appeared to take an observer role.

Some studies indicate that more girls than boys dislike science and lack interest in science careers. However, other studies especially of biology and chemistry have found that girls have better attitudes. For example Baker and Leary (1995) found that girls expressed strong feelings for more interaction with their peers; in particular they requested more group work and discussion. A key theme that emerged from their study was the social nature of group work. One student highlighted the social appeal of group work: "cause it's fun working with different people and seeing what they do and why they like it" (p. 9). Another student also commented on her preference for social interaction in groups: "It's like communication back and forth instead of just sitting there. You know, her lecturing us and us just sitting here hearing it, and you know, trying to absorb it" (p. 9).

Another aspect of classroom interactions that appears to impact positively on girls' involvement in science is lab work. Burkam, Lee and Smerdon (1997) found that hands-on lab activities were related to all students' performance, but especially to girls'. The authors suggest that "to increase girls' confidence, performance, and interest in science, the major reform that advocates call for is increasing the emphasis on hands-on instruction in schools" (p. 319).

Much of the research on lab work has found that girls have negative experiences in these settings. Further research is needed to ascertain how these negative experiences can be improved. Furthermore, research is also needed which focuses on why some young women enjoy these experiences. In this way, we will be able to figure out what can be done to make lab work a positive experience for other girls. Some research has found that group work is preferred by many female students who enjoy the social aspect of this work. Further research is needed which looks at exactly what aspects of group work girls prefer in order to apply these aspects to the curriculum. This is especially important in non-traditional sciences (e.g. physics, engineering) where girls are still highly under-represented.

Course selection

The issue of course selection has been an important one in the research concerning the under-representation of women in math and science related careers. Several researchers have found that many young women decide to drop math and science courses as soon as this choice becomes available to them, often in grade ten or eleven. In making this decision they inadvertently exclude themselves from a wide range of careers. At an early age, girls are being asked to make important decisions that will affect the rest of their lives because they are allowed to choose whether or not they want to continue taking math and science courses. It has been suggested that they may have a skewed view of their futures and may be making decisions at a time when being popular is more important than deciding on a career (Sadker & Sadker, 1994).

There is evidence to suggest that males and females enrol in different types of science courses. For example, Haggerty (1991) found that a higher percentage of Canadian high school females enroll in biology and a greater number of males enroll in physics. Other researchers have concentrated on the issue of differential course choices amongst people who continue in math and science compared to those who do not. In 1986, a study was conducted of the perceived influences on career choice among female engineers and non-engineers. This study revealed that only 27% of the non-engineers compared with 82% of the engineers had studied any physical science subjects in high school. Furthermore, 39% of the non-engineers stated that they had *chosen* not to study 'masculine' subjects compared with only 9% of the engineers (Haworth, Povey & Clift, 1986). This may be a reflection of the problem of sex-role stereotyping discussed earlier. Many of us have been socialized to believe that math and science are masculine subjects and this may be one of the factors related to the high rate of females who opt out of these courses in high school.

A 1995 longitudinal study which compared the factors related to persistence in a science related career between men and women revealed similar results. In 1980, when the study began, the participants were ninth and twelfth grade students (n = 2082). Students who were aspiring to a math/science career were identified. In 1990, results of this study indicated that among women, the most important relationship for persistence was found for elective science course-taking behaviour in high school. Women who continued to pursue a science career throughout the study indicated that they had taken more elective science courses in high school (Farmer, Wardrop, Anderson & Risinger, 1995).

Some studies went one step further and looked at the factors underlying persistence in math and science. For example, a study by Gaskell, McLaren, Oberg and Eyre (1990), looked at the course choices amongst some British Columbia high school students. Some girls were aware of the importance of keeping their options open. This awareness is evident in the following quote from one of the participants:

> Well mainly, it's for university and for later on, because there are so many more options you can go into, like, I still haven't made up my mind what I want to be or my profession, but it's hard to make up, like if you don't take a science course later on or a mathematics course. Like all universities they require prerequisites of mathematics and science (p. 92).

Betz (1997) identified lack of preparation and lack of motivation or interest as the two major barriers to a given choice. Majoring in math, science and engineering requires a strong high school record. College science majors have been found to be academically stronger students in high school than are non-science majors in other fields. Although women get better grades than men in both high school and university, they more often lack the prerequisites for a science major in college.

It has been noted by researchers that high school mathematics and science courses are the "critical filter" which keep women out of science and engineering careers (Smith and Erb, 1986). The research concerning high school course selection suggests that girls tend to drop out of these courses in greater numbers than boys, limiting their career options considerably.

Those who continue to take math and science appear to be aware of the importance of keeping their options open. Those who pursue math and science in university take more math and science courses in high school. Further research is needed to gain a stronger understanding of why *some* young women continue to enroll in senior math and science courses rather than dropping out and the effect that this has on the type of career they pursue in university.

Special Programs

Many studies have been conducted on the impact of special programs geared at increasing the participation of girls in math and science. Programs involving the use of role models, as well as other special programs have proven successful in improving girls' attitudes toward science and science related careers.

Smith and Erb conducted a study in 1986 in which students in grades five through eight were exposed to women science career role models as part of their science classes over a two month period. Instruction was the same for both the control and experimental groups except that students in the experimental group were exposed to at least three women science career role models; they heard from their teachers about women who had made important contributions in science; and they read about young women who used science in their work. The results indicated that the students in the experimental group had significantly more positive attitudes toward women in science and toward scientists in general in the post-test.

Another study of an intervention program concerning role models was conducted by Evans, Whigham and Wang in 1995. A team was trained to conduct a three-day in-class role model intervention program. The purpose was to educate students on the importance of math and science to many careers; to encourage them to stay in math and science so they do not limit their options; to inform students about science and engineering careers; and to emphasize that these careers are open to both men and women. The participants in the intervention program were ninth grade science teachers.

The results of this study indicated that the teachers who were involved in the program were successful in changing students' attitudes toward science, math and technical careers. After the intervention, students were more likely to say that they liked math and science and that they recognized the importance of these subjects and their utility in future careers (Evans, Whigam & Wang, 1995).

Marlow and Marlow (1996) suggested that what is needed are more intense forms of role model interventions such as mentorship programs. Mentors are role-models which play a more personal role in the lives of girls. They are brought together with women in math and science related careers in an attempt to raise overall awareness about these careers as well as develop a concrete understanding of career opportunities. Marlow and Marlow suggested that "by matching girls with mentors, the programs attempt to open and maintain dialogues between the mentors and the girls to provide support and encouragement for the girls that is often missing in their home and school environments" (p.147).

Bennett (1997) described a new initiative that combined role model and mentor interactions. The program entitled *Telementoring Young Women in Science, Engineering, and Computing* uses the Internet to provide high school students with role models who offer career guidance and emotional support. Professional women who are involved in science interact with students via e-mail. Students are linked with professionals for year-long relationships based on career guidance and personal development. Bennett found that the most successful relationships are those in which the mentors were comfortable sharing their personal lives along with their knowledge and expertise. The author also suggested that it is important for teachers to consistently set aside time for students to respond to their e-mail. Mentors are provided with online training in order to learn how to effectively mentor the young women (Bennett, 1997). This type of special program is interesting because it provides students with consistent information and use of computers with minimal time being taken away from other subjects.

Many other programs have also been initiated to involve more young women in math and science. For example, Operation Smart is an American program aimed at eliminating the gender gap in science, math and technology and incorporates the principle of making girls central in math and science. Teachers or leaders are encouraged to use the following strategies: 1) Reward making mistakes, taking risks and getting dirty; 2) Hold high expectations and encourage critical questioning and; 3) Emphasize clearly that math and science are gender neutral studies and equally important for the futures of both males and females (AAUW, 1995).

Other studies found that enriched programs were important. For example, Becker (1984) studied the factors that influence men and women to pursue graduate studies in math and science and found that one commonality between the participants in this study was the fact that they were involved in some type of enriched program in school. One woman was involved in a program where she spent a month on a college campus studying one subject. She said: "Everybody was just so full of wanting to learn. The whole experience was wonderful. . . that was a great experience for me because I had a lot of things I had never been exposed to" (p. 45). These kinds of experiences seemed to have a lasting impact on the participants.

Many of the intervention studies suggest that the attitudes of girls toward math and science and math/science related careers have been positively affected as a result of special programs, role models or mentors. It is less clear however if these girls believe that *they* will pursue a math/science career or that girls in general can. Acker and Oatley (1993), labeled this problem the "We can but I can't" paradox. Girls will often strongly defend the abilities of their sex in general, but tend to be less positive about their own potential and choices. It would therefore be useful to find out from women who are planning to pursue a career in science about their experiences with special programs and how they feel that these experiences affected their decision to pursue a math, science or engineering program.

Lack of Course and Career Information

Another important factor that has emerged from the literature is the fact that students are not knowledgeable about the range of math/science and engineering careers and the necessary preparation for them. In a 1992 study by Moffat, 55% of the students who were interviewed indicated that they needed more information on science careers. Even when some students expressed an interest in a science career, their narrow perceptions of scientists prevented them from labeling them as scientists. For the most part students appeared to narrowly define scientific careers. A Toronto Board of Education Study (1990) showed that both male and female high school students usually are not aware of career options or their requirements. It concluded that girls in particular would be affected by this lack of information because they tend to need an intrinsic reason to take math (Tsuji & Ziegler, 1990).

A study concerning the perceived influences on career choice amongst engineers and non-engineers also found that career information in schools is lacking. The majority of the students in this study indicated that they thought that the career advice given at their schools was less than adequate. This view was significantly more common amongst the engineers than the non-engineers (Haworth, Povey & Clift, 1986).

Frehill (1997) has also suggested that the lack of information about engineering careers is a problem. She argued: "Engineering is an occupation in which starting salaries are high and well-publicized, yet non-practitioners have little knowledge of what engineers do at work" (p.229). She went on to say that high school students are likely to have an understanding of what chemists do based on high school classes. However, because high schools rarely have courses in engineering they remain unsure about what the job entails. Furthermore, students are more likely to come into contact with people from professions such as teachers and doctors and less likely to come into contact with engineers. Frehill concludes that "a lack of accurate information about the content of engineering work would likely deter women's choice of the field" (p. 229).

The impact of the lack of information about science and engineering careers seems to be an important one that has received little attention. The limited research in this area suggests that students receive inadequate and insufficient information about these careers. Further research is needed which aims to understand how young women who do enter science and engineering programs overcome this obstacle.

In sum, Contextual Influences seem to play a role in the course and career decisions of females. Hands-on experiences are important in retaining students' interest in science, yet the literature indicates that girls may have fewer opportunities to enjoy these experiences. It is important to gain a stronger understanding of the reasons why girls prefer hands-on experiences in order to apply these factors in the classroom. Course selection is an area that has been studied extensively and results indicate that girls may be more likely to drop out of math and science courses. Results from these studies also indicate that girls who are better prepared in the maths and science are more likely to pursue a math, science or engineering program in university. It is less clear however, why some girls choose to continue taking math and science courses in high school and why some continue with these courses in university. Research studies have also found that special programs may be effective ways of encouraging young women to continue taking math and science courses. It is important to ascertain what aspects of these special programs work in order to apply them to other special programs as well as to the regular classroom. Finally, the literature has suggested that career information in high schools may be limited. Further research is needed to determine if women who do plan to pursue math and science found this information inadequate and what they did to overcome this lack of information.

Intrapersonal Influences

A third main factor that appears in the literature is the role of intrapersonal factors in the decision to pursue math, science or engineering programs. This section will include a discussion of the reasons why women continue to opt for math and science courses as well as the role of stereotypes on attitudes toward math and science.

Opting for Math and Science

Some of the reasons that young women opt into or out of science and math are due to internal factors. Some of the factors which have been found to influence girls' decision are enjoyment, confidence and the perceived usefulness of math and science (Dunham, 1990).

A study by Becker (1984) on the factors that influence men and women to pursue graduate studies in math or science found that an early interest in math or science was common among all of the participants. Some expressed a liking for these subjects as early as seven or eight. This study also indicated that the main reason that the participants liked math was because they were good at it. Some of the other reasons they gave for liking math were its objective, logical features, the fact that you usually know when a problem is right, and the tangible nature of the subject. These themes were illustrated in comments such as the following: "I am gifted in mathematics; I have always done very well in mathematics. It is very logical and I am a very logical person" (p. 43) and: "I just remember it always came easy for me. Anything easy you just kind of like. I was good at it and people would say 'you're good at it' so it was a praise. . . I've always done well in math" (p. 44). Participants highlighted the match between science and other aspects of their lives and their longstanding affinity for science.

A 1991 study by Dick and Rallis concerning factors and influences on high school students' course and career choice found that the most important reason for career choice was genuine interest. Of eleven female students who were planning a career in science or engineering, ten indicated that the most important reason for their choice was a genuine interest in the subject. These same students were influenced to take math and science mainly because they did well in those subjects, because they liked them and because they needed them for their career.

A 1990 study by Hill and Pettus also concluded that differences in the pursuit of a science career based on gender are primarily based on lack of interest in these careers on the part of girls before they enter junior high school. They suggest that girls' participation in science related activities and hobbies outside of school can also be a causal factor, but it is more likely related to lack of interest in science.

A 1992 Canadian study by Lips hypothesized that few females pursue science related careers because they do not see these careers as compatible with family roles. The subjects in this study were 488 male and female first year university students from various disciplines. Participants answered a questionnaire which was designed to predict involvement in math and science. The questionnaire focused on beliefs about the compatibility of a science career and a family. The results showed that in general, neither females nor males thought that science careers were incompatible with family roles for women. Less that 4% of the women and 5% of the men indicated strong disagreement with the statement that for women there was nothing incompatible about planning both a family and a top level scientific career. According to these results, neither males nor females consider a science career a hindrance to a family.

A 1997 study by Frehill looked at sex-differences in the choice of engineering as a university major. A total of 11 995 students were surveyed with their college major being the dependent variable and high school preparation relevant to engineering and gendered work attitudes as the independent variables. The results indicated that engineering was the third most popular major among males but it was the least popular major among females. Males had taken more advanced math and science courses than females and on average, women placed more importance on intrinsic work factors and males placed more importance on extrinsic work factors. For women, as the importance of intrinsic rewards increased, the less likely they were to choose a major in engineering. As the importance of extrinsic rewards increased, the more likely women were to choose engineering as a major. There was no significant difference between males and females on career and family orientation measures. The author suggests that if young women were provided with a positive image of the work involved in being an engineer, the more likely they would be to major in engineering.

Davey (1993) also looked at the role of motives in the choice to pursue science or engineering. A questionnaire was administered to 365 high school students from grades ten, eleven and twelve. The female students were more likely than males to express altruistic motives, then interest in the work involved, followed by lifestyle concerns as the factors influencing their career choice. The male students however most frequently cited interest in the work involved, then lifestyle, and finally altruistic motives. Interestingly, of the female students who indicated a desire to become physicians, 88% indicated that their primary motive was altruistic whereas 60% of the males who aspired to be physicians stated that they were motivated by a desire for wealth and status.

Other intrapersonal factors that have been studied are the role of self-efficacy and self-confidence on the choice to opt into or out of math and science. Leslie, McClure and Oaxaca (1998) suggest that self-concept (perception of self) and self-efficacy (belief in one's ability to perform a given behaviour) strongly affect the decision to pursue a science or engineering career. The authors state that, "As specific obstacles arise, one's self-efficacy will be instrumental in determining whether one decides to cope with adversity, to what degree, and how persistently. Bandura observes significantly that the 'strength of conviction' in one's self-efficacy will affect one's willingness to see a task or goal to completion and even whether one will make an effort" (p. 253). Leslie, McClure and Oaxaca (1998) found that a personal sense of pride is strongly associated with the decision to major in science and engineering. One of the important reasons males were more likely to select math/science majors was because they perceive themselves as being well prepared in math and science. Other intrapersonal factors these authors find important are one's expectations about the probability of success, ratings of the usefulness of math and science and confidence in math and science.

Mau, Domnick and Ellsworth (1995) took a different approach to the study of gender and career choice and studied the predictors that discriminated between females who had traditional career aspirations and those with non-traditional career aspirations. Their study involved a sample of 930 eighth grade female students who aspired to either science/engineering or homemaker roles. The students completed a questionnaire related to educational aspirations, math/science proficiency, locus of control and self-esteem. The results indicated that students with science/engineering aspirations had higher scores for internal locus of control and self-esteem. The authors suggest that counsellors need to take these factors into account when helping students prepare for science and engineering careers.

In sum, the literature on internal factors indicates that genuine interest is important in retaining girls in the maths and sciences. Further research is needed to ascertain what it is about math and science that leads to a genuine interest in and a liking for it. It is also important to understand what leads to high self-confidence and self-efficacy in math/science. This type of information is important in order to develop math and science classes and special programs which are effective at retaining the interest of young women.

Stereotypes and the Under-representation of Females in Math and Science:

Some of the research on Intrapersonal Influences has focused on the role of stereotyped beliefs on the choice to opt into or out of math and science courses and careers. These studies have looked at whether or not males and females hold stereotyped beliefs about which careers are most appropriate for each sex.

Generally the research indicates that students do not believe that one sex is better than another at math and science. Moffat (1992) found that when asked if boys or girls were better in math and science both sexes indicated that they thought they were the same. Baker and Leary's (1995) research generated similar results. In this study, none of the girls agreed with the statement that girls cannot be scientists. One fifth grade student said: "I think that girls could if they really wanted to. They can do just as good as boys". When asked what makes her think that, she says, "Because they're people too and they're just equal" (p. 20). An eleventh grade student also shows this strong equity position: "Because, uh, it's a generalization and you can't generalize about all girls 'cause lots of girls are smarter than guys in science and some guys are smarter than girls. It just depends on the individual" (p.22). On the other hand, Oakes (1990) found that many students believe that math is more useful for males than for females, that boys understand math and science better and that studying science is more important for boys.

There has been some research that has considered how teachers can counter stereotypes. Mason, Kahle and Gardner (1991) studied the impact of stereotypes in an important study which discusses the results of the Draw-A-Scientist Test. The study began with a teacher intervention program which stressed the importance of career information and the usefulness of math and science courses. The success of the program was measured by evaluating students' attitude changes and by observing the selected teachers' classes. It was hypothesized that the number of female scientists drawn by the experimental group on the Draw-A-Scientist Test would be higher than that of the control group, and the control group would draw more stereotypical indicators such as a lab coat, glasses and facial hair. The results indicated that the first hypothesis was supported, the control group drew more male scientists but the second hypothesis was not supported. The experimental group did not include a lower number of standard indicators. The authors suggest that it is important to counter stereotypes about scientists because if students' perceptions do not fit with their beliefs about themselves or their future career plans, they are not likely to pursue a science career. They also suggest that classroom teachers can have a positive effect on these beliefs with the proper classroom environment.

The results of research on stereotypes indicates that many students hold strong stereotypes about appropriate career choices for males and females. Research has also suggested that teachers can successfully counter stereotypes regarding the appropriateness of science females. Further research is needed to understand if the young women who do choose to pursue math/science programs hold these stereotypes and if so how they overcome them.

In sum, the research on Intrapersonal Influences indicates that factors such as interest, self-confidence, self-efficacy and intrinsic versus extrinsic rewards are important in the choice of whether to opt into or out of math/science courses and careers. The research on stereotyping shows that some students still hold beliefs about which careers are most appropriate for their sex. Further research is needed to develop a stronger understanding of how these factors affect young womens' decisions to pursue math, science and engineering programs in university.

Most of the literature on adolescents has focused on certain aspects of Interpersonal, Contextual and Intrapersonal Influences, yet a few studies have taken a more holistic approach which look at how all three factors interrelate in shaping decisions. The few studies that have done this focus on adult women. The following section provides a brief overview of the studies which have taken a holistic approach in examining adult women who have succeeded in non-traditional science careers. These studies reveal, from the point of view of the women, what they believe influenced them to choose a science career. This type of information is important if we hope to grasp the complexity of the factors which are involved in this decision.

Women Who Succeed in Non-Traditional Science Careers

Much has been written about the women who *have* become successful engineering and math and science related careers. In an effort to gain insight into the reasons why some of these women became so successful in their careers, Wilson and Milson (1993) interviewed women who are currently employed in one of these careers. A secondary school science teacher indicated that her mother being a registered nurse was the main factor in her decision to pursue a science career. She also liked the challenge that math and science courses provided. She indicated that she was always interested in how things work and remembered that several of her math teachers acted as positive role models. Another scientist interviewed by these researchers felt that the main influencing factor for her was strong family support and the encouragement she was given during her childhood years. She felt that teachers and parents need to push girls more in the areas of math and science in order for them to excel in these areas. All of the women interviewed by these researchers agreed that family encouragement was an important factor in their decision to pursue their chosen career. They also indicated that teachers needed to avoid treating boys and girls differently and to encourage girls more in these areas.

In an article by Johnson (1986) entitled *On Being a Scientist*, the author who is a physicist, discussed some of the reasons she attributes to choosing a science career. She indicated that personal preference was important. She commented, "there are lots of good things to be done. What is harder is to find the reasons behind these preferences" (p.105). She believed that many girls get very poor science teaching, and a lack of encouragement. Another key influence that she identified was the problem of stereotyping as a deterrent for women in science. She said:

> I've been asked at various times why ever did I choose to do something as demanding as physics. Such questions imply that it is somehow unfeminine to do things that are hard, or that take a lot of thinking. Perhaps people who ask this don't quite see the other side of this thought - namely the prejudice that it *is* feminine to be slack and lazy, and feminine to turn off one's mind (p. 105).

A paper by Fabrikant, Svitak and Kenschaft (1990) stressed the importance of family encouragement and role models in the lives of women who have succeeded in mathematics. All of the women who were interviewed by these researchers reported that they had had a highly supportive family member who was willing to sacrifice for their education and a secondary school math teacher who told them they were gifted in math and encouraged them to continue. Cathleen Morawetz, the first American woman to head a mathematics institute is the daughter of a mathematician, rear Admiral Grace Murray Hopper, who led the team that designed the first compiler. She attributed her success to her father's belief in equal educational opportunities for his sons and daughters.

In 1984, Becker conducted an ethnographic interview study of ten graduate students in mathematics. Most of the students indicated that they liked mathematics from a very early age. One female student said:

> I've always been interested in math. It was never a question of what to major in. I can remember going into math and loving adding numbers. My father taught me my multiplication and addition tables before I even went to school (p.43).

When the researchers asked the students why they chose graduate school the women seemed less sure of their goals and abilities than the men. Three of the four women mentioned that a parent was most influential on their career choice. They were not pushed into attending graduate school but rather they gave general encouragement to women's interests in math. For two of the women, a teacher was seen as an important role model or as a person who later encouraged her to go to graduate school. Only the women reported being discouraged by someone in their lives. One of them reported that her guidance counsellor encouraged her to get her BA. instead of her B.Sc., another reported that a male student had said to her "why are you going to graduate school? You're just going to get married and have babies" (p. 48).

The men and women in this study reported similar reasons for liking math but the women seemed to lack the confidence that the men had. Most of the women had strong family encouragement and teachers as role models were seen as important to the women.

Much has been written about women who have already become successful in science careers but little research has focused on young women who are planning to enter math, science or engineering in university. Most of this research also has not looked specifically at school influences. Research of this nature is important to the understanding of the underrepresentation of women in non-traditional math and science careers. Holistic research in this area is also important in order to better understand the complexity of the issue and the fact that many factors interrelate to form a decision.

Summary of the Literature Review

The research discussed here stresses the importance of the factors discussed in this paper on women's decision to pursue a non-traditional science related career. The majority of the research in this area has focused on the role of Interpersonal Influences on differential course and career choices among males and females. The research indicates that teachers interact with male and female students differently and tend to encourage males more in math and science than they do females. Teachers have been shown to praise girls less often, criticize boys more often and allow girls to be more passive in laboratory settings. Over time this differential treatment of girls could contribute to the low numbers of women who enter math and science careers. Some studies have suggested that teacher intervention programs may be helpful in training teachers to be gender sensitive in math and science classrooms. Few studies however, have looked in detail at how the young women who chose science careers believe their teachers influenced this decision.

The research on the influence of friends and peers is unclear. Little research has focused on this area and the studies that have been conducted are inconclusive. The limited research that has been conducted in this area has focused on the direct influence of friends and peers. More research is needed which looks at the indirect and subtle ways that peers and friends may influence each others' decisions

Research has also established the importance of parents' attitudes and beliefs in the attitudes and choices of their children. Much of this research has focused on how parents negatively influence their children yet it has also shown that parents can act as role-models and can affect their daughters' attitudes simply by rejecting stereotypes and encouraging them in math and science. More research is needed which focuses on how parents have influenced young women who have chosen math/science careers in order to gain a better understanding of what parents can do in order to encourage their daughters to keep their options open.

Some researchers have focused on the role of Contextual Influences on career and course choice decisions. Their research has looked at the role of lab experiences and group work on this decision. Many students indicate that they like this hands-on work but other studies indicate that girls get less of this hands-on experience than boys because boys tend to monopolize equipment and girls tend to take the role of note-taker. Further research is needed which looks at what aspects of group work and labs girls prefer in order to get a better understanding of how math and science classes can better meet the needs of female students

Research has shown that many girls drop math and science courses as soon as this choice becomes available to them. The fact that math and science courses are optional in secondary school has been cited as a "critical filter" blocking the entry of women into many math and science related careers. It is less clear however, why *some* young women continue to take math/science courses and opt for these programs in university.

Research in the area of special programs suggests that the attitudes of girls toward math and science can be influenced by participation in special programs aimed at improving the gender situation in math and science. It is less clear however if the girls who have been involved in these programs will actually go on to pursue math/science careers. More research is needed which addresses this issue as well as how the young women who do pursue math/science in university believe these programs affected their decision.

Research on Contextual Influences has also looked at the role of student services on career and course choice decisions. These studies indicate that students believe that there is a lack of career information in high schools. More research is needed in this area which focuses on how some girls overcome this lack of information and pursue math/science and engineering programs. This research should also take into account what needs to be done in high schools to make students more aware of their career options.

The final section, Intrapersonal Influences looked at the role of the self in career decision making as well as the influence of stereotyped beliefs. These studies looked at the reasons why some women continue to enrol in math/science courses. The main finding is that the young women who continue to take math and science courses appear to enjoy them and see them as important in order to keep their options open. Studies in this area have also found that self-confidence, self-efficacy and intrinsic rewards are important factors in math/science success. Most of these studies have been conducted by questionnaires with girls in elementary and high school who have not yet made a career choice. More research is needed which focuses on young women who have entered math/science or engineering in university. Interviews in this area are important in order to gain a stronger understanding of the complex reasons why women make these choices. Further research is also needed which focuses on why some girls continue to like science and have a strong interest in it in order to gain a stronger understanding of what can be done to retain girls' interest in these areas.

Another Intrapersonal factor which had gained limited attention is stereotyping. The stereotype research has indicated that many students still hold stereotyped beliefs about which careers are appropriate for each sex yet it has also shown that students generally do not believe that one sex is better at math and science. Further research is needed which focuses on why students continue to hold stereotyped beliefs and what can be done to counter them. Attention also needs to be paid to why some young women overcome these stereotypes and opt for math/science and engineering programs.

Much of the research in this area has focused on a single aspect of the issue. This study was an attempt to gain a more holistic understanding of the problem and how the three main factors interact and lead to the decision to enter a math, science or engineering program. Some research has taken a holistic approach but it has generally been conducted with older women who are working in science related careers. This study focused on young women who have recently entered a math, science or engineering program. It is important to understand the perspective of these young women from a holistic approach in order to better grasp the reasons why these young women made their decision.

Purpose of the Study

The purpose of the present study is to gain a deeper understanding of the reasons why *some* women pursue careers in science, math. and engineering. Women are highly under-represented in these careers; and this study attempts to gain insights into the reasons for this through a qualitative, retrospective study with young women who are planning to pursue careers in these areas. The following research questions guided this study:

1. In what ways did Interpersonal Influences such as teachers, parents, friends/peers and role models affect young women's decision to pursue a math/science or engineering program?
2. How did Contextual Influences such as group work and labs, course selection and career information affect the decision to pursue a math/science or engineering program?
3. How were Intrapersonal Influences involved in the decision to pursue one of these programs?
4. What other influences did these young women see as important in their decision to pursue a math/science or engineering career?

Chapter 3 - Methodology

This chapter provides an overview of the methodology involved in this study. I will begin by discussing recruitment of the participants and present a short profile of each. I will then provide information on data collection and analysis. Finally, this section will include the limitations of the study.

The present study is qualitative in nature and involves 13 interviews with young women who are currently in their first or second year at an Ontario university. As explained earlier, I was interested to learn how Interpersonal, Contextual and Intrapersonal Influences shaped the young womens' decision to pursue their chosen program.

Participants

The participants in this study are thirteen women who at the time of data collection were in their first or second year of university. These young women are all majoring in physics, chemistry, engineering, biotechnology, or math.

The process of recruiting participants took several forms. During the summer of 1998 I began by soliciting potential participants from family, friends, co-workers, and acquaintances. Four participants were recruited this way.

The second phase of recruitment was done through the science department at the University of Ottawa. During September 1998 I posted signs in the engineering and science departments, requesting that women who were interested in being interviewed to call or e-mail me. I also approached the administrator in the faculty of science for a list of the names of female students who were in first year chemistry or physics. The women on this list were contacted by mail. During this phase of recruitment, I also arranged a meeting with Professor Monique Frize who is involved in WISE (Women in Science and Engineering). She suggested that I attend a meeting of Pathmakers at the University of Ottawa, a group aimed at encouraging women to go into science and engineering. Most of the women at this meeting were in more advanced years of university studies but they assured me that they would e-mail me if they knew anyone who was interested. During this phase of recruitment, five participants were identified.

During the final phase of recruitment, I asked the participants if they could recommend others who might be interested in participating. I was able to recruit four participants through this "snowball" strategy (Bogdan and Biklen, 1998).

I gave the women the choice about where they would like the interview to take place. I went to several of the women's homes and did some of the interviews at the University of Ottawa. The final four interviews took place in the women's rooms in residence at Queens University where they were students.

The following participants were involved in interviews. Each of the participants was 18-20 years old. Pseudonyms are used throughout this report.

Sandra: Sandra is a first year math student at the University of Waterloo. I interviewed Sandra in August, three weeks before she left for University. She attended high school in Ontario.

Kim: Kim is a first year engineering student at Queens University. She is in general engineering this year but plans to go into computer engineering in her second year. Kim attended a small French high school in Ontario.

Lori: Lori is a first year chemistry student at the University of Ottawa. Lori attended high school in Quebec.

Jaime: Jaime is a first year industrial engineering student at the University of Toronto. She attended high school in Ontario.

Tracey: Tracey is a first year chemical engineering student at the University of Ottawa. She attended a small high school in Ontario.

Lisa: Lisa is a second year engineering student at the University of Ottawa. She went to high school in Quebec and is a member of the student branch of WISE (women in science and engineering).

Jen: Jen is a second year physics student at the University of Ottawa. Jen attended high school in Quebec and was asked to skip CEGEP and go straight into university.

Tina: Tina is a second year computer physics student at the University of Ottawa. She switched from general math and science to computer physics in second year. Tina attended high school in Ontario.

Sheri: Sheri is a first year math student at Queens University. She attended high school in Nova Scotia. Sheri plans to be an actuary when she is finished University.

Ann: Ann is a first year engineering student at Queens University. She attended high school in a small mining town in Newfoundland. Ann plans to major in geological or mining engineering.

Ali: Ali is a first year engineering student at Queens University. She attended high school in Ontario. After she finishes her engineering degree, she plans to do her M.B.A.

Michelle: Michelle is a first year engineering student at Queens University. She attended high school in Ontario. Michelle plans to major in mechanical engineering.

Kate: Kate is a first year biotechnology student at the University of Ottawa. She attended a special high school in Ontario which has a scientific concentration program.

Data Collection

The data collection method used in this study was in-depth interviews. Thirteen women were interviewed (see interview guide - Appendix A). Decisions about the number of participants were made on an iterative basis. Lincoln and Guba (1985), suggest that sufficient data has been collected when redundancy occurs. After thirteen interviews I felt that this goal had been achieved, as I was starting to hear similar responses from the participants.

Each interview began with introductory small talk. Bogdan and Biklen suggest that small talk is important to develop rapport and to "break the ice". I then explained the purpose of my research and had the participants sign the Letter of Informed Consent (Appendix B).

Before I turned the tape recorder on, I explained that the interview would be more like a conversation and that I wanted them to give me as much detail as possible. I told them that there were no "right" answers and that I was not looking for specific responses but rather I wanted to hear details of their experiences.

As the interviews progressed, the interview guide was modified slightly to include themes and questions which emerged during the interviews. The interviews were semi-structured and remained mainly conversational in nature. The questions were simply a guide and were not followed rigidly. Participants were given the freedom to diverge to areas of interest to them. Decisions about the focus and the sequencing of questions were made throughout the interviews. As the interviews progressed I remained open to new emerging themes or patterns, but also focused on discussion of the issues described earlier. When an interesting theme emerged in an interview it was pursued in subsequent interviews with other participants. If a participant began talking about a particular theme, I continued with that theme until it was exhausted, then moved on to something new. Therefore, each interview evolved in a slightly different way.

After the initial interview, each of the participants was sent a copy of the interview transcript to be checked for accuracy and one or more short subsequent interviews were conducted by e-mail. The e-mail interviews consisted of 3-4 questions on topics where I found gaps in the initial interviews. For example, when the interviews were completed, I did a short profile on each of the participants. These profiles were used to compare to others and to identify missing information. The questions asked in the follow-up e-mail interviews were based on this missing information. The e-mail approach was taken due to the fact that most of the participants did not live in Ottawa. The e-mail interviews were printed out and kept on file for future reference and analysis.

The young women who were involved in the interviews generally spoke freely and openly about their experiences. They were very articulate and were able to verbalize their thoughts and opinions clearly and distinctly. A few of the participants spoke French as their first language but this did not seem to impede their ability to convey their thoughts to me, nor did it impede my ability to understand them. I asked the women if I could contact them again if I required more information. This allowed me to look at the themes which emerged and to fill in any gaps in understanding across the group.

The interviews ranged from 45 minutes to one hour and were audio taped and transcribed verbatim to ensure that the data collected were accurate. The taping allowed me to focus on the women being interviewed rather than taking comprehensive notes. The taping also gave me the opportunity to replay the interviews throughout the analysis part of the study.

Throughout the data collection and data analysis portions of the study, field notes were used to provide a personal account of my feelings, ideas, impressions and hunches (Bogdan and Biklen, 1998). Notes were taken during and after each interview. These notes assisted in formulating new questions as the interviews progressed and helped to increase the comprehensiveness and richness of the details of the research. This is also where I documented impressions, reactions and thoughts about possible themes that emerged throughout the interviews.

The use of interviews allowed the participants to discuss their own perspectives in their own words and to provide a detailed window on their thinking. According to Anderson (1990), interview data reveal the participant's depth of emotion, the way she organizes her world, her thoughts, and her perceptions. Interviews yield information that is rich compared to questionnaires. In-depth interviews are "modeled after conversation between equals, rather than a formal question-and-answer exchange . . . and directed toward understanding informants' perspectives on their lives, experiences or situations as expressed in their own words" (Taylor and Bogdan, 1984, p. 77). The use of an interview guide, according to Anderson (1990), increases the comprehensiveness of the data and permits the interviewer to anticipate and close any gaps during data collection.

My study followed an emergent design approach. Maykut and Morehouse (1994) suggest that an emergent design is important in qualitative research. They suggest that important leads can be identified and explored further and situations can be explored from a slightly different perspective. I was able to do this in my study by reviewing previous interview transcripts before conducting subsequent interviews. This allowed me to review the topics explored and to identify issues which could be explored further with other participants.

In conducting qualitative research, the qualifications of the researcher are important. I have an undergraduate degree in psychology and was involved in interview research during my undergraduate studies. Throughout my graduate education, I completed several counseling courses which involved the use of interviewing skills. Most importantly, during a graduate course in qualitative research, several classmates and I conducted a small study on issues very similar to the ones explored in this study. We conducted interviews with adolescent women which explored the topics of math and science. Thus, given these experiences I feel that I was well qualified to conduct interviews with young women.

Data Analysis and Interpretation

Analysis and interpretation of the data continued throughout the data collection phase of the study. When an important theme emerged in an interview it was pursued in subsequent interviews. Each interview was transcribed verbatim and general coding was used to identify important themes. Transcription of the interviews provided 164 single spaced pages of data. My field notes consisted of 82 hand-written pages.

Codes were created which were related to the themes that were discussed in the literature review. For example when a participant mentioned parents, the quote was highlighted and a code of "P" was put in the margin, along with a one word description such as "encouraged" to describe how the parent was seen as an influence. New themes that emerged in the data and that did not appear in the literature were also identified. For example when a participant mentioned that they liked science or math an "L" was put in the margin along with a short description of why they liked it such as "problem solving". Marginal notes were also used during the coding process in order to aid in the understanding and analysis of the data. For example, I wrote notes about which themes I thought certain quotes were related to. If I thought a quote belonged in the "high school course selection" section I wrote a short explanation about exactly how it was related. Sometimes an excerpt was coded with several codes. For example, it may have related to both parents and role models. In this case, I would include both codes and decide later where the excerpt fit best.

The constant comparative method was also used during data analysis. As each new unit of meaning was selected, it was compared to all other units of meaning and grouped with similar units of meaning.

Lincoln and Guba suggest that "coding and recoding are over when the analysis itself appears to have run it's course - when all of the incidents can be readily classified, categories are 'saturated', and sufficient numbers of 'regularities' emerge" (Miles and Huberman, 1994, p. 62). I felt that the analysis portion of this study ended at the appropriate time and that "saturation" was achieved with the thirteen interviews.

After reading each transcript several times to familiarize myself with each participant, I wrote a profile on each participant. These profiles were 2-3 pages in length and included all of the information given about influences on their decision to pursue a science, math or engineering program. These profiles enabled me to better distinguish each participant and to understand the major influences on their decision.

After the coding was complete, I extracted important quotes from each transcript and created headings based on the three major factors: Interpersonal Influences, Contextual Influences and, Intrapersonal Influences The quotes were placed under the appropriate headings.

I started out concentrating on the three main areas that were identified in the literature: Interpersonal Influences, Contextual Influences and Intrapersonal Influences. During the analysis phase of the study, various subthemes emerged in the data These subthemes were grouped in each of the three factors: 1) Interpersonal Influences: teachers, friends/peers, parents and other role models; 2) Contextual Influences: group work and labs, special programs, course selection, and lack of information about science and engineering careers; and 3) Intrapersonal Influences: stereotypes and the under representation of women in science and engineering and opting for math and science. A detailed description and analysis of these subthemes is presented in the next chapter.

Limitations

The present study is limited by the fact that it is retrospective in nature. The participants reconstructed their experiences and provided me with information as they remembered it. I believe that these reconstructions however, were a useful form of data. The way a person remembers events is important and these recollections provided me with rich, meaningful data and information on how the young women view the world and their experiences. Adler (1971) believed that there are no "chance memories". He suggested that people only remember events which have an impact on their situation. Adler also believed that it is not important whether or not the recollection is accurate but the significance lies in the fact that it was remembered.

The present study is also limited because it is unclear from the data whether or not these young women will actually go on to pursue a math, science or engineering career. The young women, at this point in their lives plan to pursue these careers but it is difficult to know if they will eventually change their minds.

Finally, this study was limited by the fact that due to the location of some of the participants there was only one round of personal interviews. After the initial interview, the participants were contacted by e-mail.

Chapter 4 - Results

The following chapter is organized into three main sections. The first section is Interpersonal Influences and it includes several subthemes: a) teachers; b) peers and friends; c) parents and; d) others. The second main section is Contextual Influences. This section includes four subthemes: a) group work and labs; b) special programs; c) high school course selection; and d) lack of career information about science and engineering careers. The third main section is Intrapersonal Influences. This section includes two subthemes: a) stereotypes and the under-representation of women in math and science and; b) a passion for math and science.

Interpersonal Influences

This section will include a discussion of the people in the women's lives who were involved in their decision to pursue a math, science or engineering program. There are four subthemes in this section and they include the following: a) teachers; b) peers and friends; c) parents; and d) others.

Teachers:

Generally the participants felt that their teachers had a positive influence on their decision to pursue a science, math or engineering program. They felt that many of their math and science teachers encouraged them if they did well in math and science and pushed them so that they could "maximize their potential". Two of the participants described experiences where their teachers encouraged them to do something specific, whereas three participants described this encouragement as a more general experience.

Two of the young women described incidents where their teachers encouraged them to go into special programs or attend special events. Sandra explained that her math teacher encouraged her to enter a math competition: "My grade ten math teacher told me to do the Waterloo math competition, I remember, and I did really well and he told me you know, 'You really have a future in this, you know you're really good at math' and stuff'. Another woman, Kim, explained that one of her teachers encouraged her to attend a summer camp. She described the incident as follows: "My math teacher told me about 'Discover Engineering', and we're pretty close, so she's like 'you know you should do this, it would really benefit you' so I did". Kim also said that this teacher encouraged women in particular to go into math and engineering: "Um, with my math teacher, she was female and she pushed the women towards math you know and she has a big level of math and she said you know 'it's good for women to go into math and engineering'".

Three of the participants said that their teachers encouraged them in a more general way. For example, Jaime explained that her teachers were very encouraging: "Um, I had some really good teachers in high school. I think they helped me, they encouraged me to I guess maybe maximize my potential. My math and science teachers were very helpful". Similarly, Sandra explained that she was affected by a supportive math teacher: "It's just this one teacher, his name is Mr. Brown. He's just so smart, he's a really good teacher and he's just so supportive of like the people who do well. . . he pushes you more. . . he challenged me more, it was really cool". A third woman, Kate, felt that all of her math and science teachers in high school were helpful. She attended a small high school where she was involved in a scientific concentration program. She said, "Because it is a small school kind of, 1000 people, but the science community is pretty tight. . . I had every possible teacher in science, so they all knew us well and they encouraged us all. . . The support was there".

Besides encouraging them, teachers were also helpful to the participants by providing them with information and extra help. Kim explained:

> My math teacher. The thing is she didn't know about engineering when she went into university and if she had known she would have become an engineer now that she knows what it is. And um, any article she received about engineering and especially computer engineering, she was also the programming teacher, she'd give it to me and she'd encourage, like, 'look there's a lot of jobs out there' and she's always coaching me and helping me out saying 'you know this is a good thing to do'".

Lori explained that in addition to providing useful information her teacher would also recognize her hard work:

> I find I connected more with the teachers in science than in the other courses. Maybe because they found I had a lot of potential,

> they were always willing to answer my questions and would point out 'oh Lori got another hundred on her test' or Lori did this or that. It makes you feel good when teachers recognize you're doing well in a subject".

In addition to encouraging the participants, some teachers were seen by the young women as positive role models. Lisa described one of her teachers as a role model "from afar":

> I guess I had a really good math teacher, she didn't influence me directly, but she was really cool and organized and everything and she studied physics but she was teaching algebra. She was a role model from afar, like we never really interacted . . . she really knew her stuff and was really good at explaining it and she was one of those focused women I had the chance to meet.

When asked about role models, Kate also described one of her teachers as important: "In grade school, in grade six, I always looked up to her and she was a great teacher. She's the one who actually made me skip a class so maybe that's why I liked her so much. She recognized my potential".

Six of the participants discussed what they felt were the positive and negative aspects of the teaching methods of their teachers. Jen described what she believes makes a good math or science teacher: "Someone who is able to go and get you I think, like to stimulate your interest . . . for me it would be someone who is able to make links with science and life".

Ann liked a few of her math and science teachers and felt that they were a positive influence but also believes that her physics teacher may have negatively influenced her opinion about the subject. She said:

> Well my geology teacher was a really good guy. . . the way that he taught was really good, like I don't know maybe that's why I like geology a little bit more so because he was a really good teacher in that he explained really well what he was doing, he'd give a lot of examples, do a lot of visuals, try to get into the labs so you could get hands-on material so you actually know what you're doing. . . and my chemistry teacher was really good too. . . they try to make things really visual and concepts that you can see hands-on, by giving examples and little diagrams. So just things like that. The teachers were good but none of them actually told me 'hey, go into engineering' or none of them had special guidance on what I was going into, it was more of a general thing. Just them being good teachers. . . helped me to pursue science. Like last year, my physics teacher I didn't like, so that's why my marks dropped in physics, that's what I think. And maybe why I didn't like it as much at the end of the year as when I first took it. So teachers do have a lot to do with what you do.

Michelle felt that her teachers indirectly encouraged her and went on to explain what she thought made a good teacher:

> Someone who knows what they're doing, someone who can go beyond the text book, not just someone who reads from the text book, someone who can think of other creative ways of teaching things and if you ask a question and they answer one way and you don't understand the way they answered, a good teacher would try to answer it another way.

Sheri and Ali agreed that a good teacher, is one who can think of creative ways to explain the material. Ali said, "a good teacher knows enough that they can do it another way other than the example in the text book". Sheri said, "if you asked a question and it wasn't directly on the route they were taking, they were good enough to know, they knew the answer anyway so it didn't throw them off."

Two of the participants felt that their teachers were less effective and had some strong statements about what they saw as negative teaching methods. Lisa said "we have lots of teachers that aren't organized and teach science in a really poor way . . . well they make it so uninteresting. It could be made more interesting. Because I had extracurricular activities in science, I knew what was being taught could be more interesting". Jen describes one incident where a science teacher discouraged her from asking questions: "there was this one teacher who kept saying 'stop asking all these questions' and she put up a set of questions I'm allowed to ask in the course, I had three questions per class, and then she would make a little check mark, and then she was like 'ok that's it, no more questions for this class'".

It is apparent that the participants had very definite ideas about what makes a good teacher. Good teaching itself seems to be a positive factor in promoting math and science. These young women did not want to be passive learners and they acknowledged good teacher/student interactions when they experienced them.

In sum, generally the participants felt that some of their math and science teachers had a positive influence on their decision to pursue their program whether it be directly or indirectly. They thought that their teachers influenced them by encouraging, supporting and informing them about specific opportunities. Some of the women were directly encouraged to continue in science and some were encouraged more indirectly. Participants saw their teachers as positive role models and for the most part they liked the way that their teachers taught and they had positive statements about what they thought made an effective teacher. At the same time however a few of the women described negative experiences with teachers who limited their participation and presented material in boring, disorganized ways.

Peers/Friends:

The second subtheme included under Interpersonal Influences is peers and friends. This section will include a discussion of their influence and of how the participants felt about helping their peers in math and science. Eight of the participants did not feel that their peers had an effect on their decision to pursue a science career and most of them said that their friends generally did not go into science programs but that this did not affect their decision, although some qualified their statements. Jaime explained that all of her friends had different interests. When asked if she thought that her friends had an influence on her decision she said:

> Um, not really because we all went our separate ways. . . We knew we weren't all going to go to the same university, we all had different interests in high school like some of my friends didn't take a science class after they had to and things like that. We didn't study the same things so we kind of went our own way depending on what our interests were. . .I have a few friends in engineering from my high school but I wouldn't say they influenced my decision at all.

Tracey also felt that her friends did not influence her decision. When asked if they had an influence she said: "Not at all. I didn't. . . well my OAC ones, my friends weren't in them, but the lower ones they were. They didn't really like it as much as I did".

Likewise, Lisa did not feel that her friends had an impact on her decision but she said that some of them did discourage her:

> To go into science? No. Actually I had some friends who told me not to go into science. Well, not not to go, they just told me 'oh you should go into biology' just because they saw me as a doctor. And you have the basic 'oh physics is hard, you're stupid if you go into physics, only crazy people go into physics'.

Jen went to university a year earlier than most of her friends because she skipped one year of CEGEP. When asked what type of influence her friends had, she said: "Oh not at all. My friends are all in CEGEP, so no they didn't influence me to go into science I don't think". Ann had similar comments on the influence of her peers, "Everybody goes their separate ways, you go into whatever you like. I have friends who are just working, I have friends who are in university, I have friends who are in high school and it didn't really matter. I mean they're supportive of what I do". Tina said that although her friends were good at science, most of them did not pursue it in university: "Um, well I think none of my friends liked science. . . most of my friends were in the classes but never planned on going into that. They were good at it too".

Kate also thought that her friends did not directly impact her decision although she did comment that they expected she would enter a science program: "Cause when I talked about going into physiotherapy some people were disappointed. . . when I told them I was going into biotechnology they were all happy".

Ali, on the other hand, believed that friends did influence her decision to pursue science. She described how a friend had convinced her to go into science. She said, "she was in engineering at Mac and she was like, 'oh no, Ali, you have to go into engineering because you're so good at math and science and it would be a waste if you went into business'".

With the exception of Ali, peers did not seem to have a significant impact on the decision to pursue a math or science program. However, they did seem to be important in terms of actually doing math and science. Four of the participants described how they enjoyed helping their peers with math and science. Sandra said "I liked the idea of being able to help my friends" and Jen found that helping her friends was an efficient way to study:

> I used to really like helping others too because it helps you understand. So before my science and math exams I used to ask people, whoever has problems, call me and ask so this way I can review. I don't have to open my book and say what do I review?

Tina also liked helping her peers and as a result she started tutoring in grade eleven which she said helped her to decide that she wanted to be a science teacher. Tina explained why she likes helping others:

> Sometimes you see a completely new way of seeing a problem, that you wouldn't have thought of if you weren't explaining it. I don't know I would surprise myself sometimes that I would understand it enough to figure out another way. . . (I) take the time to figure out how they could see the problem and why they don't understand, what was it they didn't understand exactly.

Ann also said that she likes being able to help her peers: "I love being able to help other people. You learn 80% more when you teach someone to do something than when you do it yourself and that's like a part of the hands-on thing I guess because then you know that you actually have a grasp on it."

Also related to the influence of peers is the idea of a peer network who shared similar interests and talents in math and science. Kim explained: "It's just basically if you have a liking for math and science then you're in that category where you can do it". Lori saw the people in her high school as belonging in two different categories: ". . . and then you'd start to branch off, you have the business side and the science side more or less. I didn't see half the OAC's because they'd be on the other side". Michelle agreed with this idea, "I think I found that groups of friends all tend to be similar to yourself, my friends tended to be in the maths and sciences and then there's the group of people who are in drama, the group of people who like sports".

In summary, with one exception the respondents did not feel that their peers had a *direct* influence on their decision to pursue a math, science or engineering program. With a few exceptions, their friends did not pursue these areas themselves nor did they actively encourage nor discourage the participants from pursuing these fields. On the other hand, peers did seem to be important in terms of doing math and science. Some of the participants talked about liking to help their peers. They felt that this helped them to understand the material better and it helped one of the participants decide that she wanted to be a science teacher. As well, being with peers who shared similar interests in math and science also appeared to be important for some of the participants.

Parents:

The third subtheme under Interpersonal Influences is parents. The discussion of this subtheme focuses on how they were involved in the participants' decision to pursue a science, math, or engineering career. Most of the parents encouraged their daughters but did not pressure them or force them into their decision and all of the women felt that the decision was made on their own and that their parents supported their decision.

Four of the participants had fathers who were engineers and they felt that this had an influence on their decision. Kim's father is a chemical engineer and she plans to go into computer engineering. She said her father encouraged her to go into science "only when I showed an interest. It's not like he pushed me into it but when I showed an interest he was happy that I was taking that course". Kim's father also helped her by "explaining to me what his job was, what he does". Similarly, Jaime's father is a chemical engineer and she also said that her parents were supportive but not forceful: "my dad's a chemical engineer, um, my mom's a nurse so she also has a science background. Um, my parents encouraged me to go into engineering as opposed to science just because I think they knew that's where my strengths lie". Tracey's father is also an engineer and when asked what the major factor in her decision to pursue engineering was she said:

> Probably my dad. He's an engineer. . . he wanted one of his daughters to and he wanted me to. . . he never really said "I want you to go into this" but when I was younger. . . in high school, people would ask me what I wanted to go into and I hadn't made up my mind yet so I said "I don't know" but he always said "Oh she'll go into engineering".

Lisa believes that her father was an influence on her decision not only because he was a mathematician but because she actually saw him engaged in research and was able to see first hand what it involves. She believes that he had an influence on her decision to go into physics. She explained:

> Also my dad is a mathematician and I guess that influenced me. Not in the sense that he would push me towards science but I was introduced to it not only just by a teacher telling me. I actually saw what research is all about.

Before Lisa made her decision to go into science, she felt some indirect pressure from her father. When asked how he pressured her, she said:

> Little comments here and there, but he also said, cause I was struggling with the idea of going into theatrical design or physics and one day he said "You know Lisa, you don't have to go into physics" and that's, I don't know I just made my peace with that.

A couple of the participants talked about how they saw their mothers or grandmothers influencing their science career decisions. When asked about the influence of her mother, Jen said without hesitation that her mother and her grandmother were her biggest role models. She said: "They always told me wherever you go, even if you dump school, no problem everything is fine". She also said: "My mom and my grandma gave me the motivation to learn, my curiosity."

Furthermore, Jen felt that her mother and her grandmother had an influence on her decision to pursue physics by teaching her to be curious and by giving her an intellectually stimulating home life. She said: "I'm very interested in everything, my mom raised me that way, she made me interested in a lot of thought and to keep on being interested. . . I live in a very stimulating family". Jen also believes that her mother may have wanted her to pursue chemistry rather than physics:

> I think she wanted me to become a big scientist, you know, you don't hear a lot about physicists, like they don't do the same kind of stuff, like chemists do stuff that's, I don't know, more useful to humanity. . . nobody cares about relativity. . . but my mom really doesn't mind, she's interested in what I'm doing.

Similar to Jen, Kate also said that she felt some indirect pressure from her mother and when she discussed going into physiotherapy, her mother, "didn't say anything but I could see that she was kind of disappointed, cause I wouldn't be going specifically into science". Despite her mothers slight reservations, Kate explained that her parents were positive. In describing the impact of her parents on her decision to pursue biotechnology, Kate said, "I think the best thing they do is that they don't judge me, they trust me, so they know that if I do something it's for my best interest and my mother works in a lab so I guess that's one thing that led me to science".

Three of the participants indicated that their parents had a more subtle effect on their decision to enter science. Tina believed that her parents did not directly encourage her to go into physics but she said: "Well, they've always encouraged me to do my best and everything but not really. . . it's always been my choice". Similarly, Michelle explained that her parents encouraged her to do whatever she wanted to do and Sandra also said that her parents were supportive of her decision but did not pressure her into anything:

> My father wanted me to take computers, but my mom knew I was good in math. . . they didn't really make the decision for me, they knew that if they tried to force me to go into something I'd go in the opposite direction and they also know that math is a good field for me to be in right now.

Asked about the influence of her parents, Ann said, "They never really influenced me... they were both good role models. They were always supportive in the way, you can be whatever you want to be, it doesn't matter you know, whatever you like". It was Ann's father's suggestion to try co-op in engineering that led her to do this. She said:

> . . . but my dad told me. He said you know 'what about engineering? You like your maths and sciences'. And I was like 'well what's that? Then he tells me about how they apply their sciences to what they're doing and it's like an actual occupation, so that sounds interesting.

Sheri explained that her father had an impact on her decision to pursue math because he had a strong interest in it. She said:

> neither of my parents went to university but my dad really likes math and he had all these books around the house that were called like, 'Algebra the Easy Way' and I remember one time I asked him

> something and he used to take me downstairs and show me, he had a little blackboard and he used to do algebra for me and teach me how to do it. . . I think he likes the idea that I'm in math.

In summary, parents were supportive of their daughters' decision to pursue their chosen field, often acted as role models and encouraged curiosity and science involvement. These women had parents who did not try to force their daughters directly into math and science but encouraged them when they showed an aptitude for math and science. Some of the participants had parents who were in science, math or engineering and this appeared to be factor in their program choice. Other participants described incidents where they felt subtle pressure by their parents to pursue a particular area of math, science or engineering.

Other Role Models

In some instances, the young women talked about other Interpersonal Influences beyond teachers, friends/peers and parents. For example, Sandra describes her aunt as the person who gave her that extra push that she needed to pursue a math program: "My aunt talked about the actuaries at her husband's company making a lot more than the executives and it kind of perked me up. . . my aunt was kind of the nudge".

Michelle saw her brother as her most important role model. She said, "my brother also goes to Queens and he's actually in engineering too. . . I kind of looked up to him. I guess you could say he was a role model".

Lisa said that she didn't really feel that she had any major role models. When asked if she had any role models she said: "Not really. . . nobody that followed me through. . . who was pivotal". Later she says that she was encouraged by more men than women: "If I could think of all the people who encouraged me to go into science, they would have to be mostly men. I don't know if it's because there's mostly men in science, um, I can't recall being encouraged by a woman actually".

Early in the interview when Jaime and I were discussing role models she said she couldn't think of any, she said: "Um, not really (any role models). I mean I met people since I decided to go into engineering but before that I didn't really have any to base my decision on. Like I have a friend whose sister is in industrial engineering, she wanted me to go into that". Later in the interview, she remembered another role model experience: "Actually that reminds me of a role model thing. My mom was talking to this woman...she has a family and she was promoting engineering . . . she kind of let me know that it is possible to have an engineering career and a family".

While Lori could not identify any specific role models, she believed strongly that role models in general were important. She discussed role models in the broader sense and talked about the lack of role models for girls in the sciences. When asked about the low numbers of women in science, she said: "That might have something to do with their role models, if their dad was Mr. Fix-It around the house, they might see themselves being like that when they grow up. Girls don't have as many role models like that". She also said:

> It really depends on the role models they have and girls might not have that many role models, in fact there aren't many role models for girls to go into science and engineering. . . but for some people who are sort of borderline they'll look at . . . you know they'll try to look up to people and see what they're going into. Or if there's someone they respect, they'll be like what do they like or what do they do and if they don't see anybody in science they might think "there's not really a future for me in science".

It appears from these comments, that other people such as family members and acquaintances were seen as important role models influencing career and course decisions. In some instances participants named particular individuals but in at least one case a participant spoke strongly about ways in which role models in general are important for creating positive images of science for females.

To summarize the theme of Interpersonal Influences, the respondents described a complex interaction of influences among the people in their lives who affected their decision to pursue a math, science or engineering career. Among the people they identified as the main influences on their decision were teachers, peers/friends, parents and others. Some of these people had a strong direct influence on their decision, whereas others had a more subtle impact. Nevertheless, the findings revealed that the role of Interpersonal Influences on program and career choice decisions is complex and the range of people who influence these decisions is wide.

Contextual Influences

The second main section is Contextual Influences. The participants discussed many different aspects of math and science experiences, inside and outside of the school which influenced their decision to pursue a math, science or engineering career. This theme includes the following four subthemes: a)group work and labs; b) special programs; c) high school course selection and; d) lack of information about science and engineering careers.

Group work and labs:

This section will include a discussion of what the participants believed were the advantages and disadvantages of group work. Five of the participants mentioned the importance of being involved in group work and labs as a strong factor in their decision to pursue a science career. What's more they indicated that they preferred group work to lecture style classes. For example, Lisa said: "In physics that's what I like, it's all group work and that's an attraction". Lori also found that group work was important:

> I found in OAC you did a lot more group work, well not in the class but doing homework. I remember in physics OAC there was a lot of comparing answers just because you could get to the same answer different ways so it was interesting to see how other people got their answers.

Jaime thought that group work was essential to the learning process:

> I work well in a group. . . to be able to get together with people and for everybody to be able to contribute and learn from each other. I think it's really important in the learning process. . .I think sometimes you can learn better from your peers rather than somebody who knows everything.

Kate also thought that group work was important and she said, "I like having another person's point of view. It helps to clarify things. . . by exchanging ideas, we can learn from each other". Tina also expressed a preference for individual work over group but it depends on the work: "I like it sometimes but I prefer to work on my own . . . it's easier to concentrate. But for some things it's good in a group, for some physics assignments, get together and exchange ideas because sometimes you're just stuck".

Ann liked group work as long as the group works well together. She said, "And group work itself, you really learn a lot of leadership skills. I've done so much stuff with groups, like projects and stuff and you get a whole new light to it because people offer different things to a group".

Five of the participants also supported the utilization of hands-on experiences through the use of labs. Tina said that she prefers physics labs to chemistry labs: "I like physics labs but the chemistry ones, I can't see the point of them really. It doesn't seem logical, you mix two things and it turns blue, why? . . . I don't know it's more concrete and you can understand it more".

Kate and Lori also explained what they believe are the merits of labs. Kate said, "I like manipulations and doing something I guess. Actually putting theory into practice" and Lori said, "I guess it wasn't just sitting down and writing, taking down notes, it was more applying what you learned, it actually made sense".

Ann said that she "loves labs" and she described what she likes and dislikes about them:

> Hands-on stuff is really cool but like what I don't like about labs is writing, I figure a lab is about actually getting to do the hands-on stuff, getting to find out why this works, this is why it's going to be like this in your calculations, that's what really proves it to me. You can do as many problems as you want but until you get there and actually say 'look there's an equilibrium' you're not gonna understand it and that's why labs help so much. So if you didn't have all that writing to do, then at least you'd be able to experiment.

Michelle agreed that labs are interesting, but she too said that she didn't like writing them up: "In high school I liked labs, I thought they were interesting, I like doing labs but I don't like writing them up. I like the hands-on aspect".

One of the participants, Jen, said that she agrees with the purpose of labs but finds that they do not usually accomplish their aim. She explained that she likes the idea of them but thinks there is too much emphasis on marks so it is difficult to learn from them: "I hate labs. The labs I think are not well done... You end up giving in a lab report but not really knowing what you've done. . . I love learning and I'm sure we could have so much fun . . . because you're always doing stuff for marks, it kind of takes the fun out of it".

Ali also said that she doesn't like labs because generally, the result is already known. She said, "They're already set out for you and the end result is something you already know, like you're trying to show a theory that has already been proven and it seems pointless. . .it just seems like a waste of three hours". Sheri agreed with Ali on this point. She said, "I guess I just don't like doing something when you know what's going to happen. I mean the ball's going to drop in physics because gravity is there. People have done that for years, you know what's going to happen".

The participants seemed to have mixed feelings about labs. Some of them liked them but thought that they could have been conducted in more useful ways; others liked the hands-on aspect of labs. A few of the participants explained that they did not like the predictability of labs and would prefer if they involved more experimentation. Most of the participants mentioned that they liked group work but sometimes it depended on the type of work being done.

Special Programs:

The second subtheme under Contextual Influences is special programs. Nine of the participants were involved in special programs which they believe contributed to their decision to pursue a math, science or engineering program. Some of these programs were held within the school and some were held outside of the school. This section will include a discussion of these programs.

Kim was involved in a summer camp program aimed at encouraging women to enter engineering. The camp, called "Discover Engineering" took place at a university. Kim says that this camp experience "made me sure I wanted to do it". She explains what the camp was like:

> They basically explained what each discipline was and then you'd have a project to do. Like for civil engineering we had to build a tower out of straws and masking tape that would hold an egg. . . we also worked with "AutoCAD", we did some circuits, robotics and hydraulics and they really introduced us to a lot. It really explained a lot, opened our minds a lot.

She explained that it was only women who were involved in the camp and the teachers were all female engineering students in university. She felt that this was an advantage of the camp:

> I think it's better that it was only girls because everyone felt comfortable around each other and no one had to prove themselves or whatever. It wasn't a girls against guys thing which usually tends to happen in these situations.

Lisa also spoke enthusiastically about camp experiences. She explained: "Well I was always encouraged to do whatever I wanted to do so I tried all sorts of different things, summer camps and things like that, so I was introduced to the subject". She talked a bit more about the types of camps she was involved in:

> It was mostly biology, biotechnology. . . marine biology where we got to watch whales and fish, it was really cool. Biotechnology was fun too, we did cloning of plants, really intensive stuff. . . programs here at the university, the small enrichment courses. . . I didn't know at the time of any camps in physics really.

Lisa thought that these camp experiences were a major factor in her decision to pursue a physics program: "It was always the summer camp experience. They introduced you to... they were doing research and stuff like that".

Jen's experience with special programs occurred when she was younger. She explained that when she was five or six she was on a French television show similar to "Bill Nye the Science Guy". She was also in a science club when she was young:

> It was a small municipality club and you did very basic stuff, like putting pepper into water and then pouring soap. That was kind of my first experience with real science and I liked it.

Tina, along with Lisa, was involved in a camp experience which she believed was pivotal to her decision to pursue a physics program. She explained what the camp entailed:

> I went to a sort of summer camp. . . Shad Valley. It's a summer camp program and it's in nine universities across Canada right now. I went there after grade eleven and it's a whole month and it's

> about math, science and entrepreneurship and we had classes in the morning but in the afternoon we had all sorts of activities. . . Everyday we started with a class. We had all sorts of classes, we had one on AIDS, we had stuff on aqueducts and the airplanes and aerodynamics and all that. And then we had three workshops and we had a whole selection to chose from.

In addition to special programs out of school, five of the participants were involved in special programs in their school. Lori was involved in the science club at her high school from grade eleven to OAC. She explained that the science club was for students who want to enter the "Science Olympics". Lori and her friend, who she explained was not very "science oriented", entered a crystal growing competition each year. When asked if the science club experience contributed to her decision to enter chemistry she responded: "Well I think I joined it because I was interested in science and not the other way around".

Tina was also in a school based special program. She believed that her participation in a "math league" was very positive. She explained more about it:

> Well in school we had a math league, we went to different schools and we had kind of logical problems to work out and there were groups with other schools. . . there was one person from each school on each team, so we had to work with different people each time we went, it was nice, it was fun.

Kate attributed her decision to go into biotechnology in part to the special program in which she was involved in high school. She attended a small high school which involved a scientific concentration program. She had to apply for the program and had to meet certain requirements to be admitted. Kate described the program as involving special science courses and participation in science fairs. She said:

> we talked about everything in science from biotechnology to physics, to you name it. So I think it helps if someone is not really sure what they want to do. You talk about everything. It's more and different types of science courses and it's more advanced.

One participant attributed her decision in part to the hands-on experience she received in a co-op program. Ann's decision to pursue an engineering program was prompted by this co-op program she took in high school:

> So I got hooked up with an engineer. And I didn't just do engineering stuff, I went around the whole mine and I did like welding and chemistry and processing and I did engineering stuff and I did accounting, I did everything. Every little job that was in that mine, so I got a feel for the whole business altogether. But what I liked most was the engineering and that's what actually turned me on to it, cause I liked and I said 'man, I really want to do this cause it interests me so much and it has all the stuff that I like'.

> So it wasn't like oh maybe I'll go into this, it was hey you know I like this.

Michelle was also involved in a special program within her high school. She took a course called industrial physics from grade nine to thirteen. The students had the choice of whether or not they wanted to take this course but Michelle said it was not very well advertised. She knew about it because her brother went through the program. She said that it was mostly males involved in the program, "In a class of like 25, it started in grade nine with four girls, by grade 12 there were three of us". Michelle felt that this program was the major factor in her decision to pursue engineering. She said, "basically it's like a first year science course and in that course you work with companies and they present you with a project, which is basically what I want to do and that's when I decided I want to do that".

Kim and Ann felt that an important aspect of the special programs they were involved in was exposure to role models. At the camp that Kim attended all the teachers were engineering students. She explained that she saw them as role models because they were women and because they were young: "they were all women, they were all engineering students at university . . . they were closer to our age group". In discussing the fact that the teachers are all women she said: "The camp is to encourage women to go into engineering, people like to see the women doing it so that's probably what helps a lot".

Ann also talked about how she was involved with a role model through her participation in a special program. She enroled in a co-op program that enabled her to work in a mine with a female engineer. She said, "the person who took me around was an engineer. . . she really did inspire me, she was a really good woman, she knew what she was doing".

In summary, the majority of the participants were involved in a range of special programs which they described as important in their decision to pursue science or engineering programs. Only Kim was involved in a program which was aimed specifically at encouraging women to enter engineering programs. The other programs were for males and females but were also important in the women's decision to pursue their chosen field. These special programs appeared to provide the young women with a positive learning environment which was based on fun rather than marks as well as exposure to role models. The programs were voluntary and this ensured that the other participants were eager to learn as well. Special programs seem to be an extremely important factor in the decision to pursue a math, science or engineering career.

High School Course Selection:

The third subtheme under Contextual Influences is high school course selection. The participants in this study excelled at math and science throughout their elementary and high school years. When asked if they were always good at math and science, they responded that as far back as they can remember they liked math and science and were good at it. All of the participants continued to take math and science after they had the choice of whether or not to take these subjects and many of them took enriched math and science courses.

When asked about the math and science courses she took in high school, Kim responded: "I did every math, advanced math, calculus, algebra and finite. The only science I didn't take was biology and I wasn't really interested in that. Similarly, Lori said: "I took physics, chemistry and biology and for math I took calculus and algebra". Ann also took all of the math and science courses along with an enriched geology course. Similarly, Michelle took all of the math and science OAC's and was also involved in two other science courses which were not offered at any other high school in Ontario: industrial physics and power. Jaime, Tracey, Jen, Tina and Kate took all of the math and science courses available to them, throughout high school.

Lisa wanted to fit other subjects into her schedule so she skipped one math course: "(I took) all of them. From bio to chemistry to physics, algebra, calculus, oh I didn't take finite. I didn't take that one. I had all my arts that I had to fit into my schedule". When asked why she took all of these courses, she responded: "I wanted to keep all my doors open. . . and yeah some of them were interesting".

Four of the participants were also involved in enriched math and science programs. Sandra said: "In grade ten I had a really good math teacher and I was in enriched and I did really well and she was cool". Similarly, Lori was enroled in enriched classes and she liked being in these classes because they were able to skip ahead of the basics:

> When I went into grade ten, the enriched class, that was nice because everyone there wanted to learn, so we'd skip ahead of a lot of the basic stuff (to stuff) that was more interesting which is nice

> because you're not always writing down notes, you were doing extra projects.

Jaime thought that being in enriched classes helped her to achieve; "... and I think it encouraged you to be a higher achiever because if I was in just regular advanced classes in math and science I would probably be ahead of the class anyway so it wouldn't take as much effort to keep up so I think that was important in my decision".

Lisa was also in enriched classes but unlike Lori and Jaime she found them intimidating:

> The thing is, I was in a special class in high school... an enriched class. For all the important classes we were always together, which was supposed to be a higher level. So there was always smarter people in the class than me. I was somewhat intimidated by that. I thought if I don't get nineties I'm not good enough.

In summary, all of the participants excelled at math and science throughout their school years and continued to take these courses throughout high school. Many of them were also involved in enriched courses which for the most part was seen as an advantage. However, for at least one participant these courses were not regarded as a positive influence. The fact that these women continued to enrol in math and science courses throughout their high school years is important because in order to enter math, science and engineering programs, these courses are necessary. These women made a conscious decision to continue taking these courses because they recognized their importance for their future plans.

Lack of Information About Engineering and Science Careers

The last subtheme under Contextual Influences is the lack of information about careers. Five of the participants thought that they were not given enough information about engineering and science careers in high school. Kim was especially concerned about the lack of information about engineering available in her high school:

> I also find that not many people know about engineering or they've heard of engineering but they don't know what it is. . . They don't know enough about it. They don't know what engineering is and of the different types of engineering there is. . . they have no clue what it is. Meanwhile, there's civil, mechanical and computer, anything, so you can do so much in engineering but nobody knows.

Kim said that in high school you are encouraged to go into engineering but are never really told exactly what it entails: "They always say, yeah, go into engineering but they never really say what it is".

Jaime was also concerned about the lack of information about engineering careers early in high school. She thought that the information came too late and that by the time they gave the information, many students had already decided on a program or had already dropped the requirements necessary to enter engineering. She said:

> . . . because engineering to me, it always seemed like I never really knew what it was. It was very unclear as to what an engineer would do or what an engineer would study and it wasn't until later

> in high school, there was no one who explained it that well until they started coming into the school and recruiting I guess.

Michelle thought that the information was available if you looked for it. But she also said:

> I don't think that any high school actually opens up all the opportunities and tells people about all the options but in my high school there was a lot of information, you just had to look. . . there's a lot of jobs out there aside from the typical professions and you just don't learn about them.

Lisa thought that information about science and engineering careers was scarce and she also found that guidance counsellors had a role in discouraging women from these subjects:

> Even though I never, ever considered a career in engineering at all... I don't know. . . I knew they existed but I never considered it... you have to go find the information on your own if you're interested in it. And counsellors. . . they're uninformed and out of date. It's really hard. Like I knew what I wanted to do so I'd never go through them but I had a lot of friends who went through them for counselling and it was really sad the things they would get out of it . . . they would be very stereotypical. They would suggest for women to go into biology and for men to go into engineering or math.

Tina agreed that there is not enough information about science and engineering careers in high school. She has decided that she might want to be a science teacher, but thinks that it is partly because she does not know what other options she has, although she thinks co-op would help to give her a better understanding of her options. She said:

> yeah they don't tell much. They say there's a lot of jobs in science but I don't really know what. I'd like to take co-op just to have an idea what types of things I can do and if I would like it or not. We did have a day in grade ten though, co-op day, you went to work with the type of person in a field that interested us. But teaching, that doesn't help much, I've been in school all these years.

Tina also said that she chose to go into science because she hears that there are a lot of jobs in the field. She said:

> I think maybe because everybody says there's so many jobs in science and everything. I like history and geography but I didn't see what I could do with that. With science I know I can be a teacher and if not I know there's other jobs.

Many of the participants supported the idea that high schools do not provide sufficient or adequate information about math, science and engineering careers. This was especially true for the engineering students. They felt that they were encouraged to go into engineering but were never really told what it is. This is interesting in light of the fact that all of these women chose to enter math, science or engineering programs. It seems that these young women were motivated to go out and find career information on their own. The following section on Intrapersonal Influences sheds some light on what makes these young women different from those who do not seek career information.

To conclude the discussion of findings related to Contextual Influences, the participants described many experiences related to their math and science classes in high school that affected their decision to pursue their chosen program. The participants discussed the importance of group work and lab experiences in their decision to continue to enrol in math and science classes in high school. Those participants who were involved in special programs or enriched classes felt that these experiences were relevant in their program choice decision. Another important factor in this decision was the course choices these women made in high school. They recognized the importance of keeping their doors open and therefore continued to enrol in math and science courses after the choice was made available to them. They also indicated that there was a lack of information regarding math, science and engineering careers available in their high schools, yet they persisted in these subjects.

Intrapersonal Influences

The third main section which emerged from the interviews was Intrapersonal Influences. The participants in this study were not just opting for these programs out of interest, they are deeply involved in math and science, they have always excelled in these areas, and have a love for these subjects that is an integral part of their personalities. The following section includes a discussion of the following subthemes: a) stereotypes and the under-representation of women in science and engineering and; b) a passion for math and science.

Stereotypes and the under-representation of women in math science and engineering:

Although, the participants in this study did not believe that stereotypes about males and females applied to them, they did hold some strong stereotypical beliefs about why women are under-represented in math and science. In light of the fact that the participants in this study all chose to pursue a math, science or engineering program, it is interesting that many of them held such stereotypical attitudes.

Sandra believed that women might be more "expressive" and therefore better at subjects such as English:

> Like math classes are not very exciting and I think guys are more able to sit down and figure something out. . . I think girls like to be more expressive in English and writing and stuff like that instead of logical thinking. . . they're better at more creative stuff like writing and political thought, stuff like that where they can be a little more creative.

Sandra also believed that women may be turned off by dissection: "Well, with biology, I think the whole dissection thing turns them off".

Similarly, Lori held some stereotypical beliefs about men and women's different interests and abilities. She said:

> In math girls tend to give up more easily than boys, if they don't get it right away they think it's hopeless. You know the whole stereotype that girls aren't good in math, the whole "Barbie" math is hard thing, it's easier to make cookies.

Lori also believed that girls tend to memorize things more and that they tend to try harder at subjects like history or English. As well she thought that women might be more social and would therefore choose a more social career:

> Girls might be a bit more social, in the sense that they don't want to sit in front of a computer and type away numbers that don't really make sense. I'm like that, the only time I use a computer is for word processing or to go on the Internet. Girls might have better social skills or aren't as interested in hacking away at a computer.

Lisa believed that the under-representation of women in physics might have something to do with the fact that it does not deal with living things:

> It's cold in a way, in the sense that I know women will probably go towards something that's more living, like biology or even chemistry. I get comments like "it's all dead", you don't work with anything that's alive, it's like pieces of metal or rocks or light and maybe that doesn't interest women as much.

Two of the participants thought that women might not want to enter a field that is male dominated. Kim said, "well probably a lot of the reason is that it (engineering) is still very male dominated and women are afraid to go into that kind of environment". Lori also thought that women might feel intimidated: "They might be intimidated by the other guys. If they didn't do that well in high school they might not be eager to go into it in university".

Jen had a somewhat different perspective on the situation:

> I think that women are less interested in that, or maybe men have less interests apart from science. . . they have less choice because they have less interests. I think girls are interested, some might be scared to go into a field where there's only men, but I think women think about, oh , I'll have to have children and stuff and I have to have money and science is such an uncertain field you know. . . I think we're more practical, even though I hate to say that because I know I'm not practical.

When asked about the male/female ratio in their math and science classes, most of the participants said there was an even split although a few others talked about being part of a minority. For example, Sandra remembers being one of only a few girls in her math classes: ". . . and I remember in OAC there were only four girls in calculus and I was the only one in algebra. It's weird". Lori also saw some discrepancy in the number of males and females in her classes: "Well, biology is more of a girly subject. In biology, there were more girls than boys, in chemistry it was about even and in physics there was a lot more boys than girls". Apart from these two individuals, the participants thought that the number of males and females in their math and science courses was about even.

The participants did not think that there was a difference in ability among males and females in math and science. When asked if one sex was better than the other at math and science all of them responded "no". Lori remembered in high school that she thought that the girls were smarter than the boys:

> it seemed like in high school, girls were the smarter ones. . . you'd always think that it would be the girls who would rule the world since we're always so smart in school. . . it's odd that none of them wanted to pursue science or engineering.

When Lisa was asked about ability in math and science she responded: "I don't remember if there were more guys than girls, it never stood out. . . the top students, there were four of them and two of them were girls and two of them were guys". Ann was also sure that there is no difference between males and females in math and science. She said, "I know we're equal, there's no doubt about that and at home there wasn't that much of a significant difference".

In summary, most of the women had ideas as to why there are fewer women in math, science and engineering. Some of these opinions were based on how these women perceive women as being interested in different topics and for having different abilities than men. At the same time, most of the participants did not see a large discrepancy in the number of males and females in their math and science classes, although a few did feel that they were in a minority of women in some of these classes. There was unanimous support among the women for the idea that males and females are equal in their ability to do math and science. It is interesting that although the participants held some strong stereotypical beliefs about males and females and their math and science ability, they were all adamant in their belief that males and female have equal ability in these subjects.

How can we understand why these young women chose math, science and engineering careers in light of their stereotypical beliefs? Why do they not play out their beliefs about women in general? The following section sheds some light on these questions.

A passion for math and science:

When asked why they continued to take math and science courses most of the participants responded that they liked math and science and that they were good at it. They also thought it was fun. What is more, they liked the problem solving and logical thought aspects of math and science. This notion will be explored further in this section.

When asked why she chose to pursue math courses in high school, Sandra responded: "I did really well in them and I liked them. . . I did really well, I got nineties and they were the only courses I got nineties in". Jen also liked the idea that it came naturally to her, she never had to put much effort into math. She said: . . ."they (friends) would be getting really frustrated, then I could put it off to the last minute and then before a test be able to pull something out of a hat kinda thing". Ann said that she "always had a natural thing in math".

Jaime also liked math and science because she's good at it: "I guess I probably liked the feeling of being good at it, like it just came naturally to me, I guess it was the problem solving and stuff that I enjoyed, I enjoyed my success in it". Like Jaime, Jen also liked math and science because they come easily to her: "I loved math, I used to love math, I used to never study in math, never do anything and always have a hundred percent. . . It was really because it was the easiest thing for me to do. It was really by being so lazy that I took science I think".

Like the others, Kim responded that she liked math and science because she was good at it: "I've always been good at it, so I've always been interested in it". She said that she always had an interest in science and always asked a lot of questions. She said:

> I remember in science, I always had a big interest in it and I used to press my teachers for more information and most of the time they had to get back to me the next day. . . I was always into tech and doing wood working or like working with the computers and helping the teachers fix problems with the computers and stuff.

Kim talked about liking the challenge of science: "because I was good at it and also I really liked them, it was challenging and I was really up to the challenge". She says that her curiosity led her to continue taking science courses: "Just basically how things work, why is this? Why is that"? Similarly, Tracey liked math and science because she finds them challenging. She said; "It's a challenge and I like challenges, more than just doing monotonous work. . . I really liked math and science more than the other arts programs. . . I just find it more interesting and like it's harder and that makes it more interesting".

Lori stated that she was interested in science partly because there are things left to discover. She said:

> I guess it's just the interest. I find science more interesting than I do history. . . (in science) there's still some stuff left to be

> discovered which is kind of interesting and it makes you want to learn more. You think, well, maybe I could discover something, maybe there's something left for me.

Jen on the other hand, liked science because it is practical and it is about everyday life. She thinks it's fun to "learn how life works". She said: "And I found in science that if you look at science, like the theory and everything, you might see a connection between the way people act around each other and the way matter reacts among itself. . . behaviour of cells is really close to the behaviour of people among each other". Ann elaborated on a similar notion in her explanation:

> And chemistry, I liked the way that everything fits together. . . and I like the way that all the sciences come together to make one really, there's not one science that you can say is completely alone. It's really interesting how you can see, oh there's chemistry in this.

Two of the participants commented on the notion that in math and science there is often a definite answer. For example, Tina explained that she liked science because "there's a certain way, if you follow a certain pattern it gives you the right answer in the end, or it should. I like the idea that there's a right or wrong answer". Similarly, Sheri reported that she liked math because, "in history and everything else, you can have a different, like everyone can be right if they can back it up but in math there's a set way. I always like English and stuff too but in math there was a set way of doing things, more of a pattern".

Eight of the participants' reasons for liking math and science revolved around the idea that they liked problem solving and the logical thought process that goes along with it. They also liked these subjects because they believed that they are more objective than other subjects. For example, Lori thinks that math and science "make sense." She said: "it's not very abstract, it's all concrete and the stuff that you see it kind of applies to everything." Lori also explained why she prefers math and science to subjects like English: "English, you know, you're reading books and analyzing them, but what is knowing the whole plot of 'Lord of the Flies'? On a math test, the teacher can mark it and you know exactly where you lost marks, but on an English essay they can't really tell you what you did wrong, it's too subjective".

Like Lori and Sheri, Ali and Jaime liked the objectivity of math and science and disliked the subjectivity of subjects such as English. Ali explained that she likes math because there is a definite answer. She said:

> I like numbers, I don't like abstract ideas, like mech (mechanics), I don't have that whole 3-D thing happening and I don't like, I hate English. . . I'm not good at expressing myself that much and I just like the numbers and the definite answer. I like problem solving and that when you're done there's a definite answer.

Jaime commented that she likes problem solving and she was also frustrated by the subjectivity in subjects like English:

> I think I'm more of a problem solver, than just read and regurgitate, like I don't really like to read text books and memorize things. . . I

> kind of always wanted to problem solve and learn how to do things as opposed to learning things. . . one thing that frustrated me during high school was if I was in English or something where you give your opinion, you know they tell you you're wrong and how can you be? I was always frustrated with the subjectivity in those courses. In math you can't tell me I'm wrong.

Lisa indicated that she too prefers problem solving: "Well I like problem solving in general and understanding things. And if there's something that can be explained to me with mathematics, if there's a really nice formula that's concise, it's really exciting". Lisa elaborated on this opinion:

> Well I really like when I understand something and there's something mathematical related to it. That's one of the biggest thrills and it's like, isn't that beautiful. . . but if there's something that can be understood, something mathematical, something I can hold in my hands in a way and understand it and grasp it, it's thrilling. It's just sitting down and imagining or creating a world or just trying to explain things in a different way and seeing things that people never saw before or imagining things that could exist.

Jen also had a lot to say on this topic. She prefers problem solving to memorizing things. She explained why she likes problem solving: "You kind of do your problem and it's kind of fun, just like doing crosswords and stuff like that. It's kind of interesting, like you really want to find the answer". In a similar manner, Michelle compared problem solving to solving puzzles. She said, "I find math and science, particularly physics and calculus are like puzzles to solve. . . I try to think of it that way, it makes it more interesting".

Jen also explained why she does not like subjects where there is a lot of memorizing involved: "I hate memorizing things. I could recite my notes by heart, like I knew them and I would get to the exam, throw everything on the paper and then go home and not remember a thing afterwards, so I always hated these studies because you don't get anything out of it". Jen went on to explain the feeling she gets when she finally understands a certain principle and gives a detailed analogy to help explain why she likes science:

> And at one point it was like "I got it"! And I understood the whole thing. Bang! It's like some kind of thunder in my head and wow everything has worked out. . . but it makes me very, very happy when I understand the whole thing, I feel like it's part of me kind of and I'm never going to forget it again, like it's there forever because it's kind of stuck to your brain. . . Like your brain is kind of like a hand, with kind of sub-hands attached. But the more knowledge you have, the more fingers you have to stick a hand up to, so the more things you know, the more you can learn. So it's easier in science because if you go into a "by heart" field and you learn something then forget it, that's one branch you've missed. There's one less branch you can stick information to because you

> forgot it. But if it's comprehension, you understand it till they give you new information on the subject, then you find which branch you can hook it up to and then you hook it up and it sticks, then you have a bigger tree and it goes on.

Like Jaime, Lisa and Jen, Kate and Michelle also commented on the problem solving aspect of math and science. Kate said that she likes "the feeling you get when you have this big problem and you have to resolve it and finally you get it and it's a big rush".

In summary, all of the participants mentioned the fact that they liked and were good at math and science and this was the main reason that they are pursuing a math, science or engineering program in university. Most of the participants went on to explain that they liked the problem solving aspect of math and science, the objectivity of it and the fact that there is a right or wrong answer. These young women seemed to have a passion for math and science. They continued in these courses because they truly enjoyed them and loved learning math and science.

To conclude the third main section, Intrapersonal Influences the participants in this study seemed to have a passion for math and science. They were not just students who were good in math and science; they saw their ability as a part of their personality. They had very clear ideas about what subjects they liked and why they liked them. Math and science are a significant part of their lives. The participants described details of what they liked about these subjects which seemed to focus on the problem solving and objective aspects of math and science. At the same time, participants held strong stereotypical beliefs about gender differences in math/science ability. Although the participants made program choice decisions that go against the stereotypes, some of them still held strong stereotypical beliefs about males and females and their math and science ability. It is interesting to note that all these young women made decisions to enter science programs despite their stereotyped beliefs about women in science.

Conclusion

These three sections describe a complex set of factors which influence the decision to pursue a math, science or engineering program. The first factor, Interpersonal Influences, included a discussion of all of the people in the participants' lives who had an effect on their decision to pursue a math, science or engineering program. Teachers were recognized as an important influence on many of the respondents' decision. Some of the participants felt that they were directly influenced by their teachers whereas others saw this influence as more subtle. Teachers were also seen as important sources of information about science careers as well as positive role models. Many of the participants discussed what they believed were the negative and positive aspects of their teachers' teaching styles. A few described incidents where teachers had limited their participation in science classes or discouraged their involvement.

For the most part, peers and friends were not seen as a *direct* influence on the decision to pursue a math or science career, but participants described liking to help their peers because this was a useful way to become better acquainted with the material. Many of the participants described peers and friends who were not as involved in math and science and some of them described situations where their friends subtly encouraged or discouraged them from entering a math, science or engineering program.

The third subtheme under Interpersonal Influences was the role of parental influence on these womens' decision to pursue these programs. Some of the participants saw their parents as important role models but most saw them as encouraging and supportive of all of their decisions. A few of the women described incidences where they felt subtle pressure from their parents.

The final subtheme under Interpersonal Influences was the role of other people, aside from family and teachers who had an influence on the participants' course and career decisions. Interpersonal Influences are not restricted to teachers, parents and peers. A few of the participants described extended family members or acquaintances as influences on these decisions.

The second main section examined Contextual Influences. Many of the participants described math and science experiences which were important in their decision to pursue these programs. For example, group work was seen as important by many of the young women because it was a good way to compare answers and to better understand math and science material. Labs were regarded as an important way to gain hands-on experience. However, the participants were not unanimous in their support of labs and some of them described the reasons why they did not like them. Their criticisms revolved around the idea that labs are too predictable and there is not enough experimentation involved.

Special programs was another key subtheme in Contextual Influences. The participants who were involved in these programs described them as one of the main influences on their decision to pursue their chosen program. These special programs were seen as an influential factor in course and career choices. The third subtheme in this section, course selection showed that all of the participants excelled in math and science and continued to take math and science throughout their high school years. Many were involved in enriched programs. With the exception of one of the participants who found enriched courses intimidating, these young women believed that these enriched courses were a positive experience.

Another subtheme under Contextual Influences was the lack of information provided to students about math, science and engineering careers. Many of the participants felt that this information was inadequate and this was especially true for the engineering students. These young women believed that the information provided about careers in science and engineering was scarce and insufficient.

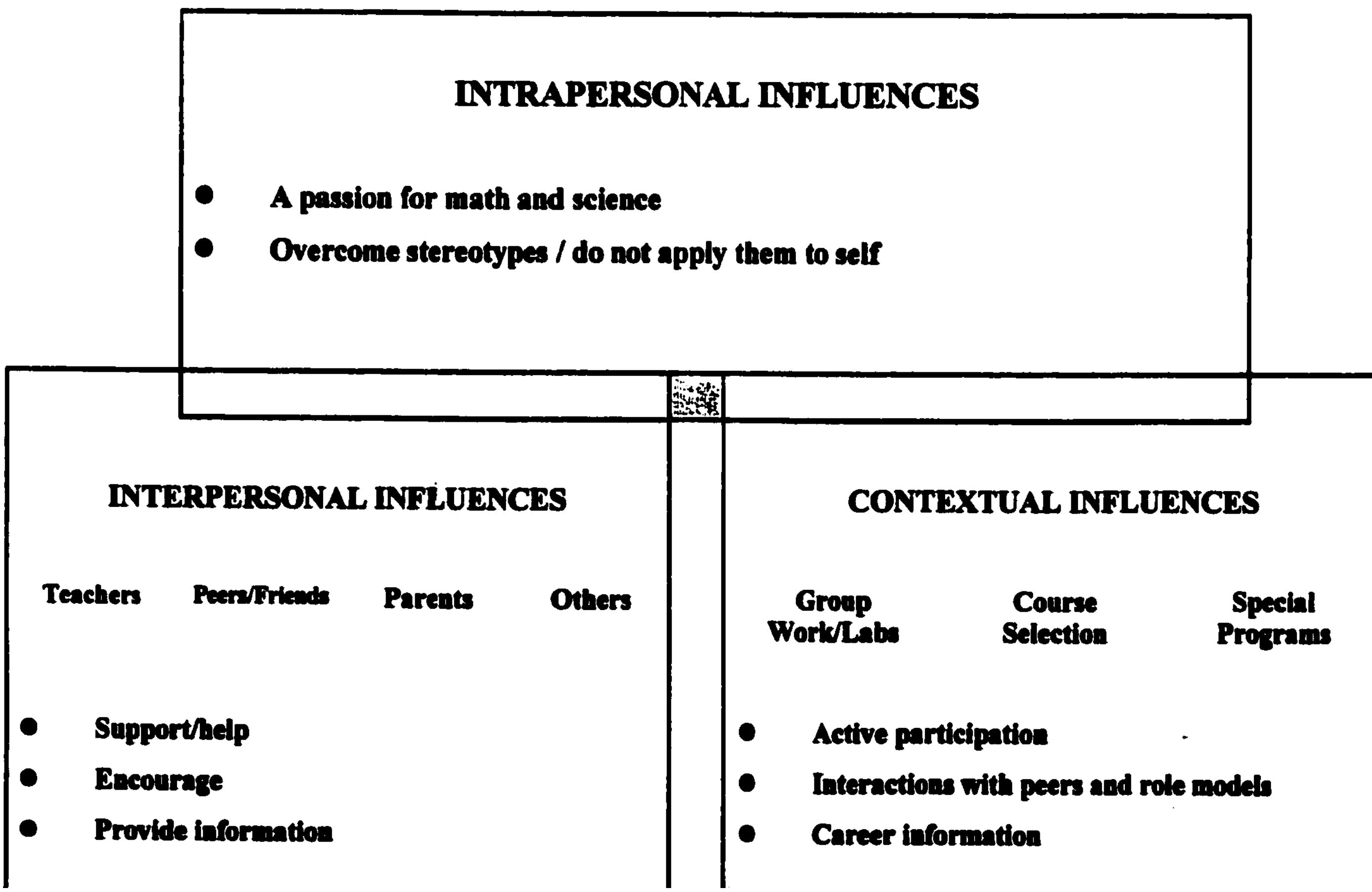
The third main section looked at Intrapersonal Influences. Most of the participants were deeply involved in math and science and saw it as a part of their personality and lifestyle. They seemed to have a real passion for these subjects and they continued to opt for math and science courses long after the choice was made available to them. At the same time some of them held stereotyped beliefs about why some women opt out of math and science.

The three main factors included in this discussion represent a wide range of the influences upon the decision to pursue a math, science or engineering program. It is important to note however, that these three factors work together across many years and lead to continued math/science involvement despite occasional negative experiences. Some of the participants described experiences involving negative teacher interactions, pressure from parents and peers and intimidating experiences in math/science classes, yet all of these young women overcame these negative experiences and continued to enrol and in math/science classes. Their passion for math and science remained strong throughout their school years and continued to excite them as they persisted in university.

Chapter 5 - Discussion and Conclusions

The purpose of this study was to gain a deeper understanding on the factors involved in young women's decisions to pursue a math, science or engineering career. Women remain considerably under-represented in these programs and it was my goal to gain a better understanding of why this is so. The critical difference between the present study and other studies conducted in this area lies in its focus on examining what women say through the lens of their own personal experiences in order to better grasp the complexity of the factors involved in this decision. The following discusses the reasons why some young women choose to pursue these programs. The findings are presented in the form of a diagram (see Figure 1) and are discussed in detail below.

Figure 1: Non-Traditional Science Participation: Intrapersonal, Interpersonal and Contextual Influences



Intrapersonal Influences

The top box in the diagram (see Figure 1) represents Intrapersonal Influences. This factor is on the top and larger because it emerged as a key one among the three influences. Through the interviews with the young women, it became clear that they had a passion for math and science. They indicated that math and science came naturally to them and said that they found these subjects fun and interesting. The young women also said that the reasons they were interested in math/science was due to aspects of math/science itself. These factors include the fact that they find it challenging, they enjoy problem solving and they like the practical and logical nature of these subjects. It appeared that being successful in math and science was a part of their personalities and this love for the subjects led to their decision to pursue math, science or engineering in university. Interestingly, some of the participants held stereotyped beliefs about women's involvement in math, science and engineering. However, these young women were able to overcome these stereotypes and not apply them to themselves because they loved math and science. Intrapersonal Influences represent the critical factor which influenced these young women to pursue a math, science or engineering program.

The results of my study indicated that these young women held a very strong interest in and enjoyed math and science. Previous research (mostly survey studies) indicates that genuine interest in and enjoyment of math and science are important in the decision to continue participation in it (Becker, 1984; Dick and Rallis, 1991). Other research has concluded that the gender difference in pursuit of a science career is due mainly to girls' lack of interest in these subjects (Hill & Pettus, 1990). The young women in my study indicated that they enjoyed solving problems and satisfying their curiosity. Therefore, it would seem that one of the most important ways to increase the number of young women in math and science is to increase their interest in these subjects. This can be done through activities that build on the enjoyable and fun aspects of these subjects. Increasing the enjoyability of math and science and fostering an interest in these subjects is critical if we expect girls to continue in these subjects throughout high school and university.

Some studies (Becker, 1984; Mau, Domnick & Ellsworth, 1995) have found that an early interest in math and science is common among women who chose to pursue these subjects. Among the participants in my study, this interest in math and science seems to have been fostered at a very early age. Therefore, it seems that it may be important to create a positive math and science atmosphere at a young age. It is important for teachers at all levels to explain a wide range of career options, to encourage both boys and girls to consider all careers and to ensure that they are aware of the consequences of closing doors too soon by opting out of math and science courses. Further research is needed to ascertain what it is about math and science which leads to a genuine interest in and a liking for it.

Some of the reasons that the young women in my study continued to opt for math and science were due to aspects of math and science themselves. The participants in my study indicated that they liked the objectivity and logical nature of math and science. Many of them disliked the subjectivity in subjects such as English and preferred the more objective approach to math and science. They prefer to have a clear-cut right or wrong answer. The research shows some support for this finding. Studies have shown that the objective and logical features of math and science as well as its tangible nature are factors which appeal to many women (Becker, 1984).

Other factors which the young women in my study mentioned as important in their decision to opt for math and science but which have not been studied extensively are its practicality and its connectedness to everyday life. The young women in my study stressed the importance of making connections between the sciences and relating these connections with life. They wanted to be able to understand a scientific theory in the context of something familiar to them. Teachers can increase the understanding of and interest in math and science by showing students how the sciences relate to each other and how they relate to the world around them. For example, it may be more effective to teach physics in relation to how things, which are familiar to both boys and girls, work rather than teaching physics concepts on their own.

The participants in the present study also stressed the importance of other Intrapersonal Influences on their decision to pursue math, science or engineering. For example, these young women indicated that math and science came naturally to them and they were always good at it. This led to a sense of confidence in their ability to do math and science and they were therefore more likely to continue taking these subjects. Previous research has looked at the role of self-efficacy and self-confidence in the decision to opt for math and science (Leslie, McClure & Oaxaca, 1998; Mau, Domnick & Ellsworth, 1995). This research has found that girls who perceive themselves as being well prepared in math and science are more likely to continue taking these subjects. This research has also suggested that those with higher self-confidence and an internal locus of control are more likely to pursue math and science. This research, along with the results of my study indicate that fostering high self-efficacy and self-confidence in girls in math and science is important in retaining them in these subjects.

There are some programs that have been initiated which appear to support the development of positive Intrapersonal Influences. Kort (1996) described a two-week full-day summer camp aimed at expanding girls' notion on mathematics. The goals of this camp are to help girls to learn to value mathematics, become confident in their ability to do math, to become mathematical problem solvers, to learn to communicate mathematically and to learn to reason mathematically.

Morrow (1996) described another summer camp, entitled SummerMath which was based on feminist notions of how females learn differently than males. The teacher's role in this camp is one of facilitator or guide as opposed to lecturer or expert. Students' self-confidence is increased by using what the author calls the "believing mode" rather than the "doubting mode". According to Morrow, "listeners in the believing mode engage in critical dialogue by trying to help the speaker elaborate, deepen and extend the ideas presented" (p. 7). Morrow also suggests that in order to become confident learners girls must be encouraged to take risks. She suggests that students must struggle for understanding in a supportive, encouraging environment.

The stereotyping of math and science as male domains has often been considered a contributing factor to the under-representation of women in math and science related careers (Inkpen, 1996; Koballa, 1988). Interestingly, although the young women in my study were pursuing math and science related careers and did not believe that they themselves were the victims of stereotyping, some of them did hold stereotypical beliefs. These young women were able to overcome the effects of stereotyping because they had a passion for math and science which helped them to overcome these stereotyped beliefs.

Gender schema theory, which was discussed in the introduction could help explain the apparent discrepancy between what the young women believe about math and science and what they do. Schemas help us to process information, and they also act to filter and interpret information and can therefore cause errors in memory. Sex-role stereotypes result from gender schemas. Some of the participants in my study displayed some stereotypical beliefs about women in science. They talked about the fact that girls might be more "expressive", and social and therefore not as strong as men in math and science. One of the participants described biology as a "girlie" subject and another suggested that her friends were surprised that she was pursuing physics, a subject where she would only be working with "dead" things. Burkam, Lee and Smerdon (1997) suggest that "biology, often considered to be a 'softer' science than chemistry or physics, is seen as a helping science, people-oriented and nurturing characteristics typically associated with females" (p. 299). Interestingly, the participants in my study described helping their peers as a very important aspect of the science experience. They seem to have integrated this characteristic which is typically associated with females into the "hard" sciences such as physics and chemistry.

In order to increase the number of women who pursue math and science careers, it is necessary to begin to counteract stereotypes at a young age. Even though the women in my study were going against the stereotypes themselves, some of the reasons they believed that other women stayed away from math/science programs were based on stereotypes. Some research has focused on how teachers can counter these stereotypes (Mason, Kahle, & Gardner, 1991). Teacher intervention programs have been helpful in making teachers more aware of the problem. Often teachers are unaware that they are promoting stereotypes, but once they are made aware they can begin to make a difference in their classrooms. Further research is needed to better understand why some young women are able to overcome these stereotypes and go on to pursue a science career. It seems that the young women in my study had a passion for math and science which helped them to overcome their stereotyped beliefs. As a result they project their stereotyped beliefs onto other women but did not believe that they apply to themselves.

Interpersonal Influences

The second factor affecting decisions to pursue math/science programs is Interpersonal Influences. Among the people in their lives who the participants believed had an influence on their decision were teachers, parents, peers/friends and other people such as acquaintances and extended family members. The diagram (see Figure 1) indicates that these people all had an influence on their decision by providing support/help, encouragement, and information.

Much of the literature on Interpersonal Influences on science participation of males and females has focused on teachers (Jones &Wheatley, 1989; Sadker & Sadker, 1994; Scantlebury & Kahle, 1993). Most of these studies have focused on negative student-teacher interactions and how differential treatment of boys and girls in math and science classrooms leads to different course and career choices. Because my study focused on the young women who did choose to pursue math and science courses, my results were somewhat different from those which have emerged in the literature. This different perspective is important in leading us to more comprehensive understandings of why women do choose to pursue these careers, rather than why they do not, which has traditionally been the focus of gender based math and science studies.

The participants in this study did not notice differential teacher/student interactions between boys and girls. Many studies have found that female students have fewer interactions with their teachers and receive less attention. These studies also show differences in questioning patterns with male students being asked more high-level questions (Barba and Cardinale, 1991). The present study was not based on observations of math and science classrooms and this could explain why these differences did not emerge. The participants I spoke with did not notice different types of interactions between boys and girls. This could be because they received equal attention, because they were strong math and science students or because it is difficult to notice these types of subtle differences when you are directly involved.

Contrary to the findings in the research that differential interactions exist between teachers and male and female students, the respondents in my study suggested that their teachers played an important role in encouraging them to pursue math and science, as well as providing them with information on these careers. Many of their teachers recognized that they excelled in math and science and helped them to maximize their potential through support, encouragement to continue in math and science and by providing them with information on these programs.

The research indicates that teachers can act as positive role models for girls by providing them with encouragement and the opportunity to see women engage in science activities (Oakes, 1990). My research supports this conclusion. Most of the participants talked about the encouragement of their teachers as a factor in their decision to pursue a math, science or engineering career. A few of the participants saw their teachers as important role models in this decision and some of the research (Oakes, 1990) has indicated that it is important for young women to have female math and science teachers. This conclusion was not supported in my study. The participants indicated that it did not matter whether their teachers were male or female as long as they taught well. The young women who saw their teachers as role models however, all spoke about female teachers.

The literature concerning the role of teachers on young women's decision to persist in math and science has generally focused on the negative aspects of teachers and the reasons why women do not continue in math and science. The present study however, focused on a group of young women who were pursuing math, science or engineering careers. This different approach led to different types of conclusions than the literature has provided. This study shows teachers in a more positive light and reflects the many different ways that teachers influenced these young women to continue taking math and science courses.

Based on the findings from the literature and those provided in this study, it is important to sensitize teachers to both the negative and positive roles they can play in the course and career choice decisions of their students. It is also important that teachers do not just encourage the students who are strong in these subjects but all students, both male and female. The findings from this study provide a better understanding of how teachers can influence girls to continue taking math and science courses. It highlights the fact that their opinions and help did not go unnoticed by these young women.

According to the American Association of University Women (AAUW)(1995), the use of teachers as student advisors is a positive way for young women to gain the support and encouragement of their teachers. The advisors help with program planning, personal development and decision making. The results of my study indicated that many of the young women felt they could talk to their teachers about career goals but it is less clear if the average student feels that this support is available to them. The use of student advisors seems like a positive way to ensure that all students have the support and guidance within the school setting.

The second Interpersonal Influence that is important is peers/friends. I found that the participants did not believe that friends *directly* influenced their decision to pursue a science career but they did recognize that peers/friends were generally supportive of their decision. This finding was supported by Moffat (1992) who found that peers did not appear to have a direct effect on career choice. As well, my study supports Baker and Leary's (1995) research which found that most young women thought that their friends would be supportive if they chose to pursue a science career.

My study however did reveal some subtle effects of peers/friends particularly in terms of actually doing math and science. I found that most of the participants indicated that they liked helping their peers. They thought that this was a good way to learn the material themselves and believed that if they could explain the material to someone else they were sure they had a grasp on it themselves. The idea of a peer network was also discussed as a subtle but important influence of peers/friends. Some of the young women believed that being involved in math and science courses provided them with a network of peers who were also involved in these courses and were an important source of information, support and encouragement.

These findings suggest that peer tutoring may be an effective way to encourage other young women to continue in math and science classes. The young women who already have an appreciation for and an interest in math and science may be better able to apply this interest to others who are not self-motivated. This in turn could increase the tutor's self-efficacy in math and science and ensure that they too would continue in these classes.

A program called Deliberate Psychological Education (AAUW, 1995) exemplifies the effectiveness of peer tutoring. This is a math tutoring program that pairs high school girls with elementary school girls and it shows the benefits to both groups in math achievement and success attribution (the reasons students give for their success).

The third Interpersonal Influence that is important is parents. The research indicates that parents are important for females in their decision to pursue math and science related careers (Campbell & Connolly, 1987; Fabrikant, Svitak & Kenschaft, 1990). My research supports this conclusion. Some researchers (Clewell, Anderson & Thorpe, 1992; Olszewski-

Kubilius & Yasumoto, 1995) have found that parents can be a strong negative influence when they hold different expectations for their sons and daughters and when they reinforce gender stereotypes. The participants in my study were all pursuing math, science or engineering programs, so this negative influence was not seen among them. All of them indicated that their parents were supportive of their decision.

A study by Montgomery (1990) indicated that women who pursued math/science careers were more likely to have fathers with careers in math or science; they were more likely to receive both their mother's and father's encouragement; and they were more likely to choose a career related to their father's field of study. My study lends support to all of these conclusions, as many of the participants had fathers who were scientists or engineers. Some of the participants who were in engineering programs had fathers who were engineers. One of them also had a mother who was a scientist. All of the participants indicated that their mother and father encouraged and supported them.

Previous research (Leslie, McClure & Oaxaca, 1998) suggests that parents who have confidence in their children's abilities and believe they can excel in math and science will have a positive influence on their children's attitude and performance. This finding was supported by the participants in my study. These young women believed that their parents were supportive and encouraging but not forceful. The participants did not feel that their parents pressured them into entering a math/science or engineering program. It is important for parents to make a distinction between supporting their daughters and pressuring them. Children should understand that they have a variety of options and that they are capable of pursuing math/science and engineering programs but not obligated to do so.

A program called Family Math is an example of a program which brings parents and daughters together in an attempt to create enthusiasm for math. Activities between parents and children are designed to teach them problem solving strategies and the ways in which math is used in everyday life and in different careers. The program helps parents become more involved in their children's' education and encourages girls to stay involved in math (AAUW, 1995).

Based on conclusions from the literature, as well as those provided in the present study it is important to sensitize parents to the potential impact of their encouragement. It is clear that parents play an important role in the course and career choices of their children. It does not appear to be necessary however, for one parent to be a scientist in order for their daughters to continue in math and science. It is important however that parents recognize that there are positive ways to encourage and support their children. Parent workshops would be a valuable way to educate parents on how they can be helpful and supportive to their children. Based on results from the present study it is important that parents are not forceful or overbearing, but rather are available with information or support for whatever their daughters choose.

A fourth Interpersonal Influence that is important is other role models. Some of the participants in my study mentioned other people such as extended family members and acquaintances as having an influence on their decision to pursue science. These other role models included people studying math and science whom the young women admired; individuals who offered encouragement; women who demonstrated it was possible to combine family and science careers and someone who highlighted the monetary value of a science career. The fact that other role models can be important in this decision is supported in the literature (Baker and Leary, 1995).

The issue of the specific or general impact of role models is not entirely clear from the literature. This issue was highlighted in my study by one of the participants who spoke at length about how role models in general are important for encouraging girls to pursue math and science although she did not have a specific role model in her life.

It is clear from the results of my study that support, encouragement and information do not necessarily have to come from teachers, peers/friends and parents. Although these people seem to play a strong role in the decision to pursue math, science or engineering, the young women in my study also stressed the importance of other role models and how role models in general play a role in this decision. There are many examples of role model intervention studies described in the literature (Bennett, 1997; Evans, Whigam & Wang, 1995; Marlow & Marlow, 1996; Smith & Erb, 1986). While the young women in my study did not necessarily participate in a formally structured role model program, they recognized that many different people could be influential in supporting, encouraging, and informing them about math and science.

It is important to point out that the influence of teachers, peers/friends, parents and others was not *always* positive. These individuals were not always supportive and encouraging. The participants in my study gave examples of teachers who limited their involvement, friends who discouraged them and parents who exerted some pressure.

However, because of positive Intrapersonal Influences and their passion for math and science the young women were able to counter these negative influences.

Contextual Influences

The third factor included in the diagram is Contextual Influences. Among these influences are group work and labs, course selection and special programs. Through these influences, participants were able to participate actively in math and science, interact with peers and role models and obtain career information.

Many studies have found that direct hands-on experience in the classroom is important in order to develop a strong interest in science (Jones and Wheatley, 1989; Klein, 1989; Scantlebury and Kahle, 1993; Peltz, 1990). Participants in my study agreed that lab experiences were important. They enjoyed the hands-on aspect of labs and thought that they were important in solidifying their understanding of many science concepts. The research suggests that during science labs, girls are often relegated to the position of note taker and that male students are more interested in participating in science activities, and female students often take an observer role. Among the participants in my study, this did not seem to be true. They seemed to be strong young women who played an active role in lab situations. This difference could be due to the fact that these are the young women who loved science. These young women could be the exceptions to the rule. A 1997 study by Burkam, Lee and Smerdon found that hands-on lab activities were related to all students' performance, but especially to girls'. The authors suggest that hands-on instruction is one of the most important ways to increase girls' confidence and interest in science.

The young women in my study, for the most part, enjoyed hands-on science experiences but it is unclear whether this was due to a natural interest in science or if early science experiences helped to nurture their love for the subject. This study revealed the need for a continued focus on when young girls develop an interest in science and why. This would give us a better idea of what specific classroom activities can be developed to foster an interest in science and math.

The participants in my study also talked about enjoying group work and thought that it was important to exchange ideas and understand another person's point of view. Similar results were found by Baker and Leary (1995) who concluded that girls expressed strong feelings for interaction with their peers in math/science classes.

It is important for teachers to experiment with different group sizes and class structures and to ensure that opportunities exist for students to participate actively in math and science activities. Some researchers believe that working in large groups perpetuates male dominance whereas working in small mixed-sex groups ensures that all students contribute and engage in decision making (AAUW, 1995). It would appear important to maximize opportunities that foster girls' active involvement in classroom math/science activities.

Much research (Haggerty, 1991; Haworth, Povey & Clift, 1986; Sadker & Sadker, 1994) has found that many young women decide to drop math and science courses as soon as this choice becomes available to them, usually in grade ten or eleven. Some research (Haggerty, 1991) suggests that a greater percentage of high school females enroll in biology and a greater number of males enroll in physics. The participants in my study, however were more likely to take physics. The majority of the young women continued to take physics throughout high school whereas several of the participants indicated that the only science course they did not take was biology. This is largely due to the fact that several of the participants were physics majors and several were in engineering. Physics would naturally be a prerequisite for these programs.

Other research (Farmer, Wardrop, Anderson & Risinger, 1995; Haworth, Povey & Clift, 1986) suggests that engineering students were more likely to study physical science in high school than non-engineering students and that the most important relationship among women for persistence in science is elective science course-taking behaviour. Results of my study support these findings, with all of the participants continuing to take physical science subjects throughout high school.

The participants in my study were also aware of the importance of keeping up with math and science in order to keep their options open and this is supported in the literature (Gaskell, McLaren, Oberg & Eyre, 1990). The young women I spoke with indicated that they understood the importance of math and science in order to keep many doors open to them. Although many of them had interests unrelated to math and science, they continued to take these courses because they believed they were important.

Some authors have suggested that a core curriculum is needed to prevent students from opting out of math and science courses. Schiebinger (1999) explains that in many of the countries where women do well in science, mandatory math and science courses are part of the high school curriculum. This strategy however, ignores the importance of liking these subjects which was clearly revealed in my study. Forcing people to continue taking math and science courses will not ensure that they will develop an interest in these subjects, nor does it ensure that they will pursue these subjects past high school. However, it does ensure that if they change career directions in university they would still have the math and science background.

Special programs is another important Contextual Influence. Many of the young women involved in the present study indicated that they were involved in special programs which contributed to their decision to pursue a math, science or engineering career. In fact nine of the thirteen participants indicated that they were involved in some type of special program either inside or outside of the school. These programs were important because they focused on providing the students with positive science experiences based on fun rather than marks. They often provided the women with hands-on, real life science experiences which the participants described as an important factor in their decision to pursue their chosen program. In addition these programs also provided the students with career information and with strong role models.

The research also indicates that the use of special programs has proven successful in improving girls' attitudes toward science and science related careers (Evans, Whigam & Wang, 1995). My study showed some support for this conclusion. Two of the participants were involved in special programs in which they were exposed to female engineers. These two participants indicated that the women they were involved with were strong role models. Many of the role model intervention studies (Smith & Erb, 1986; Evans, Whigam & Wang, 1995;

Bennett, 1997) indicate that the attitudes of girls toward math and science have been positively affected. It is less clear however whether or not these women will pursue these careers. My study shows some support for the fact that these programs work. The two participants who indicated that they were involved in special programs saw the women they were involved with as role models and were planning on pursuing engineering careers.

Becker (1984) found that one commonality among women who pursue science careers is that they were involved in some type of special program. The authors conclude that these special programs have a lasting impact on the participants. Hill and Pettus (1990) also found that science related activities and hobbies outside of school contribute to persistence in science. The participants in my study who were involved in special programs indicated that this was one of the most important reasons why they chose to pursue their program.

Special programs are important because they are usually based on fun and hands-on activities rather than on marks. The people who are involved in these programs are there by choice and are therefore eager to learn. These types of programs seem to engender a real love for the subjects they are presenting. Only one of the participants in my study was involved in a program aimed specifically at women, but this type of program seems especially important because it allows more opportunities for co-operation among participants than typically exists in co-ed classes. Another important type of special program seems to be co-op. These programs allow the women to actually enter the work force and see first hand if they like a given career. One young woman in my study based her decision to pursue an engineering career on her co-op experience. Marlow and Marlow (1996), suggest that what is needed are more intense forms of role model interventions such as mentorship programs. The participants in my study who described being involved in programs such as co-op and summer camp described their experiences here as pivotal in shaping their decision to enter science. They talked about the people they were involved with in these programs as strong role models and as the individuals who had the most significant influence on their decision to pursue a science or engineering program. These types of special programs would also be beneficial to those students who may have the ability to pursue math and science courses, but may not be demonstrating their potential. Although science and math may not be their choice for a career, such programs would encourage them to take additional math and science courses that would broaden their career choices.

A more practical and wide spread approach to gaining the advantages of special programs would be to apply the positive aspects of these programs to the regular classroom. In order to gain a better understanding of what makes these programs work it would be important to observe and interview the students who are involved in these programs to find ways in which regular math and science classes could benefit from special programs.

Although the young women in my study participated fully in math and science and sought out career information, they still experienced what they felt was a lack of career information in their high schools. An important factor that has emerged from the literature on contextual influences is the fact that students are unfamiliar with the range of math, science and engineering careers available to them. The research (Frehill, 1997; Haworth, Povey & Clift, 1986; Moffat, 1990; Tsuji & Ziegler, 1990) indicates that students believe they need more information about science and engineering careers and that both males and females are not aware of their career options. Similar findings about the lack of knowledge about career options emerged from my study. Most of the participants indicated that they were unfamiliar throughout high school with the range of careers open to them. This was especially true for engineering. The young women in my study were pursuing programs in math, science or engineering so obviously they found a way around this lack of information. Many of them indicated that they had to seek out the information themselves. They also learned about math and science careers by talking to teachers, peers/friends, parents and others; by participating in special programs; by taking courses and by practicing being scientists through group work and labs. But what about the young women who remain unaware of their career options? This could be an important factor in encouraging more women to pursue these programs. Making young women more aware might be a helpful step in the right direction. Another initiative might be to create high school engineering courses. This would introduce high school students to engineering concepts, increase their confidence in engineering before they make the decision to major in it in university and it would make them more aware of what engineers do.

It is also important for high schools to develop more effective career counseling services. The participants in the present study indicated that they had sought information from the counsellors at their schools, but received little help. It is difficult to say what the results of better counselling services could be, but it is obvious that the need is there. Counsellors need to be better trained and better educated about a wider range of careers and their requirements.

The AAUW (1995) indicates that one of the major problems facing guidance counselors is their work load. They suggest that "while many counselors are committed to helping students in a variety of ways, their quasi-administrative and disciplinary work assignments often prevent them from fulfilling the helping role for which they were trained" (p. 50). They cite the use of several programs which are attempting to overcome this problem. The National Career Development Guidelines serve as a framework for the curriculum, which is to be integrated into all subjects from kindergarten to grade 12. This curriculum includes self-exploration, career and job information and career planning. Based on the comments from the young women in my study this is the type of option that could be considered in Canadian schools as a way of enhancing girls' knowledge and experiences in math/science areas.

Conclusion

Strong high school preparation in math and science seems to be a necessary but not sufficient condition for students to take full advantage of career options. The young women in my study all seemed to be exceptional math and science students. They developed a strong interest in math and science at a very young age and continued to nurture this interest throughout high school. Math and science were an integral part of their lives and they spoke enthusiastically about their love of these subjects. They also acknowledged how many people influenced their decision to stay in math/science. As well they recognized that in-school and out of school activities reinforced their passion. The three main factors discussed here all work together as evidenced in the overlap in the diagram (see Figure 1). The women talked about how all three of these factors influenced their decision although at the core was their personal connection to math and science.

Patterns of participation in math, science and engineering careers are complex. This study provided a better understanding of why some young women do pursue these programs in university. It is clear that there is not one single influence that led these women to continue in math and science. All of the young women had a different story to tell, although there were also similarities and it is important to focus on these when trying to discern the most effective way to encourage more young women to pursue these programs. Accomplishing change requires alterations in many aspects of the education system. More hands-on experiences in the classroom, as well as an increased emphasis on career guidance are two important strategies. It is also important to develop an interest in problem solving; to highlight the fun and challenge of math/science; and to promote the relevance of these subjects for everyday life at a young age. Giving more young women the opportunity to be involved in special programs could also be an important step towards equality in math, science and engineering careers. As well, involving a wide range of people who can support, encourage and provide information is also important.

Although my study did not take a strictly feminist approach, some aspects of feminist pedagogy apply to my results. For example, this approach advocates de-emphasizing the position of the instructor as an authority figure, increasing a sense of cooperative learning and reducing competitiveness (Ayers-Nachamkin, 1992). My study provides support for these approaches to math and science teaching. This study also provided support for the idea that math and science educators need to remain aware of the fact that females learn differently than males (Barton, 1997). The feminist approach advocates the idea that female learners need to be encouraged to take risks in a supportive environment.

It is unclear from the data presented here whether or not these young women will actually go on to pursue a math, science or engineering career. Further studies, perhaps longitudinal in nature, would be helpful in determining how many of the women who are in first or second year math, science or engineering actually end up employed in one of these areas. This is important because some studies have suggested that the gap between the numbers of men and women in these careers widens in graduate school, and then again in science and engineering careers.

The major substantive findings in my study have important practical implications for the education system's efforts to increase the numbers of young women pursuing math and science related subjects. My results support the value of a classroom climate focused on the importance of science, its applicability to life and the way math and science problems are solved. This study also underlines the importance of the encouragement and support of teachers, parents and role models. The participants in my study also suggested that an increased emphasis on career guidance and special programs could be an important step towards increasing the representation of women in science related careers. Countering stereotypes at a young age as well as fostering a love of learning in math and science during childhood were also revealed by my data as important steps toward equality.

Further research is needed to provide additional insights into how Intrapersonal, Interpersonal and Contextual Influences interact to shape students' experiences in elementary, secondary and post-secondary math and science programs. Longitudinal studies could clarify how these and other factors shift over time as students decide to opt in and out of math and science. Qualitative studies could complement findings from survey research about how students experience and perceive math and science. My study highlighted the importance of talking to young women about what they saw as important during their school years in fostering their involvement in math and science programs. Investigations like this will help us gain a more complete picture of why some young women continue to pursue math, science and engineering programs and will help us to develop programs that are responsive to young women's considerations.

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Appendix A - Interview Guide

Name:______________________________

Subject of study:______________________

1. When did you become interested in science/math?
2. What are your first recollections of math/science? Math/science classes?
3. When did you decide you wanted to pursue this program?
4. What influenced you to make this decision?
5. Was there a particular experience or pivotal event that led you to pursue this career?
6. How did teachers influence your decision to pursue your program?
7. Why did you decide to take math/science courses in high school? In what ways did taking these courses affect your decision to pursue your chosen program?
8. How did role models affect your decision to pursue this program?
9. In what ways did your family influence you to pursue this program?
10. How did your friends/peers affect your decision?
11. Do you like group work and labs? Why or why not?
12. Why do you like math and science?
13. Did you feel that career information was adequate in your high school?
14. Were you involved in any special programs such as co-op or camps in school? Were you in enriched math and science classes?
15. What do you believe are the reasons why women are under represented in engineering and math and science related careers?

Letter of Informed Consent

Principal Researcher: Kelly Gill (M.A. Student)

Affiliation: The University of Ottawa

Title: A Retrospective Study of the factors That Have Influenced Women to enter Non-traditional Science Related Programs

Whenever a research project is undertaken with human participants, the written consent of the participants must be obtained. This does not imply, of course, that the project in question poses a risk. In view of the respect owed the participants, the University of Ottawa and the research funding agencies have made this type of agreement mandatory.

The purpose of this research project is to gain a deeper understanding of the factors that are involved in young womens' decision to pursue a non-traditional science program in university. I believe that you may have something of value to contribute to this study and hope you agree to take part. You will be asked about the following four factors and how they were involved in your decision to pursue your particular program: 1) classroom influences; 2) high school course selection; 3) role models; and 4) parental influences.

Consent

If I agree to participate, my participation will consist essentially of attending one individual interview which will take approximately 45 minutes to one hour. If any clarification is required I may be asked to participate in a subsequent interview which will take no longer that 30 minutes. The interview will be tape recorded. I understand that the contents of the interview will only be used for research purposes and that my confidentiality will be respected.

Although it is rare in these types of studies, this activity may deal with personal information and may induce emotional reactions which could be negative. I have received assurance form the researcher that every effort will be made to minimize these occurrences.

I understand that my participation in this study is entirely voluntary. I am free to withdraw at any time, before or during an interview, may refuse to participate; refuse to answer questions without penalty.

I have received assurance from the researchers that the information I share will remain strictly confidential. I, in turn, assure other participants that I will treat in the same confidential manner any information I may obtain in the context of this project.

Any information, requests or complaints about the ethical conduct of the project may be addressed to the Secretariat of the Ethics Committee (562-5800, ext. 4057). If you have any questions you may contact my thesis supervisor Professor Margaret McKinnon (562-5800, ext. 4043). There are two copies of the consent form, one of which I may keep.

______________________________________ ______________________

Participant's signature Date

______________________________________ ______________________

Researcher's signature Date

______________________________________ ______________________

Thesis Director Date

I, __________________________________, am interested in participating in the study conducted by Master's student Kelly Gill.