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Factors impacting females' decision to pursue mathematics-related careers: A case study approach

Atinuke Yemisi Adeyemi
University of Windsor

Factors Impacting Females' Decision to Pursue Mathematics-Related Careers:
A Case Study Approach

by

Atinuke Yemisi Adeyemi

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ABSTRACT

This qualitative case study examined factors that impact university female students' decisions to pursue careers in mathematics-related disciplines as well as the obstacles they encounter in the pursuit of their chosen careers. Data were collected through face-to-face and focus group interviews from six students in the second to final year from Mathematics and Physics departments at the mid-size university in Canada. The findings indicate that females made the decision to pursue careers mostly out of genuine interest in mathematics and science, and that they persevered in the face of obstacles due to strong self-confidence, sense of determination, hard work/effort, and enjoyment in their subjects. The findings point to the importance of stimulating female's interest in mathematics-related disciplines through exposure to positive experiences from a younger age and confirm the role that teachers and parents have as crucial for female's participation in non–traditional career pursuits.

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CHAPTER I
Introduction

Recent studies in the United States have shown that in standardized mathematics test high school female students' performance has improved and is now similar to their male counterparts (Crombie et al., 2005; Hyde, Lindberg, Linn, Ellis, & Williams, 2008). The number of females taking advanced mathematics courses, such as calculus, has increased and is about the same as the number of males (Chacon & Soto-Johnson, 2003; Hill, Corbett, & St. Rose, 2010; National Center for Education Statistics, 1995). However, despite this trend, there is sufficient evidence that female students in the United States are unwilling to engage in career paths that require advanced mathematics skills, such as mathematics, computer science, engineering, and physics (Cavanagh, 2008; Catsambis, 2005; Dick & Rallis, 1991; Hanna, 2003). The situation is similar in Canada, where female students' overall enrolment in undergraduate programs is rising while females' representation in mathematics-related disciplines, such as physics, engineering, and computer science, is falling way behind other disciplines, such as social and behavioural sciences (Statistics Canada, 2008). On the other hand, careers that involve mathematics skills are on the rise (National Science Board (NSB), 2010; Statistics Canada, 2003). Thus, females may not be fully participating in one of the highly promising and expanding areas of the North American economy. This situation raises concerns and needs to be addressed.

Researchers have attributed female students' unwillingness to pursue careers in mathematics-related disciplines to many factors, such as negative attitudes towards mathematics, mathematics stereotyped as a male domain, inappropriate teaching practices, socialisation, curriculum more geared to males, limited exposure to after-school activities in mathematics, and lack of knowledge of the need and usefulness of mathematics in career decisions making (American Association of University Women [AAUW], 1998; Boaler 1997; Eccles 1994; Gadalla, 1998; Hanna, 2003; Rogers & Kaiser 1995). There have been extensive studies on the reasons for the lack of female participation in mathematics which focused on gender differences (AAUW, 1992; Crombie et al., 2005; Ercikan, McCreith, & Lapointe, 2005; Leedy, LaLonde, & Runk, 2003; Ma & Cartwright, 2003; Kellaghan & Madaus, 2002; Walkerdine, 1998; Wilkins, Zembylas, & Travers, 2002). However, most of the research was conducted at the high school level and relied upon females' career intentions rather than females' actual career choices. In addition, comparisons have been usually made between female and male students with little research done on finding out about the disparity in motives (if they exist) amongst females who opted for non-traditional career choices. There has been a growing body of research that points to inherent differences within gender groups and therefore question viewing and treating males (Martino, Lingard, & Mills, 2004) or females (Marlino & Wilson, 2002; Slater, Guthrie, & Boyd, 2001) as uniform group. For example, it has been established that females from different racial and ethnic backgrounds also differ in their career expectations and goals.

To this day, very little research has been conducted in Canada on female students pursuing non-traditional careers at the university level. As a result, the explanations for the under representation of female students pursuing careers in mathematics-related disciplines at the university level remain indistinct and need further in-depth research. In

1998, Gadalla cautioned that "it is unlikely that female representation in [mathematics-related careers] will increase in the near future because women continue to account for relatively small proportions of total university enrolment in these fields" (p. 2). For these reasons, females who persevered in the traditionally underrepresented fields of study may prove to be valuable source for research aiming to obtain in depth information on the factors impacting career choices of university female students toward mathematics-related disciplines.

Purpose Statement

The purpose of this case study was to examine the factors impacting the decision to pursue mathematics-related disciplines of a group of second to final year undergraduate female students at the mid-size university in Southern Ontario. Factors impacting females' decision to pursue mathematics were examined and contrasted with the females' decision to pursue a related discipline (i.e., physics). For the purpose of this investigation, factors impacting the decision were generally defined as the ways undergraduate university female students choose careers related to mathematics.

Research Questions

In exploring females' reasons for pursuing careers in mathematics-related disciplines, this investigation sought to answer the following questions:

1) How do second to final year university female students decide whether to pursue studies in mathematics-related disciplines?

2) What are the most significant self-reported factors impacting second to final year university female students' decision to pursue studies in mathematics or related disciplines and why are they considered as being most dominant?

3) What obstacles are encountered by second to final year university female students in pursuing studies in mathematics-related disciplines and how are these obstacles overcome?

Importance of the Study

Any serious intervention that seeks to encourage females to engage and persist in career paths that involve mathematics-related disciplines needs also to minimize obstacles that prevent females from taking this route. By building on life experiences of females who successfully overcame the obstacles (at least to the point of enrolling into mathematics-related field of study), other females can learn how to do the same. Hence, this case study has the potential to contribute to the previous research on women's motivations for pursuing mathematics-related disciplines at the university level by providing a more detailed insight into factors impacting females' career choices in the fields of mathematics and physics.

The study will shed further light into what can be done by parents, teachers, counsellors, and school administrators to increase females' interest and willingness to pursue careers in mathematics or related fields. It will also help the policy makers to focus on motivating female students of all ability levels to seriously consider taking the mathematics-related studies. The findings of this research may help the educators in the institutions similar to the one involved in this study to better meet the needs of female students in non-traditional disciplines.

Outline of the Thesis

This thesis is organised into five chapters. Chapter One contains the background and objectives of the study, presents the research questions and establishes the importance of the study. Review of relevant literature is given in Chapter Two. Chapter Three contains a description of the research method, the profile of the participants, and presents methods of data collection. The results stemming from analysis of data collected through interviews and focus group meeting are described in Chapter Four, while Chapter Five presents and discusses the findings in view of the literature and under the themes that emerged from the data in the study. Chapter Five contains answers to research questions, recommendations and directions for future research, as well as addresses the limitations of the study.

Definitions of Terms

The terms that are used in this study include:

Attribution. These are the reasons that a person gives for his/her success or failure in achievement situations. Different types of attributions for success or failure include attribution to ability, attribution to luck, attribution to effort; and attribution to difficulty of task.

Career. This refers to student's field of study. It is used interchangeably with the field of study in this research, with an understanding that the same field of study can lead toward many different careers and that intention to work in a career related to mathematics is a driving force of one's decision to pursue a mathematics-related field of study.

Mathematical self-concept. This refers to a person's perception or belief in his or her ability to do well in mathematics (Wilkins, 2004; Meece, Parsons, Kaczala, Goff, & Futterman, 1982).

Socializers. These are parents, teachers, counsellors, and peers whose attitude and behaviour can influence student's beliefs, experiences and decision to pursue particular interests, in this case, mathematics-related disciplines.

Socialisation. This is "the process through which an individual takes on the ways of thinking, seeing, believing, behaving that prevail in the society that he or she was born into"(Barakett & Clenghorn, 2000, p. 93).

Scope and Limitations of the Study

The size of the sample ($N = 6$) is the main limitation of this study. In addition, all six participants were volunteers. As it was planned, only female students in mathematics-related disciplines took part in the study. The intent of this researcher was not to generalise but to make meaning of the factors impacting females' educational career choices toward mathematics-related disciplines. Using qualitative research methods helped gather rich in-depth information about these factors since the entire process of this approach was for the researcher to maintain a focus on discovering the meaning that the participants have about the issue, not the researcher's position on the issue (Creswell, 2009).

Conclusion

In this chapter, the context of the study, its purpose, significance and research questions for the study were provided. Also, the scope and limitation as well as the organisation of the thesis were discussed. The next chapter reviews the literature pertaining to the study and describes the model of career choice used to frame the study.

CHAPTER II

Literature Review

This chapter contains a review of the research that outlines the likely factors contributing to females' lower enrolment in the fields of study closely related to mathematics. This review is centered around a model of career choice that served as the theoretical framework for the study. However, this exposition starts by first presenting females' general enrolment trends in Canadian universities and particularly the enrolment trends at the university where the study took place.

Females' Enrolment Trends in the Canadian Universities

Over the last three decades, females' enrolment in undergraduate university programs has risen. For example, while in 1972/73, females represented 42.6% of all undergraduate students in the Canadian universities, by 1994/95, females' enrolment has grown to 55.9% of all students enrolled in Canadian universities (Gadalla, 1998). In addition, more recent statistics show that in 2006/07 females represented 58.5% of all students enrolled in Canadian university programs with the majority of the enrolment in the areas of humanities, social, and behavioral sciences (Statistics Canada, 2008). The increase in female students' enrolment in Canadian university undergraduate programs from 1995-2007 is shown in Table 1. As can be seen in the Table 1, female undergraduate enrolment almost steadily increased from 1995/96 to 2004/05, when it reverted by two deciles and then remained steady at 58.5% for several years. Other statistics reveal that the female enrolments in mathematics, computer and information sciences fields are declining. In 2005/2006, 36,600 students were enrolled in the field of mathematics and only 9,900

(27%) of these students were females. This figure was down compared to 10,900 (27%) and 12,100 (29%) which were the numbers of females that enrolled in the field in 2004/2005 and 1999/2000 respectively (Statistics Canada, 2008). Thus, females' enrolment in mathematics is low and it is worthwhile to explore the possible factors that may account for it.

Table 1.

Undergraduate Enrolment in All Instructional Programs from 1995 to 2007 at Canadian Universities by Gender (Statistics Canada, 2008).

Year	Both Sexes	Males	Females	% Females	% Increase
1995/96	648,972	278,589	370,383	57.0	
1996/97	639,588	274,332	365,256	57.1	0.1
1997/98	633,018	270,141	362,874	57.3	0.2
1998/99	633,495	268,734	364,764	57.5	0.2
1999/00	650,391	273,963	376,401	57.8	0.3
2000/01	657,231	274,266	382,902	58.2	0.4
2001/02	680,682	283,134	397,482	58.4	0.2
2002/03	719,124	299,148	419,943	58.4	0.0
2003/04	770,718	317,778	452,802	58.7	0.3
2004/05	788,781	326,772	461,901	58.5	-0.2
2005/06	803,403	333,144	470,163	58.5	0.0
2006/07	811,842	336,921	474,819	58.5	0.0

Females' Enrolment Trends at University of Study

Apart from looking at the females' undergraduate enrolment trends in Canadian universities, it is important to carry out an examination of females' enrolment trends at the university where the study was conducted. Statistics data on full-time undergraduate and graduate programs in three disciplines (mathematics and statistics, physics, and computer science) are examined (see Tables 2a and 2b).

Table 2a.

Full-Time Undergraduate Enrolment Trends in Mathematics or Related Disciplines at the University Where the Study Took Place.

Year	Mathematics and Statistics		Physics		Computer Science	
	Male	Female	Male	Female	Male	Female
1999	19.00	22.00	18.00	1.00	522.00	105.00
2000	13.00	20.50	17.50	0.00	627.00	136.50
2001	27.00	20.00	24.50	2.50	661.00	173.50
2002	36.50	19.00	28.50	2.50	610.50	140.50
2003	59.50	37.50	38.50	5.50	537.00	101.00
2004	62.25	50.75	33.50	4.50	411.50	59.00
2005	65.50	58.75	31.00	5.00	284.50	27.50
2006	61.25	66.50	25.00	6.50	232.50	35.50
2007	50.40	59.85	23.50	9.00	203.50	30.50
2008	53.95	46.45	28.50	13.00	215.50	27.50
2009	46.25	41.85	42.00	11.50	223.00	21.50

In the Table 2a, the decimals in the data accounted for some students with double majors, so part of one student is counted to one department and the rest of that same student to another. Thus, the data are not a true representation of majors in the mathematics, physics and, computer science undergraduate programs. The data show that female and male students' enrolment in undergraduate mathematics fluctuate more within males' enrolment than the females', in most of the years. However, females' enrolment is lower than males' in physics and computer science programs in all of the ten years (1999-2009). Similar statistics for graduate studies is given in Table 2b.

Table 2b. *Full-Time Graduate Enrolment Trends in Mathematics or Related Disciplines at the University Where the Study Took Place.*

Year	Mathematics and Statistics		Physics		Computer Science	
	Male	Female	Male	Female	Male	Female
1999	8	0	19	2	52	25
2000	16	3	16	2	56	25
2001	20	5	17	2	46	30
2002	17	6	20	1	64	37
2003	22	7	21	2	67	38
2004	25	11	25	2	69	23
2005	26	8	28	4	62	21
2006	19	8	28	3	57	21
2007	19	8	23	4	56	22
2008	17	10	19	6	70	20
2009	15	12	12	7	72	13

As can be seen from the Table 2b, females' full-time enrolment in the graduate programs for the three disciplines are lower than males' throughout the period from 1999-200. These numbers give a true representation of the full time graduate students (both Master's and PhD) majoring in the three disciplines. Thus, females' representation wanes both at the graduate level as well as in the transition to the workplace in mathematical and scientific fields (Hill et al., 2010). According to Chipman (1996), the females' lower participation in graduate mathematics programs, as compared to males', could be due to lack of female role models, lower employment expectations, differences in career intentions, and/or lower academic standing.

During the 1960s, concerns over female's underrepresentation in mathematics and sciences were first raised. At that time, research findings gave a fairly consistent image of gender differences in mathematics achievement that favoured male students. Predictions that the U.S. was soon to be faced with a vital shortage of scientific and technical personnel brought about the worries over females' underrepresentation in the early 1990s. Women's advocates, educators, and policy makers maintained that the shortage of females in these fields jeopardised the well-being of women, their families, and the strength of the U.S. Economy (Catsambis, 2005). Several national publications, such as, *How Schools Shortchange Girls* (AAUW, 1992), drew national awareness to the gender gap in mathematics and science which lead to the development of educational equity programs that aimed at promoting females' achievement and interest in mathematics and sciences. The extent of the success of such programs is unclear, although a significant decline in the magnitude of gender gap in mathematics achievement resulted after the issue received the national attention. Although gender gap in mathematics achievement as well as differences in grades in high-level mathematics and science courses have disappeared for the majority of middle and high school students, females still show less interest in mathematics despite reaching comparable achievement levels as their male counterparts (Catsambis, 2005). Thus, go-getting females are not pursuing mathematics-related disciplines at the level that would be in accordance with their abilities in higher education.

Numerous researchers have examined various factors in order to understand the reasons for females' lower enrolment in mathematics courses, especially in high school. In the past, studies on low enrolment in mathematics have concentrated on gender differences and offered reasons for females' poor enrolment in mathematics (AAUW, 1992; Brush, 1980; Meece et al., 1982; National Council of Teachers of Mathematics [NCTM], 1989; Fennema & Sherman, 1977). These studies have typically concentrated on aspects that include:

a) psychological factors
b) biological factors
c) attitude and belief
d) social factors, and
e) economic factors.

In the next few paragraphs, I will examine the impact of each of these aspects on the female students in mathematics.

Impact of Psychological Factors on Female Students in Mathematics

Meta analyses reviews of previous research have shown that gender differences in mathematics achievement have declined over time (AAUW, 1998; Friedman, 1996; Frost, Hype, & Fenemma, 1994; Kimball, 1989) and females are achieving at similar levels as males in high school (Catsambis, 2005; Hanna, 2003; Hype et al., 2008). However, some researchers (e.g., Ma & Kishor, 1997; Ma & Cartwright, 2003; Wilkins et al., 2002; Wilkins, 2004) proposed that females' interpretation of their experiences may be different from males' interpretation and that factors such as anxiety toward mathematics, perceived ability in mathematics, and self-concept may impact their decision to pursue mathematics-related disciplines.

Math anxiety. Extensive studies have been conducted on mathematics anxiety hypothesizing that it is one of the major factors that affect female participation in mathematics. According to Ma and Cartwright (2003), although both male and female students experience anxiety towards mathematics, the level of anxiety in females appears to be greater than in males. The authors used data from *Longitudinal Study of American Youth (LSAY)* to investigate the rate of change in *mathematics affect* (i.e., the construct encompassing attitude towards mathematics, anxiety towards mathematics, and utility of mathematics) of 1,626 male and 1,490 female students across middle and high school. Ma and Cartwright found that for both male and female students, there was a decline in attitude towards mathematics and utility of mathematics, and growth in anxiety towards mathematics from middle to high school grades. In addition, the female students' anxiety towards mathematics grew significantly faster than their male counterparts. The authors claimed that as soon as mathematics anxiety arises in females, it not only impacts their performance at that moment, but also has a lifelong effect on them throughout their years in school. Therefore, it could be concluded that if not attended to, anxiety towards mathematics can advance to avoidance of mathematics and mathematics phobia (Tobias, 1978). Avoidance of mathematical courses needed for professional advancement eliminates many career choices for individuals, and therefore females as well. As a consequence, females may drop out of the mathematics and science talent pool, and give up future studies, scholarships, and high-paying careers (AAUW, 1998).

In relation to anxiety, Altermatt and Kim (2004) suggested several explanations for why females worry more than males. These include that females may be more likely than males to feel that poor performance is the result of uncontrollable factors, such as low ability; that females may be more likely than males to experience anxiety in competitive environments; and that females are more concerned than males with pleasing others. The authors concluded that for female students, low academic confidence and higher uncertainty about how to be successful are just some of the negative outcomes of worrying. Hence, they decided that,

> females' heightened worry levels may discourage them from pursuing admission to top-level programs in top-level schools and, after admission, may lead females to avoid courses and majors that they are clearly capable of handling. The end result is that females may fail to pursue satisfying and lucrative careers, especially in mathematics and the sciences. (Altermatt & Kim, 2004, p.11)

Self-perceived ability and self-concept. Females are said to have lower self-concept than males in regard to their mathematics ability (Meeliseen & Luyten, 2008). Ma and Kishor (1997) described self-concept about mathematics as "a positive or negative orientation towards one's ability, performance, and success in the learning of mathematics" (p. 91). Researchers not only suggest that self concept is positively related to mathematics and science achievement (Ma & Kishor, 1997; Wilkins, 2004; Wilkins, et al., 2002), but also show that students' self perceived ability is directly related to educational and career choices (Meece et al., 1982). Earlier studies consistently found that by junior high school male students develop a higher self-concept of mathematics ability than female students (Brush, 1980; Fennema & Sherman, 1977; Ma & Kishor, 1997), and that the gap between males and females in self-perception of mathematics competence widens as they grow older. However, other studies found that although males have higher self-perceptions of mathematics ability than females in the early grades, these differences diminish with age and disappear by the 12^{th} grade (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002).

In a more recent study, Wilkins (2004) investigated mathematics and science self-concept from an international perspective. The author compared the general international magnitude and consistency across countries as applied to the relationship between self-concept on one side, and achievement, gender, and age, on the other. Data were drawn from the *Third International Mathematics and Science Study (TIMSS)* which sampled 290,000 students from 41 countries. Through the use of univariate, bivariate, and multivariate statistical techniques, Wilkins found that:

i) internationally, on average, students with more positive self-concept had greater achievement in the discipline, and vice versa,

ii) students' belief in their abilities to perform well in mathematics and science tends to decline as they move through school, and

iii) the difference in self-concept between males and females was statistically significant and in favour of males for both mathematics and science.

Wilkins' study suggested the importance of having early and unceasing intervention by educators all over the world to help all students nurture positive beliefs about themselves as mathematically and scientifically competent. Besides, Ma and Cartwright (2003) stated that "beliefs about self capability influence the degree to which students engage in academic tasks, experience anxiety when performing the tasks and persist when facing challenges and difficulties" (p. 414). Thus, if females have lower levels of self-concept in mathematics ability than males, this may affect their choice of majors and career decisions to pursue mathematics-related disciplines (Eccles, 1994).

Biological Factors

There are researchers who indicated biological factors as accountable for differences in female and male students' achievement in mathematics (Halpern 1992; Northrup, 2001; Thomas 1993). They argue that there is a genetic difference between males and females, and that the males' brains have neurological qualities that make it possible for them to perform better in mathematics than females. However, females' continual improvements in achievement scores refute this argument (Crombie et al., 2005; Education Quality and Accountability Office [(EQAO] Research Series, 1999;

Kimball, 1989). In addition, Margolis, Fisher, and Miller (2002) found evidence that is contrary to the argument that there exists biological disparity between genders that affects their learning of mathematics and science. The authors found that Chinese females performed better than their male counterparts in mathematics and sciences to the extent that they participate evenly in most advanced courses in high school and college, and in selecting corresponding career paths. In the interview for the study, the Chinese females expressed their concern about how females in the United States deduce that they lack "natural and innate talent," compared to males. Consequently, it seems that culture, attitude, and hard work are the contributing factors for the Chinese females' accomplishments in the field of mathematics (Margolis et al., 2002). There is no way of gauging the extent to which biology impacts females' achievement and participation in mathematics (that is if it does at all); its role in preventing females from excelling in mathematics and pursuing mathematics-related disciplines remains uncertain. Thus, other possible factors, such as attitudes and beliefs have to be explored.

Impact of Attitudes and Beliefs on Female Students' Participation in Mathematics

There is a body of literature that describes attitudes and beliefs as factors influencing females' participation in mathematics studies and related careers. The most investigated aspects are confidence, perception of usefulness of mathematics, and attribution style. These will be described in more detail in the further text.

Confidence. This is underscored as the major factor that can transform the attitude of females toward mathematics (Jones & Smart, 1995). According to some researchers (AAUW, 1998; Fennema & Sherman, 1977; Sanders & Nelson, 2004), females are less confident than males, therefore, they become uninterested, unmotivated, and are more likely to abandon academic tasks (including advanced mathematical tasks) than males. Catsambis (2005) stated that from middle grades, females are less confident of their mathematics abilities and show less interest in pursuing mathematics-related careers than males with equal talent. Being trapped in the ''learned helplessness paradigm,'' also called ''blame the victim paradigm'' (Dweck, 1986), females have higher possibility of blaming themselves for not succeeding in mathematics than males; therefore, they may demonstrate less confidence in mathematical undertaking and not take pleasure in doing mathematics. However, Boaler's (1997) research on the underachieving, female students of mathematics disproved this paradigm. In her study, females flourished when taught in an open, process-based, discussion-oriented way. Those female students were more confident and took more pleasure in doing mathematics than females who were taught in a traditional way. Boaler further found that females in traditional classes blamed the instruction method and lack of opportunity to learn at their own pace for their underachieving in mathematics. This implies that the methods used for teaching mathematics may impact students' feelings of success in mathematics and their development of mathematical self-confidence (Stuart, 2000).

Moreover, Crombie et al.'s (2005) study examined the competence beliefs as well as intrinsic and utility values as predictors of mathematics grades and enrolment intentions of 540 Canadian adolescents ($N = 277$ girls, 51.3%; $N = 263$ boys, 48.7%) in Grades 8 and 9 in advanced mathematics courses. By applying a quantitative research method approach, the authors used items from four 7-point Likert scales that measured students' competence beliefs in mathematics, perceptions of the usefulness and intrinsic value of mathematics, and intentions to take optional higher level mathematics courses. The results were that, i) although females outperformed males in mathematics tests in grade 8 and performed similarly as males in grade 9, males have stronger competence beliefs than females, ii) competence beliefs in mathematics played a central role in predicting current mathematics grades and future mathematics enrolment intentions for females, iii) self-confidence in learning mathematics had a greater impact on females' past achievement in mathematics and on their decisions to continue with advanced mathematics, and iv) both females and males have similar high perceptions of the utility value of mathematics. Crombie et al. suggested the reinforcement of competence beliefs in mathematics as a way to encourage females to participate in advanced mathematics courses and to consider careers in mathematics-related disciplines.

Usefulness of mathematics. Early studies showed that by middle school, not only do female students begin to rate mathematics as less useful than male students (Brush, 1980; Fennema & Sherman, 1977), but that their perception of usefulness decreases throughout high school (Sherman, 1980). Recent studies (Eccles, 1994; Watt, 2006) have found that female students who valued mathematics as very useful for future career are likely to pursue careers in mathematics fields. For example, Watt (2006) study used the Expectancy–Value framework to analyze the persistently low participation of females in mathematics-related educational and occupational choices. Longitudinal data were used to assess the influences of mathematics-related self-perceptions, intrinsic and utility values, perceived task difficulty, as well as career intentions of a sample of 442 students (containing 43% females) from Grades 9-11. Using regression analysis, Watt found that i) boys rated their self-perceptions of mathematical talent and expected success significantly higher than did girls despite equal levels of prior achievement in mathematics for boys and girls, ii) boys rated their intrinsic value higher and their perceptions about the difficulty of mathematics lower than girls, iii) for girls, valuing maths as highly useful is likely to lead to mathematics-related career intentions; while for boys, valuing mathematics as moderately useful is equally likely to influence mathematics-related career intentions. However, it should be noted that Watt's study was based on career intentions rather than actual career decisions, and that male and female students were treated as homogeneous groups.

Also, Wilkins and Ma (2003) used data from the *Longitudinal Study of American Youth (LSAY)* that involved 2,125 students from grades 7-12 to examine variables related to changes in students' attitudes toward mathematics, beliefs about the social importance of mathematics, and beliefs about the nature of mathematics. Their findings show that boys tend to report a higher perceived usefulness of mathematics throughout high school than girls do; that in middle school, girls developed negative beliefs about the social importance of mathematics at a faster rate than boys; that in the latter years of secondary school, females appeared to have a heightened awareness of the importance of mathematics for future educational and occupational goals; and that parents, peers, and teachers have an influence on students' perception of usefulness of mathematics for educational and occupational success. Hence, they suggested early intervention in support for the increase in females' perception of the usefulness of mathematics, which in turn may increase the possibility that they would participate more in mathematics-related careers than they did before.

Attribution style. According to other research, casual attribution can also affect female participation in mathematics. This connotes that female students have a tendency to attribute success in mathematics to luck or to situational causes such as effort and failure to low ability, while male students have a tendency to attribute success to high ability and failure to external reasons such as bad teaching (EQAO Research Series, 1999; Leder, 1992; Hanna, 2003; Kimball, 1989). These findings imply that female students are likely to display lack of confidence in their abilities in doing mathematics even when successful. Meece et al. (1982) suggested that attributions to ability contributed significantly to the formation of student's self-concept of ability and student's perceptions of task difficulty. When students attribute success in mathematics to ability rather than to luck or effort, they are more likely to persist in their studies. Dweck (1986) offered reasons why girls may be more vulnerable to the extent that they would have a higher tendency of being negatively affected by these attributions than boys. In Dweck's words, girls are likely to espouse an *entity theory of intelligence*, whereby intelligence in a given domain is believed to be something an individual either has or does not have. Boys, on the other hand, are likely holding *incremental theory of intelligence*, whereby, intelligence in a given domain could be increased by hard work.

Similar perceptions of mathematics ability that exist in society, and among parents and teachers, as something that you either have or you do not have (Tobias, 1978), may result in adoption of intelligence theories among girls and boys. Such theories are more pronounced in mathematics domain than in any other subject area (Gutbezahl, 1995). Therefore, it is necessary to look into how these social entities, through their actions and attitudes, may impact females' participation in mathematics.

Impact of Social Factors on Female Students in Mathematics

Socializers and cultural milieu have been suggested as social factors that could affect females' enrolment in mathematics. Researchers have revealed that the attitudes and behaviours of parents, teachers, counsellors, and peers have consequences on female enrolment choices in mathematics (AAUW, 1992; Koehler, 1990; Leedy et al., 2003). Research findings also indicate that these social groups think that males will outshine females in subjects such as high school calculus, and as a result, less encouragement is given to females in the pursuit of mathematics (Brush, 1980; Dick & Rallis, 1991; Meece et al., 1982; Paa & MacWhirter, 2000). Further in this text, I will present results that describe how these groups impact female participation in relation to mathematics.

Parents. According to Muller (1998), parental support, encouragement, and interest in students' schoolwork play a role in mathematics achievement and future selections of mathematics- and science-related majors. Also, the attitudes and orientations of parents may have an impact on males' and females' achievement, self-perceptions, and academic choices. Thus, differences in parental expectations of males and females may affect the learning opportunities, social-psychological attributes related to mathematics achievement, attitudes toward school, and plans for the future of both sexes.

Jacobs, Davis Kean, Bleeker, Eccles, and Malanchuk (2005) used the *Eccles' Parent Socialization Model* to explain the ways in which parents influence their children.

These ways include parents: (a) creating a general social and emotional climate that includes their general childrearing beliefs; (b) providing specific experiences for the child; (c) modeling involvement in valued activities; and (d) communicating their perception of the child's abilities and expectations for performance. As stated by this model, children's motivation to pursue mathematics and science fields is anticipated to be influenced by the environment, role modelling, and messages that reveal the values parents attach to mathematics and science activities. Eventually, children incorporate the interests or values related to mathematics and science (which they have developed over time) into their self-systems and these values, in turn, affect their future choices. In this process, the role of the parents may change from providing access for their children to opportunities and role-modelling of mathematics- and science-related activities at an early age, to giving encouragement and guidance for the activities that would constantly support development of interest in mathematics or science.

It seems that parents provide their male and female children with different mathematics experiences and messages with respect to their talents and best educational and career options (Ecclees, 1994). For example, parents give their sons more opportunity to be involved in sports and computing, while they give their daughters more opportunity to read and interact with their peers. From parents, females experience more nurturing and more restrictions while males experience more parental interventions and more engagements outside the home (Muller, 1998). In addition, male and female children are expected to assist in different tasks in the home environment as well as engage in different extracurricular activities. Parents also generate different attributions for academic successes and failures among females and males. Consequently, these gendered experiences and messages seem to weaken females' confidence in their abilities and interest in mathematics-related courses and fields, possibly resulting in highly capable females deciding not to pursue careers in mathematics-related disciplines. Some parents encourage and provide support for their male children, more than female, to engage in advanced mathematics and science courses (Clewell & Anderson, 1991). This may lead to females' reluctance to pursue careers in mathematics.

In order to investigate nature of the mathematics/science opportunities and expectations that parents provide for their daughters and sons, Jacobs et al. (2005) used data from the longitudinal *Childhood and Beyond (CAB)* study that involved 864 children, 550 parents, and 70 teachers. The authors reported that parents seem to give more mathematics-supportive environments for males than females by purchasing more educational materials for males; spending more time on mathematics/science activities with their male children; having higher perceptions of their sons' mathematics abilities than those of their daughters'; and, by having gender-type worldviews about natural talents in mathematics. Jacobs et al. concluded that parents are less likely to create mathematics-supportive or mathematics-promotive environment for females and that it seems that "the achievement environment in many homes is a gendered environment and messages from parents about achievement continued to be sent through gender-typed filters" (p. 260). However, Muller's (1998) earlier study used national longitudinal data to establish the relationship between parental involvement and achievement of 12,766 secondary school students in the US. Muller found no proof that parental practices strengthened gender stereotypes in mathematics achievement and consequently concluded that parents may play a role in balancing mathematics learning opportunities accessible to girls. Muller nevertheless stated that different parental practices activities were connected to gains in achieved test scores of both sexes; between grades 10 to 12, the gains in females' test scores were more strongly associated with parental support and verbal communication, whilst males' test scores were more strongly related to parental guidance and social control.

Parents' education and socioeconomic status (SES) have been indicated by researchers as additional factors that may account for females' participation in mathematics (AAUW, 1992; Muller, 1998). Parents that are highly educated and are of higher SES could provide more learning opportunities in academic subjects, including mathematics, for their children both at home and in school (Catsambis, 2005). Wilson and Ma (2003) found that students whose parents are more educated appear to maintain more positive feelings and higher perceptions of the usefulness of mathematics (for future educational and occupational success) all throughout their high school years than those whose parents are not as educated. However, in the midst of students of high SES, males remain consistently at an advantage in their performance in mathematics compared to females (AAUW, 1992). Recently, Ercikan et al. (2005) used data collected from three countries—Norway, Canada and USA, in their study of factors that relate to males' and females' mathematics achievement and participation in advanced mathematics courses. They found that personal- and home environment-related variables, such as SES, were constantly and highly related to mathematics achievement and participation in advanced mathematics courses for students in the three countries. Also, the education attainment of parents was one of the strongest predictors of participation in advanced mathematics for Canadian female students and for all the students from the USA. Furthermore, researchers also found that mother's employment and the nature of her occupation can have an effect on female's pursuit of mathematics-related careers (Seymour & Hewitt, 1997).

Paa and McWhirter (2000) used quantitative research method to study the perceptions of 238 male and 226 female students in high school on factors that might impact their career expectations. The researchers discovered that for female students, mothers, female teachers, and female friends were perceived as most influential on their career expectations, with mothers ranked higher than others. In the same study, role models, ability and the media were also reported as factors impacting females' career choices. Ivie, Czujko, and Stowe (2002) conducted an international study on over 1000 women physicists (from 55 countries including 48 from Canada and 82 from USA) who persisted in their chosen fields and careers. Questionnaires were used to find out about the experiences, critical incidents, effect of marriage and children, and factors influencing the success of these women in physics. The authors reported that,

a) women physicists cited support of their parents and husbands most frequently as the factor that plays a role in their success. Many study participants mentioned the influence of their teachers, professors, and advisors, while some mentioned colleagues;

b) barriers mentioned included maintaining equilibrium between demands of child care and scientific career, and the assumptions that women are not capable of doing physics;, and

c) most women in physics believed that overall, they had positive experiences in their undergraduate and graduate years and that their interest in physics developed before or during high school.

Thus, Catsambis (2005) suggests that for talented young women to maintain their high performance in mathematics and to persist in non-traditional pursuits, support and encouragement by parents may be crucial.

Teachers. Studies have shown that gender differences in teacher-student interactions may have a negative impact on female students' problem-solving skills and interest in mathematics-related careers (AAUW, 1998). It appears that teachers interact with and treat male and female students differently within the mathematics classroom, and that the difference is usually in favour of males (AAUW, 1992; Jones & Dindia 2004; Sanders & Nelson, 2004). Teachers not only tend to encourage males more than females but they also frequently display higher expectations for males and provide more feedback to males than to females. In her review of studies related to differential treatment by the teachers, Koehler (1990) states that female students are not often asked high cognitive level mathematics questions and are not encouraged to be independent thinkers. In addition, female students spend more time helping their peers and not getting helped in return, and are often placed in groups that are not appropriate to their level. Sanders and Nelson (2004) show that teachers most times and unknowingly spend more time responding to males' questions than females' and allow males to interrupt females in discussion as well as take over the leadership positions in the classroom. As a result, females may be labelled as quiet and males as outspoken, which may lead to less female participation in mathematics-related disciplines. In a recent meta-analysis of 32 studies on sex differences in teacher-student interaction, Jones and Dindia (2004) indicated that there is a tendency for teachers to start more interactions, especially in a negative way, with males than females in most classrooms.

Besides teachers' attitudes and behaviour, the abstract nature of mathematics instruction as well as the traditional teaching practices, such as competitive reward structure, may not be beneficial for females. AAUW (1998), for example, states that female students tend to be more comfortable and perform better in cooperative classroom environments than in competitive ones. Fenemma, Carpenter, Jacobs, Franke, and Levi (1998) reported that in grade school, teaching practices may affect the young girls' competences and orientations in a manner that does not give them skills for advanced mathematical problem solving that they require later in school. The authors claim that when solving mathematics problems, males and females use different strategies. Males are not only autonomous learners in mathematics (persist more in solving complex tasks than females), but also tend to exert independence and be inventive when solving problems in mathematics. This permits them to become highly skilled at advanced mathematics. Females, on the other hand, tend to follow standard problem-solving techniques. Thus, there is a need for the teacher education programs and professional development activities in schools to bring awareness about any potential gender-stereotype biases in the interactions with students and also to prepare young teachers with more unbiased teaching practices (Catsambis, 2005).

Zeldin and Pajares' (2000) interviews with women successful in mathematics and science careers not only revealed that majority of these women reported teachers' influence and support for their mathematics pursuits, but also showed that one of the most important factors that sustained their career decisions was the confidence that significant others had in their abilities; this confidence was clearly expressed to them. Ultimately, teacher's encouragement, regardless of the teacher's gender, seems particularly crucial for development of positive attitudes among female students toward mathematics and for the strengthened notion of their capability in the field.

Peers. Social interaction happens between teachers and students, as well as among students themselves. Interaction between students is a factor because "[p]eer values reflect and reinforce the behaviours of the individuals who comprise the group" (Leder, 1992, p. 611). Peers can impact participation in mathematics activities in a lot of ways, such as by expressing negative connotations about mathematics, by taking part in different activities and pastimes, and giving or refusing to give support for mathematics-related activities. From middle grades, peers' influence starts to have an effect on students' interests and achievement in mathematics; similarly, adolescents become exposed to peer pressure that frequently strengthens gender stereotypical behaviours (Catsambis, 2005). This is the age at which young females start losing their self-esteem and start worrying about their physical appearance and popularity; whilst males show concerns about being competent and independent. It is not surprising then that females do not develop the confidence essential for success in male-dominated fields, such as mathematics and science, as a consequence of the drop in their self-esteem (AAUW, 1992).

Students may evade mathematics if their peer group, for any reason, has negative opinion about it (Wilson & Ma, 2003). Eccles (1994) reported that peers can affect the career options that are considered by a student by either providing or withholding support. The peers' support could be direct (e.g., laughing at a girl because she is interested in becoming a physicist) and indirect (e.g., having expectations of future spouse's support for career dedication). Zeldin and Pajares (2000) study of how self-efficacy levels of 15 women impacted their academic and career choices in areas of mathematics, science, and technology revealed that i) peers and friends were mentioned less often as positive influences on the women's pursuit of mathematics-related fields than were family and teachers; and, ii) the peer influences were portrayed as support after the women have already made their decisions to engage in mathematics fields and had entered the academic area of mathematics. Thus, Zeldin and Pajares argued that having supportive peers, particularly those that are interested and engaged in mathematics and science studies, is crucial for young females' commitment to mathematics-related achievements and choices.

Riegle-Crumb, Farkas, and Muller (2006) described ways by which friends could have a positive influence on adolescents' educational outcomes: through sharing knowledge and skills, such as offering help with homework and offering information about the best teachers; by acknowledging the individual's academic efforts, such as studying hard; and by offering encouragement. These researchers investigated how friends impact students' taking of advanced courses and how they influence girls' mathematics and science attainment. Riegle-Crumb, Farkas, and Muller used longitudinal data from "Add Health" that involved 11,013 students from grades 7-12 and found an increase in likelihood that females will take advanced courses such as physics and calculus when they have female friends who excel academically. Thus, the researchers suggested that having mostly high achieving female friends in mathematics and science could facilitate a female's continued pursuit of these subjects in an advanced path. Extracurricular activities in mathematics and sciences provide opportunities for like-minded peers to mingle and increase their learning opportunities, may promote supportive peer relationships, and sustain students' interest in mathematics fields (Catsambis, 2005). Although gifted females are less likely to participate in extracurricular activities that are related to mathematics and science than their male counterparts (Catsambis, 1994; Clewell & Anderson, 1991), success in non traditional activities, such as sports, may provide additional uplift to young females' confidence, giving them more opportunities to select non-traditional routes associated with high achievement in mathematics.

Mathematics as a male-domain. Additional negative impact on females' decision to pursue mathematics may happen when teachers, parents, and peers portray mathematics in a negative way by making stereotypical remarks, such as "math is only for boys." As a result, a female thriving in mathematics might feel that others see her as less feminine (Koehler, 1990). In addition, she may not put in the needed effort to sustain her accomplishments in mathematics if she perceives that her success is not appreciated or suitable. Stereotypical comments, such as the one mentioned earlier, can weaken the female's self-confidence in her mathematics ability and lessen her interest in pursuing mathematics-related disciplines.

More specifically, mathematics as a male domain is defined as "the perception that males are more suited to pursue studies in mathematics and science-related fields than are females" (Forgasz, Leder & Kloosterman, 2004, p. 391). High school students' views of mathematics as a male domain are coherent with traditional gender roles' values and beliefs (Meece et al., 1982). Students learn about gender roles and societal views of what is acceptable for different genders at a very young age. Eccles (1994) cautioned that females internalise the culture's definition of their roles and they view many adult activities and choices differently from their male counterparts. Thus, for females who excel in mathematics, the belief that mathematics is a male domain may bring about a conflict between their success in mathematics and fulfilling the traditional female role that is expected of them by the society.

A report issued by the *American Institutes for Research* (1998) theorised that the inadequate methods used against gender stereotyping in the labour force may likely be responsible for the imbalance in gender distribution in career fields. The report stated that females still tend to pursue traditional careers even when they are treated equally, given the same career preparation, counselling, and school-to-work programs as their male counterparts. It also argued that gender stereotyping harms both males and females and suggested that the school-to-work programs must consider the effects of factors such as cultural expectations, self-concept, parents' and peers' roles, and mathematics and science stereotyping so as to encourage students to delve into non-traditional careers.

Other researchers (Leedy et al., 2003) found that female students gifted in mathematics are not unaffected by gender bias. The study done on students, their parents, and teachers, revealed that students as well as fathers, parents of boys, and specific mathematics teachers believe that mathematics is a male domain. Thus, unintentional biases embraced by some teachers and guidance counsellors may steer female students away from careers in mathematics or sciences (Berube & Glanz, 2008). In addition, Steele, James, and Barnett (2002) examined the perceptions of undergraduate female students in non-traditional careers and found that females in these academic areas are not only most likely to report feeling threatened by negative gender stereotyping, but are also most likely to report considering change of their academic areas. Eccles (cited in Cavanagh, 2008) concluded that many females have the ability to pursue mathematics-related disciplines but avoid such disciplines because they consider them as male-dominated and conflicting with their interests. Thus, viewing mathematics as a male-specific field by both females and society is considered as a crucial contributor to the lack of successful females at the highest levels of mathematics (Forgasz et al., 2004; Leder, 2001).

Cultural Milieu. Apart from the socialisers' and societal perceptions, the cultural milieu in terms of the division of labour by gender in the society has also been considered to account for low participation of females in mathematics (Dick &Rallis, 1991; Paa & Whirter, 2000). Employment trends indicate that women are still underrepresented in mathematics fields. On the other hand, most women are employed in female-dominated careers such as health and nursing (Statistics Canada, 2007; National Science Foundation [NSF], 2007), as well as teaching, particularly in elementary grades (see Figure 1).

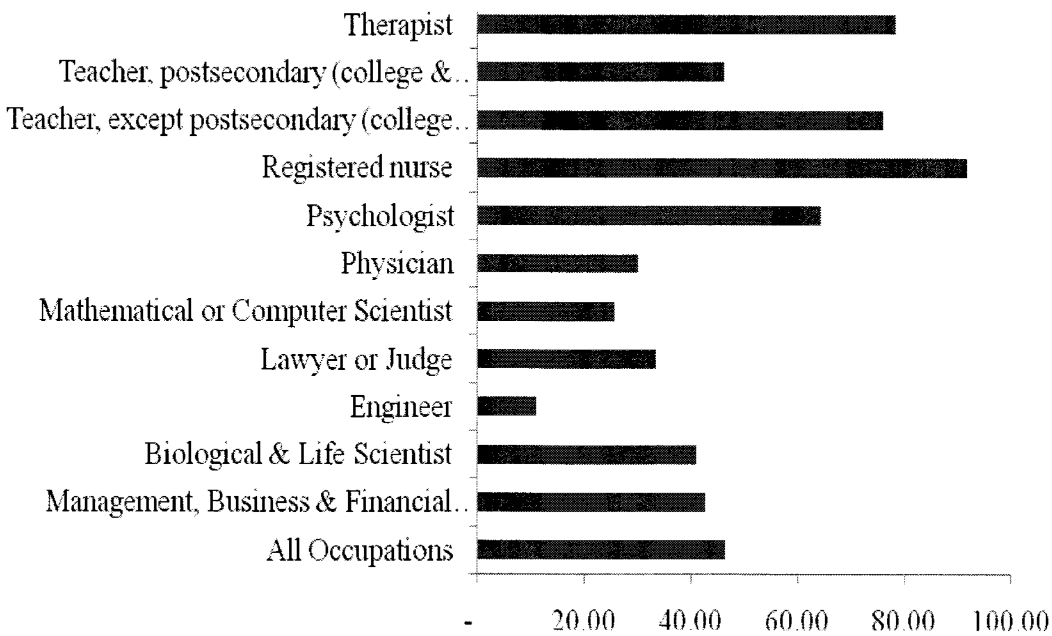

Figure 1. NSF, 2007 Report on employed women 16 years and older as a percentage of selected occupations (source: Bureau of Labor Statistics, Current Population Survey, 2007).

As can be seen from Figure 1 and according to the NSF (2007) report titled, *Women, Minorities, and Persons with Disabilities in Science and Engineering*, more than three-quarters of registered nurses, therapists, and non-postsecondary teachers were female; women were somewhat below half of employees in all occupations, half of postsecondary teachers, one-third of lawyers and judges, and one-third of physicians. In addition, the NSF (2007) also reported that in science and engineering careers, females represented 64% of psychologists, 41% of biological and life scientists, 26% of mathematical and computer scientists, and 11% of engineers. The situation is similar in

Canada. In 2006, 87% of nurses and health-related therapists, 75% of clerks and other administrators, 64% of teachers and 57% of sales and service personnel were women. However, in the same year, women represented only 22% of those employed in natural sciences, engineering, and mathematics, a figure up only marginally from 1987 when women represented 20% these occupations (see Table 3).

These statistics show that few role models exist for female students that are making decisions to pursue careers in mathematical fields. Lack of appropriate role models and same-sex mentors that will encourage females' pursuits of non-traditional fields can affect both females' efforts to succeed in mathematics as well as their interest in the field (Catsambis, 2005). Role models are necessary as they enhance one's confidence, performance, and raise students' aspirations (Jacobs et al., 2005). For example, Super (1990) found that role models or key figures in the immediate environment of an adolescent significantly influence their career aspirations. Under environmental factors, males ranked father, mother, and male friends as their influences while females ranked mother, father, and female friends as their influences.

Table 3.

Distribution of women by occupation, 1987, 1996, and 2006 (Source: Statistics Canada 2007, Labour Force Survey).

Occupation	Women as a % of total employed 1987	Women as a % of total employed 1996	Women as a % of total employed 2006
Total Management	30.1	37.0	36.3
Business, Finance	38.3	46.9	51.6
Natural Sciences, Engineering, Mathematics	19.6	19.1	22.0
Social Sciences, Religion	61.4	68.8	71.3
Teaching	52.3	60.1	63.9
Doctors, Dentists, Other Health	43.1	48.1	55.3
Nursing, Therapy, Other Health-related	87.1	87.0	87.4
Artistic, Literacy, Recreational	48.4	51.5	54.1
Clerical, Administrative	73.9	74.9	75.0
Sales and Services	55.2	55.4	56.8
Primary	19.7	20.9	20.5
Trades, Transports, Construction	5.2	6.1	6.5
Processing, Manufacturing, Utilities	32.4	30.6	31.1
Total	43.0	45.4	47.1

Apart from parents and teachers acting as role models, female students need to see the work and success of other women in mathematics-related fields so that they could see themselves represented in these fields. Also, these women can be role models and sources of information for female students through their educational experiences and careers. The trend of low female participation in male-dominated careers may result in further segregation by gender in the labour force, less females in the highest paying occupations, and more concentration of females in the lower levels of the professional ladder.

Impact of Economic Factors on Female Students in Mathematics

Economic factors have also been considered in relation to their possible impact on female students' enrolment in undergraduate mathematics programs. These factors, which include career values and interest, will be explored in the following text.

Career values and interest. Perceived economic value of return (such as salary expectations) of the academic programs, as well as students' interests, have been isolated as determinants of students' enrolment in any post-secondary program. For females, interests generally have an impact on their choice of career, while monetary incentives (Dick & Rallis, 1991; Paa & MacWhirter, 2000) as well as interest (Pelletier, 2006) concern males when making career decisions.

Interest has been related to students' attitudes toward the study of mathematics. Dewey's (1913) definition of interest that is generally cited is "...the accompaniment of the identification, through action, of the self with some object or idea, because of the necessity of that object or idea for the maintenance of self-initiated activity" (p. 14). Hidi (1990) reveals that interest has a "profound effect on cognitive functioning and the facilitation of learning" (p. 565). Features of interest include willingness to learn, increased attention, greater focus, high level of persistence at a task, and enjoyable feelings of applied effort. Studies involving interests in mathematics are rooted in the certainty that student's interest in learning mathematics is a significant factor, that the methods of teaching mathematics should arouse and expand students' interests, and that the situational interest (interest that is obtained in the classroom) generated by environment factors (such as a text or a presentation), may evoke or contribute to the development of long-lasting individual interest (Hidi, 1990). Research findings suggest that if girls do not develop interest in mathematics and science at early ages (particularly, the middle childhood years) they may be less likely to pursue these disciplines as they get older (Jacobs et al., 2005). In addition, it has been noted that females' interest in mathematics continues to deteriorate across high school, despite their performance (as measured by grades) that surpasses the males' (Linver et al., 2002). Thus, the chances that female students will be interested in pursuing mathematics-related disciplines in higher education is low even if they are performing well in mathematics. There exist relations between interest and self-concept (Hidi, Berndorff, & Ainley, 2002) and reciprocal relationship between the constructs (Marsh Trautwein, Lüdtke, Köller, & Baumert, 2005). According to Denissen, Zarrett, and Eccles (2007) "Individuals generally felt competent and interested in domains where they achieve well, and were interested in domains where they perceive their personal strengths" (p. 430).

In their study, Denissen et al. (2007) used the *Childhood and Beyond* longitudinal data collected from 1,000 students between grades 1-12. The researchers examined the intra-individual associations (also called *coupling*) between interest, self-concept of ability [SCA], and achievement, and their modification by gender and conscientiousness. The mean levels of coupling between achievement and interest, achievement and SCA, and interest and SCA were calculated and expected to change as students grow older.

Denissen et al. found that, a) although the level of coupling was positive for all indexes calculated, the level of coupling between interest and self-concepts of ability was the greater in magnitude compared to other indexes (but lowest in interest and achievement), and that, b) females have lower level of coupling between achievement and interest and achievement and self-concepts of ability, which could be damaging to them in the field of mathematics, physical sciences and technology. On the other hand, the persistency of a gender gap in mathematics-related educational and career choices, despite the disappearing differences in achievement, implies that such choices are rooted in much more than achievement.

Building on the reports of findings from previous studies, it is therefore valuable to examine how female students in higher education make choices to pursue mathematics-related disciplines; why they made the decision and what contributed to their decision are the main foci of this study.

Theoretical Framework

In examining the factors that impact females' decision to pursue mathematics-related disciplines, the researcher decided to frame this study around a theoretical model of career choice developed by Dick and Rallis (1991) (see Figure 2). This model was adapted by Dick and Rallis from the model of academic achievement behaviours originally developed by Meece et al. It aimed at functioning as a guide in the females' and males' career choice inquiry. This model is considered for the study because it not only presents more inclusive factors that the literature claims to have impacts on students' career choices, but it also shows how these factors work together in influencing these choices.

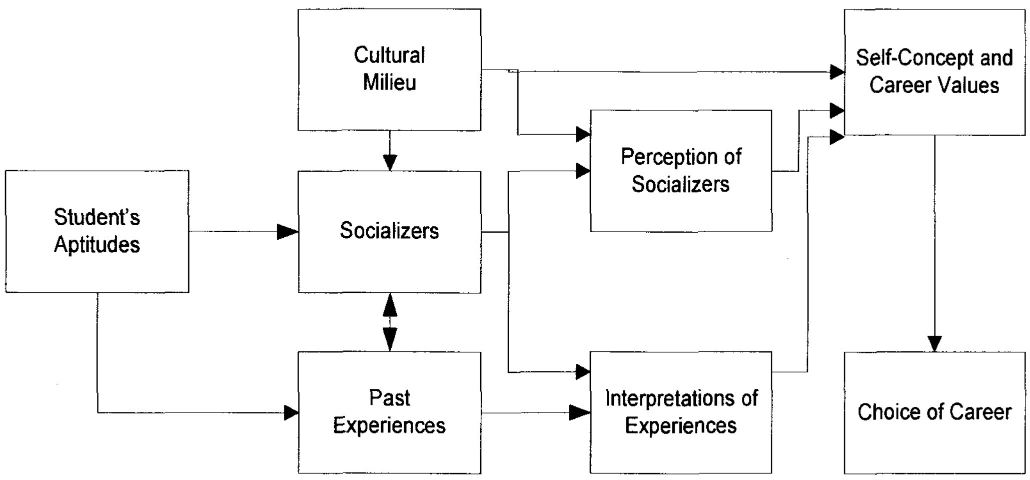

Figure 2. Dick and Rallis' (1991) model of career choice, modified from Meece et al., 1982.

According to Dick and Rallis' (1991) theory, students choose careers based on their beliefs about themselves, their abilities, and comparative values of pursuit of different careers. In addition, students' interpretations of experiences, perception of attitudes and expectations of socializers have a direct effect on the formation of their beliefs. Other factors, such as interest, salary expectation, cost and length of training, determine students' perceived value of careers. Besides, socializers (through their attitudes, expectations and by providing experiences), students' past achievements and performances in mathematics impact students' career choice. On the other hand, students' aptitudes shape their past experiences and both in turn can have an effect on socializers' attitudes and expectations for the students. In addition, the cultural milieu in which students and socializers dwell influences the attitudes and expectations of socializers, the students' perceptions of attitudes and expectations of socializers, and eventually students' self concepts and career values.

Dick and Rallis (1991) used this model to investigate the factors that shaped career choices of 59 female and 74 male students who studied both calculus and physics in one American high school. Using a qualitative research method, the researchers found that only 19% of female students with strong backgrounds in mathematics had the intention of pursuing mathematics or related disciplines in post secondary education, compared to 64% of male students.

Pelletier (2006) used the same model to examine the career intentions of 30 female and 27 male students in Canadian Grade 12 advanced mathematics classes. The study used a mixed method approach and found that only a small number of female students (21%) with strong mathematics backgrounds intended to pursue mathematics as a major in university. These females' intentions were linked with genuine interest in mathematics, as compared to males' intentions which were linked to both genuine interest and pay.

Both of these studies have focused on female and male high school students and compared their reasons for career choice. Therefore, for this study, the model of Dick and Rallis (1991) was used as a framework in order to explore how and why female university students made the decision to pursue mathematics-related disciplines. This model clearly reveals how different factors, which were all supported by the body of research presented in this chapter, may have an impact on students' career choices. This theoretical framework was therefore adapted to better fit university students (rather than high school students, as it is in its original form) and the qualitative research instruments were drawn from the variables in the model. Open-ended questions were generated in relation to each of the variables in the model with a focus on student's present (actual) chosen field of study.

Conclusion

This chapter focused on the factors that the literature claims to have impact on females' participation in mathematics which in turn may affect their decisions to pursue mathematics-related disciplines. These factors are of psychological nature (mathematics anxiety and self-concept/self-perceived ability); attitude and belief (usefulness of mathematics and attribution style); social factors (socialisers-attitude and beliefs of parents, teachers, and peers, as well as cultural milieu); and economic factors (career values and interest). It also introduced the career choice model (Dick & Rallis, 1991) that was used to shape the study. The next chapter contains a description of the methodology that was used, and details about participants' recruitment, data collection, and analysis.

CHAPTER III

Methodology

This chapter contains rationale for the overall design of the study. After reiterating the research questions that were driving this research and discussing the underlying principles of the qualitative methodology of choice, the author describes the ways in which she conducted and structured the study, so as to find out whether some or all the variables from the Dick and Rallis's (1991) model have an impact on the females' decisions to pursue mathematics-related disciplines.

Research Questions

The purpose of this study, as previously stated, was to examine the reasons behind females' decisions to pursue careers in mathematics-related disciplines. As such, the study sought to answer the following questions:

1) How do second to final year university female students decide whether to pursue studies in mathematics or related disciplines?
2) What are the most significant self-reported factors impacting second to final year university female students' decision to pursue studies in mathematics or related disciplines and why are they considered as being most dominant?
3) What obstacles are encountered by second to final year university female students in pursuing studies in mathematics or related disciplines and how are these obstacles overcome?

Research Design

For this study, the researcher employed a qualitative case study research method. In general, a qualitative research method is used when the goal is to understand the situation that is being examined primarily from the participants' perspectives and not the researcher's perspective (Hancock & Algozzine, 2006). In particular, Creswell explains that "Case study is a strategy of inquiry in which researchers explore in depth a program, event, activity, process, or one or more individuals" (2009, p. 13). Yin (2009) views "case study [as] the preferred method to use in research when a 'how' and 'why' question is being asked about a contemporary set of events, over which the investigator has little or no control of" (p. 13). In addition, Merriam (1988) states that case studies permit researchers to focus on one particular phenomenon of interest and study that phenomenon in depth.

Consequently, in designing this study, the researcher opted for the case study approach as its purpose as well as the research questions closely matched the descriptions given by Hancock and Algozzine (2006), Creswell (2009), Yin (2009) and Merriam (1998). The researcher embarked to investigate females' real-life decisions to pursue mathematics-related disciplines by focusing on the factors that have an impact on their decisions and the obstacles that they may have encountered in this process. In order to reach this goal, the researcher needed to gather perspectives of females enrolled in the mathematics-related university programs, to explore in depth their decisions to pursue their chosen career field, and to answer the "how" question in relation to their career choices.

In addition, the focus of case study research is explained as a "bounded system" (Merriam, 1988, p. 9). In this case, the study is bounded by the unit of analysis (the female participants), the context (pursuing mathematics-related disciplines at a mid-size university in Southern Ontario), and sampling criteria (involving only second to final year undergraduate female students in mathematics and physics). Since the aim of case-study research is to gain in-depth understanding of the case (Hancock & Algozzine, 2006; Stake, 1995), this method provided the researcher with a well-detailed data which allowed for deeper understanding of the factors impacting female's decision to pursue mathematics-related disciplines in higher education. Hancock and Algozzine (2006) define three types of case study research designs as: *exploratory*, which aims at defining research questions of a subsequent study or at determining the possibility of research procedures; *descriptive*, which aims at presenting a thorough description of a phenomenon within its context; and *explanatory*, which aims at establishing cause-and-effect relationships by determining how events occur and which ones may affect particular outcomes. Accordingly, this case study is both descriptive and explanatory with the aim of examining and providing a description of females' experiences and identifying factors that lead to their decision to pursue and persist in the pursuit of their chosen (non traditional) careers as well as the obstacles encountered in the pursuit.

Site and Participant Selection

The study took place at a mid-size university in Southern Ontario of about 16,000 students, out of whom more than 11,000 were enrolled full-time. This university attracts students of diverse ethnic and cultural backgrounds, including international students. At the time of data collection, the Faculty of Science had over 2,200 students and around 110 instructors.

Approval from the Research Ethics Board for the study to commence was received on Feb 1, 2010. In the meantime, the enrolment numbers of second to final year female undergraduate students in mathematics and physics were obtained from the Faculty of Science. The researcher decided to focus on the second to final year female students so as to have a group of students that persisted in the pursuit of mathematics-related disciplines. The convenience non-probability sampling method (Cohen, Manion, & Morrison, 2000; Nardi, 2006) was used to select participants from two departments (Mathematics and Statistics, and Physics) in Faculty of Science. After permission had been obtained from the Dean of Faculty of Science to approach the students, the researcher wrote an e-mail to the potential participants, explaining the study and conditions under which it would be undertaken, asking them to volunteer for the study. The email was distributed by the Secretary of the Faculty of Science. The researcher intended to select participants from each of the departments, in order to have representation of female students from the second, third and fourth years. After sending the invitation to participate twice (over the span of two months) , the researcher received an e-mail notification from six female students (one from Mathematics and Statistics department and five from Physics) that were interested in participating in the study. All six respondents became participants for the study and remained in the study throughout data collection.

The participants' age ranged from 19 to 25; they were all full-time undergraduate students in the Faculty of Science. Although three of the participants were not born in Canada, all of them obtained their high school education in Canada. This gave room for obtaining insights pertinent to female decisions to pursue non-traditional fields in the Canadian educational system. By making sure that the sample consists of participants from years 2-4, from two departments and that data collection was done in a relatively short time, the researcher followed Hoepfl (1997, "Sampling Strategies for Qualitative Researchers"), who cautioned qualitative researchers that sampling errors, for example, insufficient breadth in sampling, changes in participants/procedures over time, and lack of depth in data collection at the research site, may result in distorted findings.

Data Collection

The use of multiple sources of evidence is an important feature of case study research (Yin 2009), therefore, two approaches were used to collect data in this study: face-to-face interview and focus group interview. By so doing, the researcher followed Mason (2002), who states that interviews of individuals or groups give the researcher the opportunity to obtain rich, personalised information. Data were collected over the period of seven weeks from February 3, 2010 to March 25, 2010. More details about both data collection methods and procedures are given in the text that follows.

Interviews. Qualitative interview is described by Glesne and Peshkin (1992), as "an occasion for [in] depth probes-for getting to the bottom of things . . . [in order to] do justice to the complexity of [the] topic" (p. 85). It is a purposeful conversation that not only allows researchers to collect descriptive data in participants' own words but also provides opportunity to develop insights into some parts of the participants' worlds (Bogdan & Biklen, 1992). In this study, the semi-structured interviews were used to collect data.

Semi-structured interviews give structure to the questions-and-interview format, give room for flexible wording, and allow for flexibility to probe more deeply the issues that participants bring up (Hancock & Algozzine, 2006; Merriam, 1988). Six interviews were conducted and each one started with more structured questions, but then moved toward open-ended questions (Martinovic, 2004). An interview protocol that contained twenty to twenty five open-ended questions was used (which guided the interviews) so as to ensure the collection of comparable data among the female participants. These questions were developed by using the Dick and Rallis' model of career choice (see Appendix F).

Interviews with each of the participants were conducted privately in one of the rooms in the graduate lounge of the Faculty of Education. The interviews ranged from 30-55 minutes. In order to adhere to ethical requirements specified by the University of Windsor Research Ethics Board guidelines, participants were asked to read and sign the letters of Consent to Participate in Research and Consent for audio taping of the interview, before commencing each interview (see Appendices A & C). They were also informed that they could withdraw without penalty of any sort, at any time during the study. Confidentiality was also assured. After all documents were signed, the researcher proceeded with the interview and audio-taped the conversation. Questions were asked to probe how and why these female students decided to pursue mathematics-related disciplines and to learn about the obstacles they might have encountered in the pursuit of their careers. The researcher took notes during the interview and wrote down a statement or idea that required further probing so as not to interrupt the participant at an inappropriate time.

Focus group meeting. The focus group meeting involved six female participants that took part in the face-to-face interviews. The meeting was conducted so as to confirm the data that were collected through the face-to-face interviews, as well as to probe for additional information in order to gain better insight into female students' decision making and their ways of overcoming the barriers that they might have encountered in the pursuit of mathematics-related disciplines. Besides, group interaction was expected to generate new ideas as participants build on others' comments (Nardi, 2006). Some questions asked in the face-face interview were repeated in order to clarify responses and stimulate thoughts on a particular component in the question. All the participants were asked to sign the Consent for Audio Taping of the focus group interview (see Appendix D) before starting the interview. Also, they were reminded before, during, and after the focus group meetings of confidentially issues and were asked to sign a form where they pledged to keep the conversation there private (see Appendix E). Focus group interview questions are provided in Appendix G.

Data Analysis

Interview with each participant and the focus group meeting were recorded on a digital recorder and transcribed by the researcher. At first, the participants' responses were tabled in Microsoft Word in relation to each interview question. The researcher then looked for emerging themes, both across the answers to specific questions/prompts and overall. The aim of using a thematic analysis was to integrate many different pieces of information that were obtained during data collection so as to identify and report meaningful findings; new information was then examined in light of the research questions so as to construct tentative answers, which were categorized into themes (Hancock & Algozzine, 2006). Thus, the researcher reviewed all responses in the table and coded them so as to identify themes. Emerging themes and patterns in the participants' responses were noted. This was done in such a way that when the researcher discovered a theme in a response, she examined other responses to find out whether the same theme was present there too. Data that had been put together into themes were crossed out and the remaining data were re-examined so as to develop more themes. This process was carried on until no more themes were identified. In addition, the researcher removed some of the "um", "ah", "like", and other hesitation particles and filler words in the quotes that were used for this study, to improve clarity and understanding. However, caution was taken so as not to misconstrue what the participants had said.

Methodological Limitations of the Study

The small sample of six female students and the fact that they volunteered to participate in the study may limit the generalizability of the results (Martinovic, 2004). Because the researcher had to accept all the volunteers, she was not able to choose a richer and more purposefully selected sample.

This is especially related to having only one participant from the Mathematics department (while others were from Physics department), which consequently made comparison between motives for going into specific disciplines difficult. Ideally, it would have been better to have the same number of participants from each discipline. However, despite of its limited generalizability, because of the researcher's careful attention to details and achieved variability in the sample with respect to demographical information, it is hoped that this study will be a useful addition to and/or expansion of previous research and theory on factors that may impact female decision to pursue mathematics-related disciplines.

Reliability and Validity/Establishing Credibility

Data triangulation is a key strength of case study data collection (Yin, 2009). In addressing the validity and reliability of the study, two types of data triangulation were used: (a) multiple sources, that is, multiple participants, and (b) multiple data collection methods, that is, individual and focus group interviews. The researcher was, from the beginning of the study, mindful of the potential biases arising from her strong educational background in mathematics-related discipline. Thus, the researcher aimed at representing participants' experiences and opinions accurately. The data collected and interpreted were taken back to participants for review to check for accuracy, also called "member checking" (Guba & Lincoln, 1981). In addition, an external observer was asked to review the data and the findings so as to ensure that data were not lost through the researcher's bias or carelessness. Reliability threats were addressed through documentation. A detailed record of how data were collected and how participants were contacted were kept.

Ethical Considerations

The study followed all ethics procedure and guidelines for research. The study was conducted with the approval of the University of Windsor Research Ethics Board. All participants were adults who signed a letter of consent. They were informed that they can withdraw without penalty of any sort, at any time during the study. The identity of the participants was kept confidential. Their true names were replaced by pseudonyms so as to protect their identity and any information that may show their identity was not reported. All information provided by participants was securely stored in a locked cabinet in the office at the University of Windsor.

Conclusion

In order to provide insight into the planning and execution of the research processes related to this study, in this chapter, the researcher described the research method and the rationale for choosing the methodology, defined role of researcher, and provided details of recruitment of participants as well as data collection methods and analysis. A case study research design was used in this thesis. Data were collected by using semi- structured face-to-face and focus group interviews. The next chapter presents the results and details of analysis of the data collected during the study; introduces the participants and discusses the emerging themes that were identified from the data collected.

CHAPTER IV

Analysis of Results

This chapter contains the findings emerging from the analysis of data gathered during face-to-face and focus group interviews. The study results indicate that there is an overlap of factors that may have influenced the participants' decisions to pursue studies/careers in mathematics-related disciplines. The participants shall be introduced first and this will be followed by the discussion of the themes that emerged from their responses.

Introducing the Participants

Anna. Anna is 20 years old. She is a third year student of Mathematics. She works part-time as a mathematics tutor and has attended several mathematics conferences while at the university. Her friends are mostly engaged in mathematics-related disciplines. Her mother works in a non-traditional field, where she is much isolated as a female. Anna appears to be very confident and outspoken. She has a great passion for mathematics that she shares openly. She enjoys manual work to the extent that she wanted to be a welder, but went into engineering instead. She switched from engineering to mathematics in her second year because of her love for the subject. Her parents disapproved of her decision, but she knew exactly what she wanted in life. She believes that one should pursue a discipline one loves; the discipline one could work in happily for years. In her own words, if she could have done anything differently about her career, she would have gone into mathematics from the beginning, instead of engineering. For now, she does not know if she would apply for graduate studies, but if she does, it would be in some mathematics-related discipline.

Betty. Betty is 20 years old. She is a second year Physics student. One of her parents is an educator and the other has retired. She has tutored mathematics in grade school, through the Board of Education, and by doing so, has witnessed students having difficulties with the subject, especially when it comes to mathematics theory and proofs. Although she liked mathematics, as it was one of the subjects in which she got top marks in high school, she was not sure what she wanted to pursue as a career after high school. Thus, she applied for mathematics, arts and science, and business programs in the university and chose to pursue an arts and science degree in her first year. She took some physics courses in her first year, realized that her passion lies in that discipline and thus switched to physics in her second year. Betty is still very much attached to her high school physics teacher and would love to have friends in her department that she could study with. She is very ambitious, self-driven, loves schooling, and has never considered quitting her studies. Although she is positive about pursuing a graduate program, for now, she is not sure of the desired field. She believes that she would perform exceptionally well in university mathematics if she gives herself enough time to study it.

Cathy. Cathy is 19 years old. She is a third year Physics student. Her parents do not have fixed careers. She chose to pursue a mathematics-related career out of interest and curiosity. She appears to be confident, determined and direct in her responses. For her, mathematics is intuitive and there is no difficulty in the subject that she cannot overcome. She knows exactly what is expected of her to succeed and by pursuing her career she believes that she is fulfilling "the smartness that people see in [her]." Cathy has never considered quitting her studies because of her scholarship. She does not have friends in science and no role model in her career path. She had considered switching from physics to another mathematics-related field because of the realization that she could not relate well with people in her chosen discipline. She would like if her peers would be more willing to "make time for life" instead of usually engaging in solitary studying activities. She is a "people person" who believes in working with the people she enjoys being around for the rest of her life. She intends to apply for a graduate program in mathematics-related discipline but is still not sure in which course to enrol.

Debbie. Debbie is 25 years old. She is a third year Physics student. She first chose to study arts because she was under the impression that scientists are very cold, competitive and not humane enough. However, somewhere along the way, she lost interest in studying arts because she found the courses and teaching style there to be "narrow [minded] and boring." She decided to pursue physics after seeing some of her older friends excel in undergraduate programs in the discipline and continuing with graduate studies in related fields. Debbie wanted a career where she could be both smart and pretty; having fun while being a scientist. If she could have done anything differently, she would have enrolled into physics right after high school. Her present position is that a physicist is, in fact, a very well-rounded person—a view that would appeal to many other females upon realization that they could simultaneously have interests in fashion and social issues and while being a scientist. She persevered in her chosen field by establishing firmly set goals and having a professor who has been inspirational for her. Debbie intends to pursue a PhD in physics because she not only finds the discipline and the people in it fascinating, but also finds in the subject everything she has ever been interested in.

Ella. Ella is 21 years old. She is a fourth year Physics student. Having both parents in engineering, she always had perfect grades in mathematics at elementary school and had also obtained high grades (in the top decile) in physics and mathematics in high school. She sees mathematics as an inborn subject that comes to her naturally. When contemplating where she should go after high school, she realized that she did not want to follow in the footsteps of her parents by enrolling in engineering. Instead, she decided to pursue a career in mathematics or in related disciplines. She considered studying pure mathematics, but chose physics as an alternative, because it has more career options, was her strongest science subject in school, and she had her father's help and advice. She strongly believes that physics has a role in every kind of industry. In the future, she does not see herself doing much solitary research in the discipline; she would rather pursue a career where she could work with people (e.g., patients) and in a team setting. She has loved her job, the environment and everything, that she experienced during her CO-OP term. Ella's positive experiences during the term and the idea that she will be working in the field one day, kept her going in her chosen field of study. She intends to pursue a graduate program in medical biophysics.

Femida. Femida is 19 years old. She is a second year Physics student. With both parents having engineering degrees, she was encouraged from childhood to do well in school and to be among the top students in her class. She appears to be very shy, smart, determined, and taciturn. She was not sure what she wanted to do after high school, so she applied for both engineering and science programs. She later chose physics out of interest and was not disappointed, although, at times, she found her studies both hard and challenging. However, she has never regretted choosing physics as a career, because she is convinced that her knowledge would be used to help people. Femida appreciates successful people in her field who are modest about their achievements. She prefers not to disclose to casual acquaintances that she is pursuing a career in physics because of the "weird reactions" she had received in the past. Although she loves mathematics and finds it easy after studying it, she feels that her high school teachers did not prepare her well for studies in theoretical mathematics. She does not have friends in the Physics department and intends to continue with a graduate program in physics.

Table 4 contains summative information on the study participants, suitable for overview and comparison.

Table 4.

Summary of Demographics Information about Participants

Name[1]	Anna	Betty	Cathy	Debbie	Ella	Femida
Nationality	Born Canadian	Born Canadian	Born Canadian	Naturalised Canadian	Naturalised Canadian	Naturalised Canadian
Age	20	19	19	25	21	19
High School	Canada	Canada	Canada	Canada	Canada	Canada
Major	Mathematics	Physics	Physics	Physics	Physics	Physics
Interview Date	Feb, 03	Feb, 04	Feb, 18	March, 01	March, 01	Feb,11
Father's Highest Degree	College Diploma	High School Diploma	No Degree or Diploma	Master's	Master's	Bachelor's
Mother's Highest Degree	Master's	Master's	High School Diploma	Master's	Bachelor's	Bachelor's

Themes Emerging from the Face-to-face Interviews

Four main themes emerged from the participants' responses in the face-to-face interviews that showed how they made their decisions to pursue mathematics or related careers. Two themes were also identified from their accounts on the obstacles they encountered and how they overcame them. The themes are hereby discussed.

[1] All participants' names are fictitious.

Theme 1—impact of socializers; parental/teachers' support and encouragement. Questions 4-5 on the interview script were designed to investigate how others (family/teachers/ peers) impacted participants' decisions to pursue their chosen career. All the participants reported that their individual decision to pursue career in mathematics-related disciplines was solely made by them. They, however, stated that they had some form of support and encouragement from their parents and teachers that impacted their career choice decisions. For example, Anna recalled:

> Basically, my mom always encouraged me to do whatever I wanted to do regardless of barriers, like gender barriers, because she worked in forestry and she had to deal with that a lot...she was more like pushing me to continue in the sciences and mathematics...

Debbie, who had first gone into arts before deciding to pursue a career in the mathematics-related field, stated that her parents thought that switching to physics was a good idea. Her mother expressed her excitement by saying: "This is what I thought you should have done in the very beginning." Unlike in Anna's and Debbie's cases, Ella's father helped her pick one out of her preferred career options after she had made the decision to pursue mathematics-related discipline. She commented:

> My Dad wanted me to go into physics, because I was undecided whether to go into physics or biochemistry, he kind of helped in choosing...my mom just told me to do whatever I wanted to do... My parents encouraged me to keep going.

Cathy said that her mother always encouraged her to do well in school (grade wise) and pushed her into doing whatever she enjoyed most rather than just going for something because of the monetary gains. Femida did not say that someone influenced her decision. Instead, she found something attractive about physics which made her decide to pursue it. However, she recalled:

> When I was really young, my Dad would tell me and my sister that I would be a dentist and she would be a doctor. My parents always encouraged me and my sister when we were young to do well and be at the top of the class. That is why I was kind of geared towards that direction [science].

Besides parents, all the participants identified teachers as having influenced their career choices at some points in their education. Anna not only claimed that she had "awesome" physics and mathematics teachers in high school that impacted her decision to pursue her career but also that she has some "fantastic" professors in university that encouraged her to stay in the field. For Betty, one of her teachers not only influenced her decision, but also became a friend whom she still approaches when she cannot solve some physics problems and make career decisions for herself. She stated:

> My parents did not really push me into anything; they are supportive of whatever I wanted to do. As far as for choosing physics, I had my high school physics teacher, she was really supportive; she always thought that it would be a good idea. She did not push me into it but she is definitely one of the reasons why I decided to go into physics. I think if I have not gotten a good physics teacher I might have not gotten into physics. I still go back and I still talk to her all the time if I have problems. I go back and talk to her ... I kind of have a friendship with

her. I know her family too; she does not seem like a teacher kind of so much, she is [more] like a role model.

Cathy also added:

My physics [Grade 11] teacher would have been probably the person who made me want to go into physics because he would add little things to the courses that would stimulate interest in the subject.

Besides, four participants referred to parents or teachers as role models while two said they never had role models for choosing a career. Role models varied by gender for those who had them; that is, they may have been a parent or a teacher (regardless of gender). Anna and Betty claimed their high school physics teachers (male and female) were their role models; Ella said her father was her role model; Femida claimed her professor (female) is her role model; and Cathy and Debbie said they never had one.

Interestingly, all the participants identified either parents or teachers as having the greatest impacts on their decisions to pursue their careers but did not mention peers or siblings as having any influence on them. Figure 3 visualizes the socializers and their influence on females' decision to pursue a mathematics-related career, as found through data analysis.

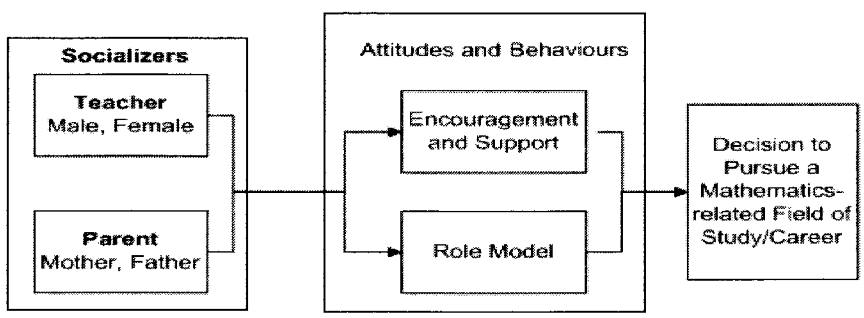

Figure 3. Influence of Socializers on Female's Career Choice.

Theme 2—past experiences. Participants were asked to describe experiences that they believe most contributed to their decisions to pursue their chosen careers, as well as favourite and least favourite subjects from elementary school to university level. All the participants reported positive experiences in relation to mathematics and sciences; they were very good in the subjects, had good grades and some also had very good mathematics and science teachers. For example, Anna said:

> I enjoy math; I love playing with numbers and equations. I had good maths teachers, and in particular my male physics teacher encouraged and inspired me... I'm the biggest math nerd, I love my numbers a lot ...I would rather go home and spend four hours doing mathematics homework than doing homework in other subject...maths is not cut and dry like other subjects, when you are writing a theorem or proving a theorem there is no right or wrong answer,...there is no one right way to do a math problem.

Betty responded:

> I enjoy and do well in maths and physics; I feel really good about doing well in exams. It feels good to do well in something. I like math, like working through maths.

Cathy commented:

> I enjoyed it, I liked it, I don't want to say it's fun; it's, like, I don't get bored of it. I think it's challenging and fulfilling and I like math because it is creative..., when you make a proof or something, it requires your ingenuity.

While these females reported only positive experiences, Debbie reported both positive and negative experiences. She said that if she had considered her high school mathematics and physics teachers' attitudes and teaching methods, she would not have pursued a career in the mathematics-related field (this could be linked to her choosing Arts in the beginning of her career). She expressed her disappointment by stating:

> ...my math and physics teachers made me not want to do it [pursue career in mathematics], those are the teachers that made me hate math because of the way they taught — it was so dry. The kids that didn't know how to do the math, they kind of like ignored them. I felt it would have been more beneficial if kids could have helped each other—they could have come up with ways to introduce or explain the mechanics of the concepts...They would start lectures and kids would raise their hand, "Oh, we don't know what is going on," and because they are worst students or something, the teacher would be like, "Okay" and then he would just keep going. I felt it was horrible and my physics teacher was completely unqualified to teach physics...I guess he was doing a certificate and teaching senior level physics at the time, but he had a civil engineering background and we learned nothing in that class...My first year (in physics) was really difficult because I felt I was learning twice the material as some of the other kids because I didn't have the background.

However, further along, Debbie recalled having a couple of teachers that really impacted her and stimulated her interest in sciences. She stated:

> I think the first teacher I had was in Grade 2, the first teacher that made me really love science, love physics and that was the teacher that taught us about solar system, dinosaurs...Another teacher in Grade 5 taught me science and talked about natural phenomena, kind of made you want to know how that kind of happen... The teacher that was most influential was probably in high school,... the man who taught us French used to come in and just up off the top of his head do some mathematics, do some French, do some history, do some French, talk about science, do some French ...He also taught us about Voltaire [François-Marie Arouet] — all these people who are in maths and who are also very humanistic.

Besides, all the participants mentioned that mathematics and/or science were their favourite school subjects. The reasons they gave for being their favourite choice included, mathematics—because it is easy, it does not take much time to do, it is challenging; physics—because the class is interesting and helps one learn why things happen the way they do; and science—because, it is the only subject that answered "WHY?" and "WHY?" questions. The participants were also asked about their least favourite subjects. Some of those that were mentioned are religion, arts, English composition, and gym.

Figure 4 presents interplay between additional factors that influence females' decisions to pursue a mathematics-related discipline. This diagram contains elements from the Dick and Rallis (1991) model that were found in relation to past experiences.

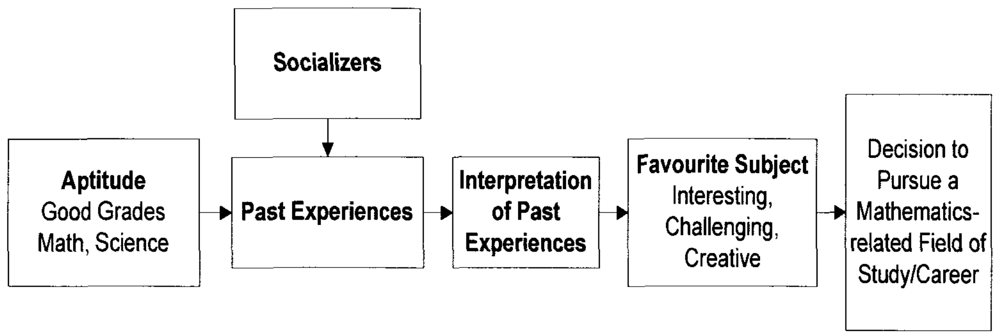

Figure 4. The Effect of Past Experiences on Attitude and Career Decisions.

Theme 3—value system. When asked about their beliefs about mathematics (Question 10), the participants used words such as *"crucial", "extremely useful", "important"*, and *"applicable everywhere,"* to express their high esteem for mathematics and its usefulness in their daily lives and in their future careers. They also commented on the valuable place that mathematicians/physicists have in the society. Although their descriptions of commonalities that mathematicians or physicists have differed, they all agreed that these professionals are very important and are well respected in the society. For example, Anna expressed her views about the usefulness of mathematics by saying:

> I am a math tutor and one of the best things I used [as a hook] for my students is, "you can use math in everything, like when stopping a car you don't realise you are unconsciously determining the amount you gonna have to stop and that's a math number; in soccer you go straight down the field instead of a curve because you know the straight line is the shortest path, which is math" ... Basically math people make the formula that engineers use. I don't really see numbers any more in math, it's mostly just manipulating formulas and it seems like there is a formula that can determine any sort of life, like it's used in sciences, accounting.... It

> seems like mathematicians are loved in the industry for predicting trends, in marketing for predicting what will work the best, statisticians are used everywhere, I know somebody who is working in biostatistics, so... it's just crazy - the number of things you can use it for.

Ella expressed a similar opinion when she stated:

> It is applied everywhere, I think everything needs kind of math, every program does do some kind of math; we do a lot of math in physics; definitely you have to be good in math to study physics ...When you think about physicists, you think about people in the lab (laughed), that's always how it is, but I don't view it that way because physicists go into every kind of industry.

Unlike Anna and Ella, Betty is a 2nd year student that believes that she still has a long way to go to become a professional in her chosen career. She is however very much aware of its usefulness which is reflected in her responses:

> Math is very useful and important. Physics is basically math, in order to study physics you have to enjoy studying math; you cannot work in physics if you don't like maths because it is a big part of physics... Mathematicians are very smart, well respected, they come up with stuff that most people don't realise [are of their doing].

Debbie's view of the usefulness of mathematics is a bit different from the other participants in that it emphasises the importance of teaching mathematics well. She stated:

To do physics you have to be good at math. Math is very important and really useful and applicable. My belief is that if you don't teach it properly then it becomes useless and inapplicable...Mathematicians are like the calculators while the physicists make all of the inventions in science, like medicine, but we need the mathematicians to do the calculations.

Apart from their views of the usefulness of mathematics, the participants not only expressed that one or both of their parents value mathematics but also pass on the value to the family. Some made short comments like: *"my parents have good opinion of maths", "they love and enjoy math", "they believe that math is an important science"* while Debbie specifically said,

> They really think math is important. I can tell from like a really young age that knowing math was a really important part of the concept in my family of being intelligent or educated.

All the comments show that the participants value mathematics as very useful in relation to their careers and that they have strong perceptions of their parents' values for mathematics. Apart from this, the participants have positive views about the professionals (i.e., mathematicians and physicists) in mathematics-related field.

It is important to note that the parental education of the participants differed. The majority of the parents are well educated and received degrees in areas considered as non-traditional for females. Among fathers, two had Master's degrees in civil engineering and physics; one had an undergraduate degree in petroleum engineering; one had a college diploma in Mechanics; one high school diploma; and one did not finish high school. For mothers, three had Master's degrees in civil engineering, ergonomics, and education; two had undergraduate degrees in petroleum engineering, and one had a high school diploma. Overall, mothers of the participants were more educated than the fathers. For some of the participants, it appears that having parents in mathematics–related careers influenced their career choices (especially Ella and Femida as discussed above). Figure 5 visualizes relations between different factors that influence formation of the value system among females and ultimately affects their career choice, as found through data analysis processes.

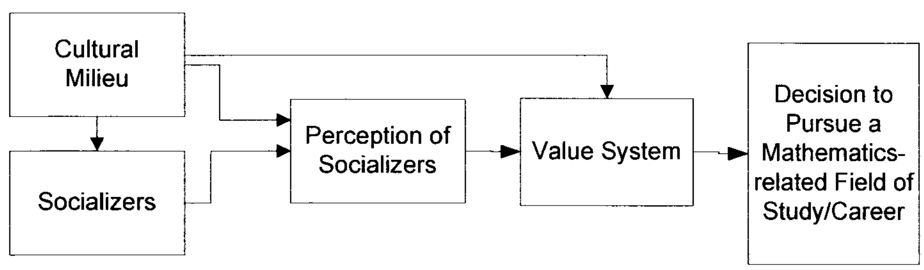

Figure 5. Factors that Influence Female's Value System and Career Decision.

Theme 4—self concept/self-perceived ability. The six participants interviewed showed strong mathematical self-concept and reported a high level of achievement in mathematics right from their elementary school. They reported mathematics grades between 80% to 100% in both elementary school and high school and marks in top quartile (i.e., A's and B's) in the mathematics courses they have taken in the university. They all claimed to be good at mathematics and did not find it difficult. For two of them, mathematics came naturally whilst others had to put in some effort to achieve high grades. For those in the latter category, they could easily overcome any seemingly difficult mathematics concept by studying it. The participants not only expressed strong beliefs about themselves and their abilities in mathematics, they also showed positive attitudes towards mathematics and physics. For example, when asked about how she sees herself as a mathematician, Anna said,

> I like to think I'm a good mathematician [laughed]. I do fairly well with my courses; [mathematics is] not as intuitive for me as it is for some other students in my class. I think I spend more time rereading notes and teaching myself theorems, because if I don't see something that automatically makes sense to me, I have to put a lot work into it, but I always think I will be a good mathematician when I'm done.

Anna does not doubt her ability in mathematics; she has strong self-confidence and she gives herself extra time to study mathematics so as to get good grades and achieve her goals. Betty reported that, although she does not have the highest grades in physics compared to other courses, she values those grades the most (e.g., "it feels like the best grade"). She relies a lot on working with other people as she prefers verbally solving problems through communicating with others, but she has no friends in physics to work with. Even though she studies alone, she continues to search for people to study with. Betty said:

> There have definitely been times when I thought "Oh I hate this. Why am I doing this? But, at the same time, it's those moments that make it so much more rewarding when you finally get it.

Not having learning partners in physics has not deterred Betty from fulfilling her goals. In order to achieve good grades in her courses, she has become a lot more disciplined than before. Also, she tries to motivate herself to study, become more self-reliant, and teach herself things that she does not understand. This shows that she has strong confidence in herself and her ability. Like Betty, Cathy does not have friends in physics. She chose to study physics because she did exceptionally well in it and enjoyed it in high school. Her friends from other fields think that physics is hard to study and often make comments that could discourage her from continuing in her field. Cathy said:

> ...the biggest reaction is, "Why would you bother doing it?"...Whenever they call me, they say I'm crazy [laughed], yeah, yeah, it's positive and a good thing, it is almost bad and sometimes it's just like they don't understand why I'm doing something so hard...They call me a nerd...[they say] "Oh you're so pretty, but you will just be a trophy wife"...I tell them, "I just like [physics]".

Cathy does not let her friends' comments stop her. She has strong confidence in her abilities to pursue physics, to the extent that she would feel like a failure if she had not enrolled in it. Debbie's, Ella's and Femida's friends also wonder why they are pursuing career that is so hard. The three of them claimed that regardless of the large workload that they experience in their chosen field, they enjoy the classes they take and would feel a sense of accomplishment when they finish their undergraduate programs.

Based on the interviews, the researcher was under the impression that the participants' interest in mathematics and science developed quite early in their school years. This was later reflected in their answers to question 13: *"What are the most important factors that had an impact on your decision to pursue career in science or mathematics?* All respondents mentioned their genuine interest in the field as the dominant factor. Other, less significant factors mentioned were job availability, pay, and influence of socializers. Anna said she wanted a career that would not only translate into a job, but also would not drive her crazy for the four years that she had to study it. Betty said she would not have considered any career with no job availability. Cathy, Ella, and Femida also mentioned job availability and pay as some of the reasons for their choices of careers in mathematics-related disciplines. Overall, the participants in this study revealed positive orientation towards their ability, performance, and success in the learning of mathematics and sciences.

Figure 6 presents factors found in respondents' answers that fall under the *Self Concept and Career Values* section of the Dick and Rallis (1991) model.

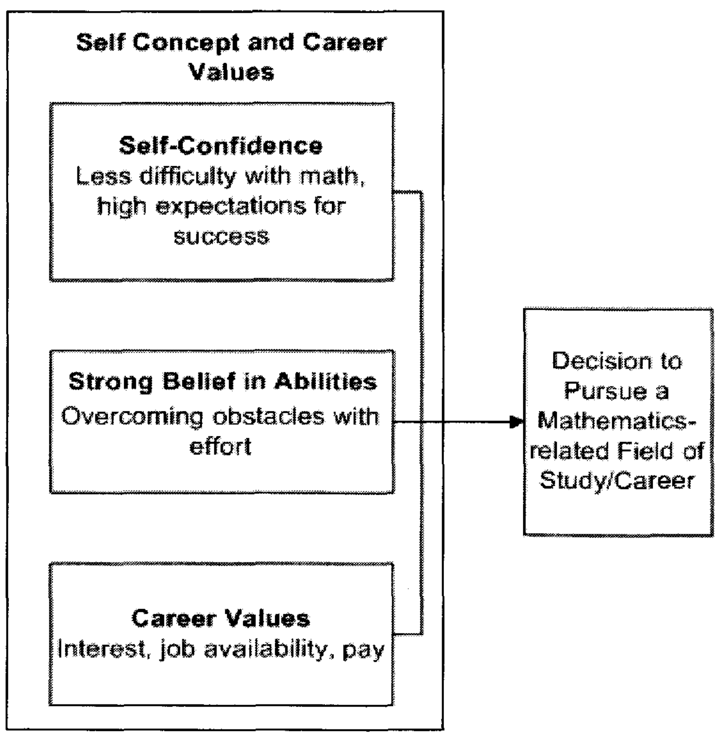

Figure 6. The Influence of Self-concept and Career Values on and Career Decision.

Obstacles Encountered in the Pursuit of the Chosen Field of Study/Career

Questions 17 and 18 investigated the difficulties and challenges that the participants may have encountered in pursuing their field of study and how they overcame them. Some of the negative emotions that the researcher observed and/or participants reported during the conversation about difficulties included anger, depression, exhaustion from workload, as well as disappointment with teaching methods. Two themes were observed in the responses—*inadequate teaching methods* (e.g., lecturing) and *lack of social interaction/solitary feelings*. These themes will be elaborated on in the further text.

Inadequate teaching methods. Most of the participants not only commented on the heavy workload during their studies, but also on the teaching methods employed by the professors, as some of the barriers. The teaching methods mentioned in this context range from lecturing to paraphrasing (without giving enough details) of notes. In addition, the participants stated that they feel that the courses are geared more towards male style of learning. As Anna explained:

> ...I am more of a visual learner, so I've had a few professors that just talk (did not write down their notes)... It's really hard for me because..., I need to see it on paper to be able know what is going on.....Or, a couple of my profs had really messy handwriting, as well as the language barrier, and it was just you have to read the textbook or you have no idea what's going on...

Betty confirmed Anna's comment on the messy handwriting and mentioned that one of the professors used to provide handouts that were of very poor quality and written in the professor's handwriting. She said the notes required too much extra attention from her because they were hard to read. Debbie was against the "male dominated style of teaching" that she and her female colleagues experience. She explained this by saying:

> ...a lot of the male dominated style of teaching, especially in the first two years, is because you are not used to it and it gets to the point where you were like, "I don't know if I want to do this; I love this, but the way it's being taught to me is horrible." These teachers doing it, is like all the guys understand it because their minds are the same way and the girls are sitting there like we need the big picture...They've (teachers) been teaching to males and when they went to school, they went to school only with males and then when you talk to your male student friends and you are explaining things to each other, they explain things differently. While they are explaining things to you in words, they skip certain thing that girls find important and so you don't know what they are talking about, and they look at you like (she made a face) condescendingly; meanwhile, if you show them what you are talking about, often times, you are right (laughed).

Ella agreed that some of the teaching methods in the classes she takes should be changed, "to make it more interesting, to interact with the student more, instead of just lecturing," while Cathy argued that lectures are not sufficient to thoroughly learn physics. She said that as an effective teaching method, "you need to clear [up] your sessions and [make room to] put more problem solving sessions." Femida frowned at some professors that only paraphrase what they had on the screen instead of giving more explanation.

Lack of social interaction/solitary feelings. Although all the participants claimed that having almost exclusively male-populated classes in their faculty is not an obstacle to them, the lack of social interaction with their peers was mentioned as an obstacle. Cathy in particular complained that: "I don't like the solitary type of work that we do; it's like sitting there by yourself, for sure that is an obstacle for me. I wish there was a job that is more social, that you would work with people more." This obstacle came out very strongly when she was asked what she would have done differently in her choice of career. She then said that she would have done a double major that would include arts or social sciences, and that this program, in conjunction with the physics program, would give her a well-rounded education. In the same manner, when asked how she sees herself as a professional in her field, Debbie said:

> Some of the women physicists that I could really respect are well dressed; they look good, command respect, socially [are] not awkward. I have this idea of being a physicist is like being a very well rounded person; as a woman, trying to make more appearance to other women so that they will have interest in fashion, art, and social things, and also be a scientist.

In her words Ella described feeling of being looked down upon, which may be related to being isolated. She said:

> The more up the years you go, the harder it is, school gets harder. More so, it's usually a lot of males (in the class), a lot of times you do get looked down upon, it's like, "Are you here because you can actually achieve this or because you are female and we need female to work here?"

Although participants did not explicitly mention having no friends in the field of study, as well as having nobody to talk in school, as an obstacle, this could be inferred from some of their responses. For example, Betty said, "It's hard to talk especially since all my friends are not in physics and neither of my parents did physics; it's hard to talk about what you are doing ... except to somebody who has done it, who knows physics." She was not the only participant that expressed such feelings. Debbie also had something similar to say, "I don't think I have anybody to talk to." Out of the six participants only one stated that she had someone to talk to about her career.

Overcoming Obstacles

During their studies and before, the participants developed certain strategies they used to overcome the mentioned obstacles. The researcher decided to group them all under one theme entitled, "self-reliance."

Self-reliance. When asked how they overcame the obstacles they encountered (question 19), the participants described some adjustments in the ways of doing things. For example, Anna said:

> ...my textbook is my friend, if I read it, I will be okay... I learned between first and second year that going to class is not enough, you have to do so much work at home; teaching yourself the theorems and doing the exercise, and redoing the exercise, because otherwise you are just not going to do well in class...

For Femida, studying harder is the key, whilst for Betty, both self-discipline and self motivation are very important for survival. Betty stated that she would purchase and read textbooks that are not required, so as to enhance her understanding of the material. Ella's recipe for dealing with "the workload and being looked down upon, [is to] organise your time better, prove yourself, prove that you are capable and equal to everybody else in the class." Debbie said that whenever she encounters an obstacle, she says to herself, "I'm learning for myself... Anytime I need advice about my career, I would read biographies of the people that I really respect, like Einstein...I would read about women scientist. " In such situations, Debbie thinks of other women in the field that have gone through similar experiences and survived them. By taking such "global" perspective, Debbie motivates herself to think that no matter what the obstacles are she would be able to overcome them. Apart from finding time to interact with her friends involved in traditional fields, Cathy is planning to organize a Physics Club where females can mingle. By doing so, Cathy wants to reduce or eliminate the problem of lack of social interaction and social isolation that females experience in the school environment.

Based on the previously stated quotes, it can be concluded that the participants in principle relied upon themselves in order to perform well in their studies and also to overcome some of the barriers that they encounter in the pursuit of their studies/careers.

Focus Group Interview

After interviewing each participant individually, the researcher organized a focus group meeting, with the intent to motivate participants to discuss some topics relevant for the study. Four themes emerged from the focus group meeting. They are: *parental support and effective teachers*; *lack of awareness of career options*; *mathematics as a gendered domain*; and *self- concept and persistence*. These are discussed below.

Theme1—parental support and effective teachers. Participants were asked to express their opinions on why few females pursue careers in mathematics and to elaborate on the factors that contributed the most to their career choices (Questions 1 and 3). Most of their responses were about teachers which they related to their past (grade school and high school) and present experiences (university). Four reported having good mathematics and physics teachers in high school with good teaching methods. Two were disappointed in the attitudes and teaching strategies of their high school physics teachers. Although they all reported having parental encouragement, only four reported having parental support at home at some points in their studies. The support came in the form of helping with homework and explaining problems in mathematics and/or science. One never asked for parental support whilst one resorted mostly to her high school friends when she needed help with mathematics. According to Anna, her elementary school teachers did not give her much attention in mathematics because attention was given more to the struggling students in her class. She recalled:

> I didn't have good grade school math teachers but my mom just like taught me on the side...My grade 12 math teacher was awesome; he taught about parabolas by making us do parabola dance; he'd make kids stand up; he'd call up the parabola, you'd have to make it with your arms up or down and traveling side to side, yes, that was awesome ...At the university every calculus teacher that I had was excited about life

Anna's comments not only made the whole group laugh but they astonished it. Anna added that students will neither excel nor have interest in mathematics if they are taught by teachers that don't like the subject. She said:

> I know people that had bad math teachers in elementary school and they never liked it since. [Teachers] may not be good in maths and if they are forced to teach it and if they don't like it, the kids don't really have a chance

All participants agreed with Anna that having good math teachers in grade school is very important. Anna, Betty and Cathy got really excited when they talked about elementary teachers with no mathematics background (louder voice; interrupted each other). Betty said apart from her parents pushing her to do well in school, she had good mathematics and physics teachers both in grade school and high school. She said:

> I have always had really good, really good teachers [in grade school]. In high school my grade 11 and 12 physics teacher was a woman and she was a big part of why I decided to go into physics just because I could talk to her...; If I had a different physics teacher, I might not have gotten into physics, I might have gotten into arts and science...but she definitely influenced my decision a lot.

Betty compared the learning opportunities (group work) that she had in high school to the one she had in the university and said:

> In high school, my physics class was like eight people and we all worked together on assignments,...I mean we weren't doing each others' work but when we got stuck, we definitely worked through things...In a real world when you are working as a physicist, you are not working completely by yourself, you are working in

groups, in teams, so why can't we do that more in the university...it's easier and it's more fun.

Betty expressed her thoughts that stimulating interest in student is important even at a younger age. Although, she had good mathematics teachers in her grade school years, she commented on (grade) school teachers that lacked sound mathematical background by saying:

> I tutored math in grade school, if you can't make [students] interested in it, it doesn't matter if they are good at it or not, they just don't [want to do math]... There are a lot of [teachers in grade school] that shouldn't be teaching math. I have had conversation by going over a question that was marked wrong and the student did right with the teacher; [the teacher] did not understand it and I was trying to explain to him.

Cathy pointed that grade school teachers can influence students' decisions to go into mathematics-related fields in higher education. In the grade school, Cathy was "correcting [her mathematics] teachers a bunch of times" and she often worked with her mother on homework. However, Cathy praised her high school physics teachers:

> I had really good high school physics teachers too and I think if I had very bad high school physics teachers I probably would not have gone into it. I had really bad chemistry teachers, it was horrible and I think that is why I have always hated chemistry because of my weak foundation in it and I just had very bad attitude towards it; whereas in physics, I really liked my teachers.

Unlike Cathy, Femida claimed she had good Chemistry teachers but expressed a completely different opinion on her physics teachers in high school. She said:

> My physics teachers in high school, they weren't role models for me at all... One of them is in engineering and he was okay, but this other one was very bitter about life and he did not want people to think physics was something you are able to comprehend and so, I kind of strove for more.

Femida had also received regular help from her parents in both grade and high schools. Debbie, on the other hand, did not directly receive parental support at home because she never asked for it. She stated:

> I just always did my homework by myself ..., we never really discussed it. In my family, the most important thing was we would have family dinner, we'd discuss everything from maths to [anything else]...My parents for, like, the first 8 years of my education thought kids didn't get homework because I never showed it to them [she laughed].

Debbie was also of the opinion that the unappealing teaching methods could discourage both males and females from pursuing mathematics-related disciplines. She said:

> I am not surprised that the physics program and mathematics program aren't that big because the way they teach it in high school is like it's not appealing to anybody....[In high school] I had really, really old teachers...they made [mathematics/physics classes] so uninteresting,...it was awful.

Debbie made some suggestions on how to solve this problem. She said:

> I think that if they have that thing where teachers ... after every certain amount of years have to be retested or undergo some continuing education; I think that is very important because once they devise that lesson plan, they just keep using it.

Debbie also addressed the unappealing teaching methods found in university courses when she was asked about the difficulty and frustration that she has experienced. She said:

> I just find that [professors] teach male centre, so everything is really dry and it's kind of for male thinking; they don't try to put a lot of creativity into the program, and when you try to do research or something, usually the way they would present it to you isn't like really appealing to you... I think girls need to be talked to in a different way [laughed] ... When people talk to you, you want to see the big picture, and guys are like, there is a lot they don't say and after you are done talking to a male professor or a male PhD student, you are like "Uhmmm, I don't know if I want to do this, this is kind of boring."

Ella agreed with Debbie on the male-centered teaching methods as a difficulty at the university, but she had a different opinion on the unappealing ways of teaching mathematics and physics in high school. She said "...that kind of depends on the high school you went and teachers that you get. My physics teacher in grade 12 is amazing." Ella not only had a good physics teacher but also had family support and push which she confirmed by saying: "My whole family, not just say my parents, if I needed help with maths or physics, they can ...they wanted me to [go for mathematics tournaments] but I never actually did."

During the discussion, the participants expressed the need for having more effective subject teachers. Even starting from grade school, such teachers would stimulate students' interest in mathematics and physics, through their teaching methods as well as with appropriate advice. They also commented on some of the difficulties that they encountered in their present studies. The researcher was under impression that for all, expect for Debbie, their high school teachers seemed to have made an impact by stimulating their interest in mathematics and physics, which in turn influenced their decisions to pursue their current fields of study.

Theme 2—lack of awareness of career options. Apart from emphasising the importance of having good teachers from grade school to high school, participants also discussed lack of awareness among students of the available career options in the fields of mathematics and physics. Though the participants reported not giving career options too much thought when choosing their fields of study, they maintained that lack of information may account for low female enrolment in their departments. For example, Betty said:

> I don't think a lot of [girls] see or know what kind of jobs you get after maths and physics degrees, so, if you have the degree what do you do with it; whereas if you go into chemistry or biology there seems to be, chemist goes into pharmacy and biologist goes into medical school; it seems to be a lot more clear [what are] available careers once you graduate...you don't know those careers, even when you are young you think "Oh, when I grow up, I wanna be a paediatrician, or I wanna be a veterinarian."... I know people who know what they wanted to be

> since they were really young and most of the people that I know in physics and maths didn't think they were gonna go into physics and maths when they were younger. Most people in biology are kind of, "I always wanted to be a doctor, I wanna go to biology, I wanna go to medical school".

When Betty was asked about what could be done to make more females pursue mathematics-related disciplines she said:

> More involvement on and on,... get them into the environment where they see what their possibilities are if they are going into maths and physics post secondary education. People know that there is pharmacy, med school and stuff but they don't necessarily know what you can do with physics and maths over there.

Anna could not agree more. She said that most people love mathematics but they don't know the career options that are available for them in higher education. She referred to her experience:

> I wanted to go into trade and my parents told me I have to go into the university and it was like "What's the university equivalent of a mechanic?" "Mechanical Engineering" and I am like "sweet." That was how I picked my program...people do not see [Mathematics degree] as really useful or practical. They don't see the practicality of having one of esoteric science degrees. Like, "you are gonna know all these crazy theorems, what are you going to do with them?"

Cathy added that she never saw or experienced any physics or mathematics outreach programs for girls, so for her, this could contribute to females' lack of awareness of career options and participation in the mathematics field. Femida claimed that "there are more women in [Chemistry and Biology] because [these sciences are] more known and developed." Debbie, in expressing her opinion on females' lack of awareness, related her experience in high school to what she knows now about career options in physics. She said:

> I think girls in high school are totally unaware of the possibilities. I think they don't even really know what physicists do other than "experiments." I think it is important to let them know that with a bachelor in physics, you are a good candidate for law school, med school, MBA. I think that it is important to understand that you can skip a Master's and do a PhD; that after you have your PhD, there are a lot of grants to do post grad work internationally. There are also a lot of physics PhDs working at the top tiers of Wall Street because they understand the maths behind the financial tools used today. I think, also, it is important to note that a lot of professors patent their research as a side business and profit from it. I think knowing these things would have got me into physics right from high school.

Besides, Ella added that "with physics you get a lot of [career] options, so you don't have to narrow it down to just one thing from the very beginning." Debbie agreed that with a physics degree, "you can pretty much do anything you want. So, if you decide to change and go into finance you can go into finance". Anna and Betty, however, argued that not everybody thinks that one can do anything with physics or mathematics degrees. For example, when Anna was asked about the most frustrating aspect in the pursuit of her studies, she complained about how difficult it has been for her to get summer jobs because the employers do not see the usefulness and connection between mathematics or science degrees with the required job skills. Anna said:

> When you call around to different like financing firms, they are like, "we only take accounting major" ..."we only hire business majors"..., and even in an actuary firm, they are like "do you have any exams yet?"... I got a job with the government because I'm bilingual, they don't even care about the maths, they just like "oh, French, take it"... I think a lot of companies don't see the fact that I'm in a science-based degree,... that I have a high-order thinking, computing [skills].

Although the participants may not have given much consideration to career options when deciding to pursue their programs, they still felt that lack of awareness of these options may prevent females from pursuing mathematics-related disciplines.

Theme 3—mathematics as a gendered domain. Participants were also asked to comment on the low participation of females in mathematics-related disciplines and if they see mathematics as a male domain (Questions 1 and 4). They came to the agreement that the reasons for under representation of females in the mathematics-related disciplines are more of "a gender issue." They argued that generally, enrolment numbers in mathematics are lower than in other disciplines; that is, both males and females lag behind. They identified several reasons for why females lag behind, such as, having family as their priority, being more social, getting involved in non scientific activities at a younger age, and having a feeling of 'it is not expected of them even when they are capable.'. The participants agreed with Anna's response to the question "Is mathematics a male domain?" where she said, "by number, yes, but by attitude, no." She explained:

> It's not like, anybody is saying "Oh you are a girl, you can't do math," because if you think about it, in elementary school and high school there tend to be a lot more girls that do better in maths than boys; it just seems [that] girls do other things with it...a lot of little girls want to do what their mom did, ... "I know what my mom did and that was a good job, why would I do something non-traditional."

Cathy emphasized that females do not participate in mathematics-related disciplines because that is not expected of them and also they have family as a priority. She said:

> I really think girls don't need to [pursue career in mathematics fields] to survive in the society. I think emphasis for females is first to be good looking or be a trophy wife of a sort. Even though girls are supposed to be equal, I think we are still back in the days where women were dependent on their companion.... I don't think there is direct link between going into a field like, say engineering, and having a happy life. I just don't think it fits into [girls] idea [plan]... we did not grow up with a Barbie mathematician

Debbie added that "most girls have to choose between being good in language or arts and being good in mathematics, because they are good in both; while most boys that I know, most of them are very spatial." For Ella, there are three reasons why few females pursue her discipline: (a) "girls are more verbal, while boys are more spatial"; (b) "when younger girls are into Barbies, boys are into building stuff, which kind of pushes you into a field"; and (c) "maths and physics require a lot of time throughout your educational life to be successful and for women the main priority is the family, well, for most women".

Contrary to other participants, Debbie and Ella talked more about males' attitudes towards females. Debbie said:

> I think men still have this idea that it's their domain and that women are novelty in it; It's not necessarily a bad thing that there's a woman in there, but it's not the most normal thing either.

Ella commented on males' attitudes by saying:

> Some of them don't think that [women] are as capable... especially with right now a lot companies are trying to make everything equal, a lot of men go, "Oh you only got the job because you are a girl," but it is not really the case.

Debbie agreed with Ella and added "I think [males] look more to you as not capable, but if you prove yourself, that's fine, you get on their team."

In hindsight, the participants identified different possible reasons why women may not want to pursue studies/careers in mathematics-related disciplines. Obviously, they were not discouraged or wanted to quit their studies even with their awareness of these mentioned reasons.

Theme 4—self-concept and persistence. When participants were asked to elaborate on the factors that contributed to their decisions to pursue mathematics-related disciplines, they all mentioned interest first before other factors such as influence of parents and teachers, job availability, and pay. Similar to their responses in the one-to-one interviews, they used words such as "being passionate about it", "understanding it", "enjoyed it", "having good grades in it", "being my strongest subject in high school", "liking numbers", and "wasn't going to take something I wasn't good at," to show their attachment to mathematics/physics. Their responses indicated that they all have high self-concept of their mathematics/physics abilities. The researcher observed that the participants are confident and that they have high expectations for success in their academic pursuits. They are not only determined to finish their studies, they also take pleasure in doing so. This was confirmed in their description of themselves as “having strong personality”, being “very ambitious” and “certain in our beliefs”; and, being able to “stand our ground”.

Toward the end of the focus group meeting, the participants were invited to give advice to any female who is about to pursue or about to quit studies in mathematics-related field (See Table 5).

From the participants’ responses, it appears that liking the subject, getting pleasure from studies, hard work, and strong belief in oneself are all very important for persisting in the pursuit of mathematics-related careers.

Table 5.

Advice Given by the Focus Group Participants to Females that are about to Enrol or to Quit Studies in Mathematics-Related Disciplines.

Advice To Females Ready To Enrol In Mathematics-Related Disciplines	Advice To Females Ready To Quit Pursuing Mathematics-Related Disciplines
Femida: "Get to know everybody around the faculty." Betty: "Get involved in things that you like and make it kind of fun for yourself."; "Make it as enjoyable as you can." Cathy: "The more you network and if you are a social person, the easier is—try not to be shy." Debbie: "Expect them to break you and rebuild you." Ella: "Don't expect it to be easy." Anna: "Volunteer in mathematics and physics conferences and have people recognise you." Cathy: "Don't get caught up in a competition and make time for a life."	For a female who is about to quit because she is under pressure (workload), and feels she is incapable: "Stick up, breathe it out, it gets better." If a female is quitting because she genuinely does not like the subject/studies or does not get pleasure from it: "Get out as fast as you can."

Conclusion

This chapter contained the report of the findings from the study; the themes that emerged from participants' responses in the face-to-face interviews as well as themes that came up in the focus group interview. The next chapter reviews the summary of the findings in relation to the relevant literature this study builds upon. It also discusses the implications of the study, recommendations, suggestions for future research and limitations of this research.

CHAPTER V

Conclusions and Recommendations

This chapter contains a summary of findings related to the relevant literature used for this study. It also contains a discussion of the implications of the study, recommendations for improvement of practice, suggestions for future research, and limitations of the results in terms of their scope and generalizability. The next section explains the major findings of the study that aimed at examining the factors that have impact on females' decisions to pursue mathematics-related disciplines in higher education as well as the obstacles encountered in the pursuit of these disciplines.

Major Findings

In order to answer the three research questions that were driving the study, the researcher used a qualitative methodological approach, namely, a case study approach. The discussion of the findings in relation to the first two questions, that is: *How do second to final year university female students decide whether to pursue studies in mathematics-related disciplines?*; and, *What are the most significant self-reported factors impacting second to final year university female students' decision to pursue studies in mathematics or related disciplines and why are they considered as being most dominant?*, will be presented first.

The findings revealed that the females in this study made their decisions to pursue mathematics-related disciplines mainly due to their interest in mathematics and science. This is consistent with previous research (Dick & Rallis, 1991; Gadalla, 1998; Pertiller, 2006; Tsagala & Kordaki, 2007) that states that females' interests influence their intentions to pursue a particular career and that interest is the most common reason influencing females' decision for choosing physics as a career (Ivie & Guo, 2006). In this study, it appears that the females' interests were stimulated by past experiences with these subjects prior to and during high school. Thus, the females' interpretation of their past experiences had an impact on their decisions to engage in mathematics-related fields of study. This result is confirmed by Jacobs et al. (2005), who suggested that females would likely pursue careers in mathematics and science if they develop an interest in the subjects at a young age.

Besides, the findings present socializers, specifically parents and teachers, as influential on the females' decisions—by encouragement and support, and/or by being role models. The parents of the females in this study supported and encouraged their daughters' interest in mathematics and science. The females did not only have positive perceptions of their parents' attitudes towards mathematics, but were also brought up in a mathematics-supportive environment from a young age. This finding is confirmed by researchers who claim that children place more value on mathematics when they are supported and encouraged at home (Wilkins & Ma, 2003; Jacobs et al., 2005). Parental support and encouragement have also been reported by other researchers (Catsambis, 2005; Dick & Rallis, 1991; Muller, 1998; Robinson, 2006) as significant, because of their impact on students' attitudes towards mathematics, achievements and participation in mathematics, career aspirations, career-choice development, and future selections of mathematics- and science-related majors. In addition, the females in the study seemed to have strong awareness of the importance of mathematics for society and for their educational goals. Participants' perceptions of their parents' attitudes towards mathematics as valuable and useful were contributing factors in building up their own values regarding mathematics as a significant, useful, and important domain which resulted in decisions to pursue mathematics-related disciplines. This coincides with research that found that for females, valuing mathematics as highly useful is likely to lead to pursuing careers in mathematics fields (Eccles, 1994; Watt, 2006), and that parents and teachers have an influence on students' perception of the usefulness of mathematics for educational and occupational success (Wilkins & Ma, 2003). For these females, the perception that their parents view mathematics as important, may have led them to believe that the subject was indeed important, thus allowing them to maintain more positive attitudes towards mathematics and a higher esteem of its usefulness throughout their high school education.

The findings also show that the majority of the parents of the females involved in this study were well educated, with good jobs. Many researchers (AAUW, 1992; Ercikan et al., 2005; Muller, 1998) found a direct relation between the parents' education and SES on their daughters' participation in mathematics. However, in this study, the researcher found only a few direct influences of parental education and SES on the females' career decisions. This direct influence could have contributed to participants developing an interest in mathematics and their continued participation in mathematics-related disciplines. This is consistent with the findings of Wilson and Ma (2003), that students whose parents are more educated appear to maintain more positive feelings and higher perceptions of the usefulness of mathematics (for future educational and occupational success) all throughout their high school education than those whose parents are not such.

This study also identified teachers as having a great impact on females' decisions to pursue mathematics-related disciplines. This is consistent with results of researchers (Ivie & Guo, 2006; Zeldin & Pajares, 2000) who found that teachers influenced women who were successful in mathematics and science careers. In this study, positive experiences provided by the teachers took the form of providing encouragement, using adequate teaching methods, and acting as role models at some points in these females' school years. Based on the participants' recollections, these factors increased their interest in, enjoyment of, and fondness for mathematics and science. Thus, teachers helped these females to develop positive attitudes toward mathematics and other sciences. Similar findings are supported by researchers (Catsambis, 2005; Winkins & Ma, 2003) who emphasize that teachers' encouragement, inclusive of the support from significant others (e.g., parents), may be particularly important for the development of positive attitudes towards mathematics among females. Dick and Rallis (1991) also noted that teachers' encouragement was mentioned more often by students intending to pursue careers in mathematics and science; this suggests that teachers may make a critical difference in the decisions of their pupils to pursue careers in mathematics-related fields.

In this study, the females not only commended teaching methods of their teachers but also emphasised the importance of good mathematics and science teaching during primary and secondary schooling. They also highlighted the importance of employing a variety of methods for teaching and engaging students at all educational levels so as to stimulate their interests and better their performances/grades in these subjects. This finding is similar to that of Ivie and Guo (2006), who reported the influences teachers have early in a student's career; where a good mathematics or science class often is the motivation for a subsequent career in these fields. Besides, females in this study acknowledged parents or teachers as *role models*. This is consistent with Robinson (2006) who found that role models are important motivators for females in mathematics-related careers. However, it is important to note that role models' impact on career choices had little to do with gender but had a lot to do with the quality of encouragement, support, advice, and teaching methods. Other research also points to the influences of peers on students' career choices (Eccles, 1994) and on female's continual pursuit of mathematics and science at advanced levels (Riegle-Crumb, Farkas, & Muller, 2006). Unlike these findings, this researcher did not find evidence of the peers' impact on these females' decisions on what to study. It seems that peers more explicitly influence males' career intentions to study mathematics–related disciplines (in particular, computing) than females' (Tsagala & Kordaki, 2007). However, peers appear as important for providing support after the women had made their decisions to engage in mathematics fields and had entered the academic area of mathematics (Zeldin & Pajares, 2000).

In this study, the females' career decisions were made based on their strong beliefs in self and in their abilities in mathematics and science. Other studies (Meece et al., 1982) have shown that self-concept of mathematics ability has an indirect impact on student's academic choices by increasing or decreasing their achievement expectations. In the same way, the females in this study appeared confident in their mathematics abilities by describing mathematics as manageable; they felt that they could excel in mathematics related-disciplines. This is aligned with Eccles (1994), who argued that individuals would prefer careers that they feel they can succeed at and that hold high value for them. Thus, these females believed that they have the appropriate level of skills and ability to pursue mathematics-related fields and that they would succeed in their pursuits. Their high self-concepts became even more obvious by their reliance on themselves and their efforts to overcome some of the obstacles they have encountered in the pursuit of their studies. In addition, they were not deterred by the awareness of some of the reasons behind the low female participation in their chosen fields of study. This confirms Ma and Cartwright's (2003) assertion that beliefs about self capability have an effect on the level of students' engagement in academic tasks as well as their persistence in the face of obstacles. Also, high self-concept in mathematics ability may not only influence females' decisions to pursue mathematics-related disciplines (Eccles, 1994) but may also relate to increased interest and achievement in mathematics and science (Denissen et al., 2007). For these females, it appears that having strong beliefs about themselves and their abilities in mathematics and science, combined with their interest and high achievement in mathematics, have an impact on their decisions to pursue, persist and succeed in their chosen mathematics-related disciplines. This confirms Denissen et al.'s statement that "individuals generally felt competent and interested in domains where they achieve well, and were interested in domains where they perceive their personal strengths" (2007, p. 340).

From the females' responses, just like Pertiller (2006), this researcher found that job availability and financial stability were less significant factors that had but a slight impact on females' decisions to pursue-mathematics related disciplines. Genuine interest in mathematics and science was the most significant factor that influenced their decisions. Ultimately, consistent with Dick and Rallis' (1991), this researcher found that *socializers*, *past experiences*, and *cultural milieu* influenced females' self concept and career value. However, cost and length of training (that were included in Dick and Rallis' model) did not appear as an impact or as factor on these females' decisions to pursue mathematics-related disciplines.

Obstacles

This section contains arguments related to the third research question in this study, that is: *What obstacles are encountered by second to final year university female students in pursuing studies in mathematics-related disciplines and how are these obstacles overcome?*

The results reveal that the females in this study encountered two main obstacles in the pursuit of their studies in mathematics-related disciplines. Firstly, the participants pointed to inadequate teaching methods as an obstacle. The bad teaching quality and unappealing lectures may impact females more, since previous research (Dick & Rallis'; Paa & McWhriter, 2000) found that female choose their careers based upon interest whilst money was a more important factor for males when making career decisions. Similarly, Gadalla (1998) suggested that methods of instruction have an influence on women's participation in the fields of mathematics, science, and technology. Secondly, lack of social interaction/solitary feelings such as working alone and not having someone to talk to about careers (which probably relates to lack of role model), is another difficulty faced by the females in this study. This finding is consistent with Tsagala and Kordaki, (2007) who found that among other factors, working in isolation impacts females' career intentions in mathematics-related fields. Accordingly, Robinson (2006) found social interaction concerns among females in mathematics-related careers.

Although the females in this study encountered the noted obstacles in pursuing their chosen disciplines the researcher observed their high level of self-confidence and self-concept, sense of determination, hard work/efforts, and enjoyment in their subjects, helped them succeed and persist. This observation is supported by Ivie and Guo (2006) who found that women in mathematics-related careers relied on their determination, will power, hard work, and excitement about their subject for success and perseverance. Overall, it is possible that the obstacles that were shared and overcame by these females may have been responsible for low female participation in mathematics-related disciplines.

Implications for Theory

Interviews with females that chose to pursue and persist in mathematics-related disciplines are important in order to gain a deeper understanding of the factors that drew them to their careers as well as to identify factors that are responsible for female reluctance to pursue these careers. Dick and Rallis' (1991) model provided interplay of factors that may influence students' career choice. As previously discussed, some of these factors were found to have an impact on females' decision to pursue mathematics-related disciplines. However, variation may occur in the relationship between the variables in this model due to the subject or the domain of study. Thus, these results suggest that the factors in the model are dependent on the specific subject domain; in this case, mathematics-related disciplines (see Figure 7). According to this adapted model, targeting females' interest and likeness for mathematics, their self-concepts of mathematics ability, the influences of socializers in providing positive past experiences in school and at home, their cultural milieu (awareness of social importance of mathematics), and their appreciation of the utility of mathematics may facilitate and encourage females' participation in mathematics and science; thus leading to the pursuit of careers in mathematics-related disciplines. Thus, by zooming into the building blocks of the Dick and Rallis' model and expanding it, this study contributed to research on females' motivations to pursue mathematics-related disciplines in higher education.

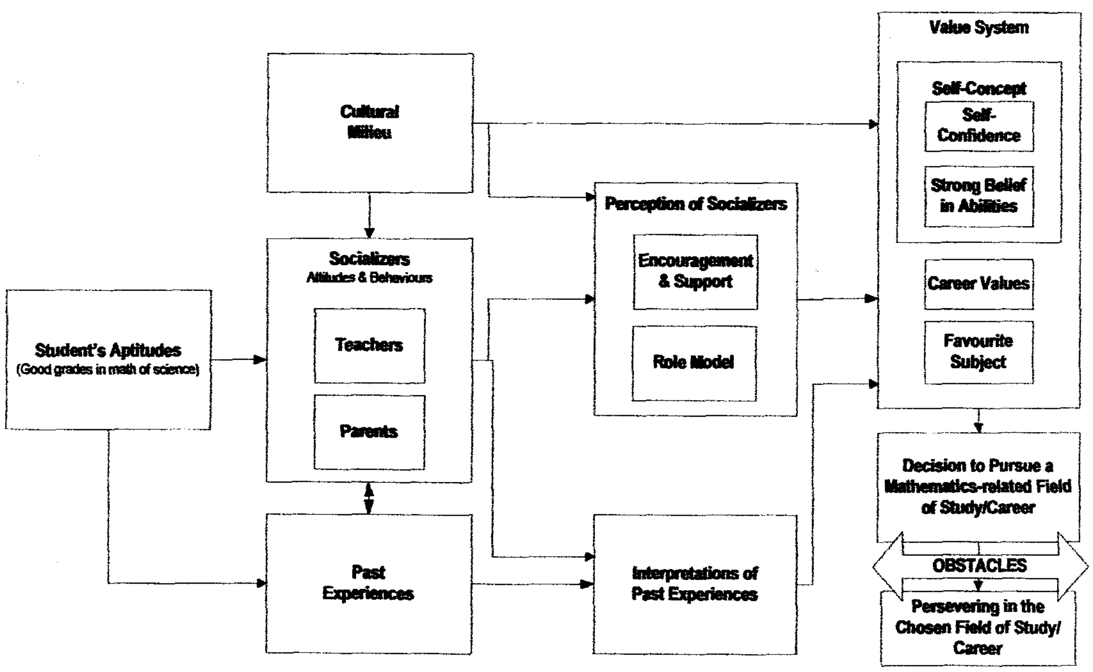

Figure 7. Dick and Rallis' (1991) model adapted to the findings of this study.

This expanded model contains obstacles encountered by females after their decisions to pursue careers in mathematics-related discipline were already made. Removing these obstacles may result in more females being able to persevere in their chosen disciplines.

Limitations of the Study

One limitation of this study is in the selection of the qualitative research approach with a small sample size. This results in a limited generalizability of the research findings. Future research should employ both quantitative and qualitative methodologies, as well as a combination of randomized and purposeful selection of participants, to overcome the stated restrictions. Only undergraduate students from two departments took part in this research (i.e., Mathematics and Statistics, and Physics). Future studies may pay attention to the involvement of students from other departments, for example Computer Science and Engineering. Another limitation is in exploring only perceived factors as seen by the female participants in this study. This limitation could be overcome by involving socializers (e.g., parents, elementary and high school teachers, counsellors and university professors) as participants, which would provide views from different perspectives.

Implication for Practice/Recommendations

Given that both males and females are pursuing mathematics-related disciplines in such low numbers, it is therefore important to concentrate on ways to increase their participation in these fields. The next text discusses the specific changes that need to take place at different educational levels so as to accomplish this target.

The educators and parents should strive at increasing students' (both males and females) interest in mathematics and science from an early age by providing mathematics-supportive and mathematics-promotive environments. Some examples are introducing toys such as Lego and building blocks and sports activities that are related to mathematics and science. Students need to become aware of the careers and professions that are related to mathematics starting from grade school; both teachers and parents should emphasise the importance and usefulness of mathematics. Teachers may introduce female students to working and successful women in male-dominated fields, organize guest speaker sessions, career days and visits to offices during the field trips. Emphasis must be placed on the importance of theoretical research in mathematics and science, irrespective of the time-frame needed for their real values to appear. Elementary school teachers should be well prepared to teach mathematics and science, especially from the perspective of the existing gender issues, through teacher training programs in schools of education. Teachers and instructors should be made aware of different learning and teaching styles that females may prefer. Consequently, the educators should be encouraged to use appropriate instructional activities that reflect females' experiences with relevance to daily lives. Teaching methods that allow students to explore mathematics and science should be encouraged, while teaching practices such as those that portray mathematics careers as very demanding, competitive (whether for males or females), and involving solitary work only, should be avoided.

Positive self-concept in mathematics and science is a vital feature to develop in females. Parents and teachers need to provide females with positive experiences in schools and in homes that would help their daughters and students to develop confidence in their ability to perform in mathematics (or science) situations which in turn, as Wilkins (2004) suggested, may reduce their reluctance to participate in mathematics-related fields. Females who have inclinations toward mathematics and science disciplines should be monitored throughout their schooling to catch early signs of both academic and social obstacles they may encounter in the course of learning mathematics and sciences or in pursuing careers in mathematics-related fields. Appropriate intervention plans should be developed for such situations, with the purpose of helping females persist and persevere in their mathematics-related studies/careers.

More outreach programs and mathematics-related extracurricular activities, such as math clubs, need to be organised in schools so that students can get involved and learn more about mathematics, mathematicians, and careers in related disciplines. These activities could involve parents, so as to increase students' participation through their encouragement. Instructors should employ teaching methods that are more appealing, engaging and interesting for female students in undergraduate programs to excel, engage, and persist in their chosen fields of study. Educators should be aware of the impact they have on females' career decisions, they should strive more to be role models and mentors for these students. Also, social gatherings initiated by the Faculty members where females can interact and mingle with other students and other female professionals (even from other universities) that are successful in the field may reduce their feelings of isolation and also provide them with role models in the field. Hiring bodies should be made aware of the impact female instructors may have on their female students, they may encourage their new faculty members to become involved in the promotional activities, organization of mathematics/science clubs and competitions where female involvement should be promoted.

However, all these stated interventions should not remain isolated and short-lived. There is the need to support females not only during their studies in non-traditional domains but also during their work in non-traditional careers/workplaces.

Suggestions for Future Research

Suggestion 1. This research was inspired by the noted gap in previous research, where there were a few studies that addressed why females choose to pursue careers in mathematics-related fields. Instead, studies focussed on why females avoid such careers. Thus, more Canadian-based research is needed to explore the reasons behind females' decisions to pursue and persist in these fields at the university level, including decisions to pursue graduate programs in these fields after completing their bachelor degrees.

Suggestion 2. Clearer understanding of the factors behind females' decisions and experiences in the pursuit of their studies in mathematics-related fields revealed the lack of awareness among the high school students of career options that are available in these fields. Therefore, more research is needed to find out the level of high school counsellors' knowledge and attitudes about potential careers and the labour market. This would help to develop training programs that would clear the misconceptions about careers and provide students with the needed awareness as well as accurate information on different career options that are available.

Suggestion 3. A comparative study between females' experiences in different departments of mathematics-related disciplines may offer additional insights about factors that contribute to low female participation in these fields.

Suggestion 4. The full-time undergraduate enrolment data for students in mathematics, physics and computer sciences showed that gender imbalance is not uniform across these fields. Thus, *natural sciences should not be considered as homogenous*. More research is needed to decipher characteristics of each discipline and their impact on females' decisions.

Suggestion 5. This study provided insight into differences that may exist between Canadian-born females and those who immigrated to Canada, but finished high school in Canada. Canadian-born females revealed positive experiences from their high schools, which they perceive as strong contributing factors to their career choices. On the other hand, immigrant females revealed more negative experiences from Canadian high schools, yet, these experiences did not discouraged them from pursuing their careers. It appears that the immigrants' positive experiences from elementary school as well as the influence of socializers helped them in their decisions to pursue mathematics-related disciplines. Thus, more research is needed to examine the impact of elementary and high school experiences on females' (Canadian-born and immigrants) decisions to pursue mathematics-related disciplines.

Suggestion 6. The females in this study revealed through their experiences that insights related to their career decisions in mathematics and science can be provided by understanding the contribution of socializers (in this case, parents and teachers) in their lives. Thus, research could find out about the socializer that has the greatest impact on students' career choice as well as how parents and teachers influence students' academic interest in mathematics and science from early ages (before and during high school).

Suggestion 7. Some participants in the study emphasised that teaching methods in their chosen fields are more geared towards males. More research is needed to find out if such teaching methods are really less appropriate for females or if females react differently to such teaching.

Suggestion 8. Revision of Dick and Rallis' model may be needed in order to better present the complexity of career choice. For example, the females' career choices may influence perceptions and attitudes of socializers and instil changes in the cultural milieu.

Conclusion

Results of this descriptive and explanatory case study, that intended to examine and provide a description of the second to final year female students' experiences and identifying factors that lead to their decision to pursue and persist in the pursuit of their chosen (non traditional) careers, may be used as an informative guide for educators, program organizers and hiring bodies. These results may be further taken to female students who may learn about challenges and gratifications that wait for them on their chosen (or contemplated about) career path. The researcher intends to continue promoting educational programs in mathematics-related disciplines and to further investigate factors impacting female career choices.

References

Altermatt, E., & Kim, M. (2004). Can anxiety explain sex differences in college entrance exams scores? *Journal of College Admission*, 183, 6-11.

American Association of University Women (AAUW) (1992). *How schools shortchange girls*. Washington, DC: American Association of University Women Educational Foundation.

American Association of University Women (1998). *Gender gaps: Where schools still fail our children*. American Association of University Women Educational Foundation.

American Institute for Researcher (1998). *Gender gaps: Where schools still fail our children*. American Association of University Women Educational Foundation.

Barakett, J., & Cleghorn, A. (2000). *Sociology of Education. An introductory view from Canada*. Scarborough, ON. Prentice Hall Allyn & Bacon Canada.

Berube, C., & Glanz, J. (2008). Equal Opportunity: Reframing Gender Differences in Science and Math. *Principal Leadership* (Middle School Ed.) 8 (9) 28-33.

Boaler, J. (1997). Reclaiming school mathematics: The girls fight back. *Gender and Education, 9*(3), 285–306.

Bogdan R.C., & Biklen, S.K. (1992). Qualitative research in education: An introduction to theory and methods. Needham Heights, MA: Allyn & Bacon.

Brush, L.R. (1980). Encouraging Girls in Mathematics. *The problem and the solution*. Cambridge, MA: ABT Books.

Chipman, S. (1996). Female participation in the study of mathematics: The US situation. In G. Hanna (Ed.), Towards gender equity in mathematics education, an ICMI study (pp 285-296). Dordrecht: Kluwer Academic Publishers.

Catsambis, S. (1994). The path to math: Gender and racial-ethinic differences in mathematics participation from middle school to high school. *Sociology of Education, 67*(3), 199-215.

Catsambis, S. (2005). The Gender Gap in Mathematics: Merely a Step Function? In A. Gallagher and J. Kaufman (Eds.), *Gender Differences in Mathematics. An Integrative Psychological Approach* (pp. 220-245) Cambridge: Cambridge University Press.

Cavanaugh, S. (2008). Stereotype of Mathematical Inferiority Still Plagues Girls. Education Week, *28*(1), 9.

Chacon, P., & Soto-Johnson, H. (2003). Encouraging young women to stay in the mathematics pipeline: Mathematics camps for young women. *School Science and Mathematics, 103*(6), 274-284.

Clewell, B., & Anderson, B. (1991). *Women of color in mathematics, science & engineering.* Washington, DC: Centre for Women Policy Studies.

Cohen, L., Manion, L., & Morrison, K. (2000). Research methods in education (5th Ed.). London, UK: Routledge.

Creswell J. (2009). Research *design: Quantitative, qualitative, and mixed methods approaches. (3rd Ed).* SAGE Publications.

Crombie, G., Sinclair, N., Silverthorn, N., Byrne, B.M., Dubois, D. L., & Trinneer, A. (2005). Predictors of young adolescents' math grades and course enrolment intentions: Gender similarities and differences. *Sex Roles*, *52*(5/6), 351–367.

Denissen, J., Zarrett, N., & Eccles, J. (2007). I Like to Do It, I'm Able, and I Know I Am: Longitudinal Couplings between Domain-Specific Achievement, Self Concept, and Interest. *Child Development*, *78*(2), 549-571.

Dewey, J. (1913). Interest and effort in education. Boston: Houghton Mifflin.

Dick, T.P., & Rallis, S.F. (1991). Factors and Influences on High School Students' Career Choices, *Journal for Research in Mathematics Education*, *22*(4), 281- 292.

Dweck, C. (1986). Motivational processes affecting learning. *American Psychologist* (Special Issue: Psychological science and education), 41, 1040-1048.

Eccles, J. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, 18, 585-609.

Education Quality and Accountability Office (1999). *EQAO research series*, Number 1. Toronto, Ontario.

Ercikan, K., McCreith, T., & Lapointe, V. (2005). Factors associated with mathematics achievement and participation in advanced mathematics courses: An examination of gender differences from an international perspective. *School Science and Mathematics*, *105*(1), 5-14.

Fennema, E., Carpenter, T., Jacobs, V., Franke, M., & Levi, L. (1998). A longitudinal study of gender differences in young children's mathematical thinking. *Educational Researcher, 27*(5), 6-11

Fennema, E., & Sherman, J. (1977). Sex-related differences in mathematics achievement, spatial visualisation, and affective factors. *American Educational Research Journal*, 14, 51-71.

Gadalla T. (1998). *Patterns of women's enrolment in university mathematics, engineering and computer science in Canada, 1972-1995.* Ontario Institute for Studies in Education of the University of Toronto.

Forgasz, H., Leder, G., & Kloosterman, P. (2004). New Perspectives on the Gender Stereotyping of Mathematics. *Mathematical Thinking and Learning*, *6*(4), 389–420.

Friedman, L. (1996). Meta analysis and quantitative gender differences: Reconciliation. *Focus on Learning Problems in Mathematics.* 18, 123-128.

Frost, L. A., Hype, J., & Fennema, E. (1994). Gender, mathematics performance, and mathematics-related attitude and affect. A meta analysis synthesis. *International Journal of Educational Research*, 21, 373-386.

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction.* White Plains, New York: Longman.

Guba, E.G., & Lincoln, Y.S. (1981). Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches. San Francisco, CA: Jossey-Bass.

Gutbezahl, J. (1995). How Negative Expectancies and Attitudes Undermine Females' *Math* Confidence and Performance: A Review of the Literature. Retrieved January, 2009 from http://www.math.ca/Women/BOOK/Gutbezahl.txt

Halpern, D.F. (1992). *Sex differences in cognitive abilities.* Hillsdale, NJ: Lawrence Erlbaum.

Hancock D. R., & Algozzine, B. (2006). Doing case study research. A practical guide for beginning researchers. Teachers College Press. NY & London.

Hanna, G. (2003). Reaching gender equity in mathematics education. *The Educational Forum, 67*(3), 204-214.

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research, 60*(4), 549-571.

Hidi, S., Berndorff, D., & Ainley, M. (2002). Children's argument writing, interest and self-efficacy: An intervention study. *Learning and Instruction*, 12, 429 – 446.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Rapport on women in science, technology, engineering, and mathematics.* American Association of University Women. Retrieved April 30, 2010 from http://www.aauw.org/learn/research/upload/whysofew.pdf

Hoepfl, M.C. (1997). Choosing qualitative research: A primer for technology education researchers. *Journal of Technology Education, 9*(1) - Fall 1997. Retrieved March 30, 2010, from http://scholar.lib.vt.edu/ejournals/JTE/v9n1/hoepfl.html

Hyde, J., Lindberg, S., Linn, M., Ellis, A., & Williams, C. (2008). Gender Similarities Characterize Math Performance. *Science* v (321), 494-495.

Ivie, R., Czujko, R. & Stowe, K. (2002). Women physicists speak: The 2001 international study of women in physics. In B.K. Artline & D. Li (Eds.),Women in Physics: The IUPAP International Conference on Women in Physics. American Institute of Physics. Melville, NY (pp. 49-67).

Ivie, R., & Guo, S. (2006). Women physicists speak Again: The International study of women in physics. In B.K. Artline & D. Li (Eds.), Women in Physics: The IUPAP International Conference on Women in Physics. American Institute of Physics. Melville, NY.

Jacobs, J., Davis-Kean, P., Bleeker, M., Eccles, J., & Malanchuk, O. (2005). "I can, but I don't want to." The Impact of Parents, Interests, and Activities on Gender Differences in Math. In A. Gallagher and J. Kaufman (Eds.), *Gender Differences in Mathematics. An Integrative Psychological Approach* (pp. 246-263). Cambridge: Cambridge University Press.

Jacobs, J., Lanza, S., Osgood, D., Eccles, J., & Wigfield, A. (2002). Changes in children's self competences and values: Gender and domain differences across grades one through twelve. *Child Development*, 73, 509-527.

Jones, L, & Smart, T. (1995). Confidence and mathematics: A gender issue? *Gender and Education*, 7, 157-166.

Jones, S., & Dindia, K. (2004). A meta-analytic perspective on sex equity in the classroom. *Review of Educational Research*, 74, 443-471.

Kellaghan, T., & Madaus, G.F. (2002). Teachers' sources and uses of assessment information. In D.F. Robitaille & A.E. Beaton (Eds.), *Secondary analysis of the TIMSS data.* Boston, MA: Kluwer Academic Publishers.

Kimball, M. (1989). A new perspective on women's math achievement. *Psychological Bulletin, 105*(2), 198-214.

Koehler, S.M. (1990). Classroom, Teachers, and Gender differences in Mathematics. In E. Fennema & G.C. Leder (Eds.), *Mathematics and Gender* (pp. 128-148). New York: Teachers College Press.

Leder, G. (2001). *Mathematics as a gendered domain: New measurement tools.* Paper presented at the annual meeting of the American Educational Research Association. Seattle, WA.

Leder, G. (1992). Gender Differences in Mathematics: An Overview. In E. Fennema & G.C. Leder (Eds.), *Mathematics and Gender* (p. 10-26) New York: Teachers College Press.

Leder, G. (1992). Mathematics and gender, changing perspectives. In D. A. Grouws (Ed.), *Handbook of research of mathematics and learning.* New York: Macmillan Publishing Company.

Leedy, G., LaLonde, D., & Runk, K. (2003). Gender equity in mathematics: Beliefs of students, parents, and teachers. *School Science and Mathematics, 103*(6), 285-292.

Linver, M., Davis-Kean, P., & Eccles J. (2002). *Influences of gender on academic achievement.* Paper presented at the Society for Research on Adolescence, New Orleans, LA.

Ma, X., & Cartwright, F. (2003). A longitudinal analysis of gender differences in affective outcomes in mathematics during middle and high school. *School Effectiveness and School Improvement, 14*(4), 413–439.

Ma, X., & Kishor, N. (1997). Attitude toward self, social factors, and achievement in mathematics: A meta-analytic review. *Educational Psychology Review*, *9*(2), 89-120.

Margolis, J., Fisher, A., & Miller, F. (2002). Failure is not an option: International women in computer science. Work in progress, Carnegie Mellon Project on Gender and Computer Science. Retrieved on January 27, 2009 from www.cs.cmu.edu/afs/cs/project/gendergap/www/intwomen.html

Marlino, D., & Wilson, F. (2002). Teen Girls on Business: Are They Being Empowered? Simmon College School of Management. Retrieved September 2009 from www.sophia-associates.com/Teen_Girls_in_Business.pdf

Marsh, H. W., Trautwein, U., Lüdtke, O., Koller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development*, 76, 397 – 416.

Martino, W., Lingard, B., & Mills, M. (2004). Issues in boys' education: A question of teacher threshold knowledges? *Gender and Education*, *16*(4), 435-454.

Martinovic, D. (2004). Communicating mathematics online: The case of online help. Ph.D. dissertation, University of Toronto (Canada), Canada. Retrieved April 18, 2010, from Dissertations & Theses: Full Text. (Publication No. AAT NQ94292).

Mason, J. (2002). *Qualitative researching (2^{nd} ed.)*. Thousand Oaks, CA: Sage Publication.

Meece, J., Parsons, J., Kaczala, C., Goff, S., & Futterman, R. (1982). Sex differences in mathachievement: Toward a model of academic choice. *Psychological Bulletin, 91*(2), 324-348.

Meeliseen, M., & Luyten, H. (2008). The Dutch gender gap in mathematics: Small for achievement, substantial for beliefs and attitudes. *Studies in Educational Evaluation, 34*(2), 82-93.

Merriam, S.B. (1988). *Case study research in education: A qualitative approach.* San Francisco: Jossey-Bass.

Muller, C. (1998). Gender differences in parental involvement and adolescents' mathematics achievement. *Sociology of Education, 71*(4), 256-336.

Nardi, P.M. (2006). Doing survey research: A guide to quantitative methods. (2^{nd} Ed.) Boston: Pearson Education.

National Center for Education Statistics (1995). Findings from the condition of education. No. 5: The educational progress of women (NC 96-768). Washington, DC: United States Department of Education, Office of Educational Research and Improvement.

National Council of Teachers of Mathematics, (1989). The mathematics education of underserved and underrepresented groups: A continuing challenge. *Journal for Research in Mathematics Education, 20*, 371-375.

National Science Board (2010). *Science and engineering indicators, 2010* (NSB 10-01). Arlington, VA:National Science Foundation. Retrieved on March, 2010 from http://www.nsf.gov/statistics/seind10/pdf/seind10.pdf

National Science Foundation (NSF) (2007). Women, minorities, and persons with disabilities in sciences and technology. Retrieved on December, 2009 from http://www.nsf.gov/statistics/wmpd/figh-1.htm

Northrup, C. (2001). *The wisdom of menopause: Creating physical and emotional health and healing during the change.* New York: Bantam Books.

Paa, H., & McWhirter, E. (2000). Perceived influences on high school students' current career expectations. *The Career Development Quarterly, 49*(1), 29-44.

Padula, M., & Miller, D. (1999). Understanding graduate women's re-entry experiences. *Psychology of Women Quarterly*, 23, 327-343.

Pelletier, M. (2006). Factors Influencing Women's' Participation in Mathematical disciplines. M.Ed. thesis, Lakehead University,Canada, Retrieved November11, 2009 from Dissertations & Theses.

Riegle-Crumb, C., Farkas, G., & Muller, C. (2006). The Role of Gender and Friendship in Advanced Course. *Sociology of Education*, *79*(3), 206-228.

Robinson, J. (2006). Women who chose mathematics: The external and internal factors influencing their participation in a math- related occupation. Unpublished MA Thesis, Concordia University Montreal, Canada.

Rogers, P. & Kaiser, G. (Eds.) (1995). Equity in Mathematics Education: Influences of feminism and culture. London: Falmer Press.

Sanders, J., & Nelson, S.C. (2004). Closing gender gaps in science. *Educational Leadership, 62*(3), 74-77.

Seymour, E., & Hewitt, N. (1997). Talking about leaving: *Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Slater, J., Guthrie, B., & Boyd, C. (2001). A feminist theoretical approach to understanding health of adolescent females. *Journal of Adolescent Health, 28*(6), 443-449.

Sherman, J. (1980). Mathematics, spatial visualization, and related factors: Changes in girls and boys, grades 8-11. *Journal of Educational Psychology*, 72, 476-482.

Stake, R. (1995). *The art of case research.* Thousand Oaks, CA: Sage Publications.

Statistics Canada (2003). The Changing profile of Canada's labour force, 2001 census. Catalogue no 96F0030X2001009.

Statistics Canada (2007).Women in Canada: *Work chapter updates.* Catalogue no 89F0133XWE.

Statistics Canada (2008). University enrolment. *The Daily*, February 7, 2008.

Statistics Canada (2009). University enrolment. *The Daily*, March 11, 2009.

Steele, J., James, J., & Barnett, R. (2002). Learning in a man's world: Examining the perceptions of undergraduate women in male-dominated academic areas. *Psychology of Women Quarterly, 26*(1), 46-50.

Stuart, V. (2000). Math curse or Math anxiety? *Teaching Children Mathematics, 6*(5), 330-336.

Super, D.E. (1990). A life-span, life space approach to career development. San Francisco: Jossey- Bass, 197-261.

Thomas, H. 1993. A theory explaining sex differences in high mathematical ability has been around for some time. *Behavioral and Brain Sciences, 16*(1), 187-215.

Tobias, S., (1978). *Overcoming Math Anxiety.* New York: W.W. Norton & Co.

Tsagala, E. & Kordaki, M. (2007). Critical factors influencing secondary school pupil's decision to study computing in tertiary education: Gender differences. *Education and Information Technologies*, *12*(4), 281-295.

U.S. Department of Education (2000). Trends in educational equity for girls and women (NCES No. 2000-030). Washington, DC: Office of Educational Research and Improvement.

Walkerdine, V. (1998). *Counting girls out. Girls and mathematics.* Bristol, PA: Falmer Press.

Watt, H. (2006). The Role of Motivation in Gendered Educational and Occupational Trajectories Related to Maths. *Educational Research and Evaluation* 12(4), 305 – 322.

Wilkins, J. (2004). Mathematics and Science Self-Concept: An International Investigation. *The Journal of Experimental Education*, *72*(4), 331-346.

Wilkins, J. & Ma, X. (2003). Modeling change in student attitude toward and beliefs about mathematics. *Journal of Educational Research*, *97*(1), 52-63.

Wilkins, J., Zembylas, M., & Travers, K.J. (2002). Investigating correlates of mathematics and science literacy in the final year of secondary school. In D.F.

Robitaille & A.E. Beaton (Eds.), *Secondary analysis of the TIMSS data* (pp. 291-316). Boston, MA: Kluwer Academic Publishers.

Yin, R.K. (2009). *Case study research: Design and methods (4th Ed.).*Sage publications.

Zeldin, A., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*(1), 215–246.

APPENDIX A: Consent to Participate in Research

University of Windsor

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: **Factors Impacting Female's Decision to Pursue Mathematics-Related Careers: A Case Study Approach**

You are asked to participate in a research study conducted by Atinuke Adeyemi from the Faculty of Education at the University of Windsor for her Master's thesis project. If you have any questions or concerns about the research, please feel free to contact Atinuke Adeyemi at adeyemia@uwindsor.ca or her supervisor, Dr. Dragana Martinovic at dragana@uwindsor.ca or (519) 253-3000#3962

PURPOSE OF THE STUDY
The study will examine the factors that impact female's decision to pursue mathematics or related disciplines in higher education. It seeks to reveal the dominant factors that affect the decisions as well as the obstacles encountered by undergraduate female students in mathematics or related disciplines.

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

a) You will be interviewed in depth through semi-structured, 45mins long, one-to-one interview that will be audio-recorded and transcribed for detailed analysis.
b) You will participate in one, about 45mins long, focus group interview that will involve six participants. The meeting will be audio-recorded and transcribed for detailed analysis.

POTENTIAL RISKS AND DISCOMFORTS
There are no known risks (including for example, physical, psychological, emotional, or financial) for the participants in this study. Before the focus group meeting, you will be asked to sign the confidentiality pledge to minimize social risks associated with group interview.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

By participating in this study, the female students could learn how to better adjust and address some of the obstacles that are involved in the pursuit of careers in mathematics or related discipline. Expected benefits of the study to society are that:

- By working with undergraduate females who overcame the obstacles (at least to the point to enroll into mathematics or related disciplines), other females can learn how to overcome such obstacles.
- It will further inform parents and educators of better ways of increasing females' interest and willingness to pursue mathematics or related careers.
- The findings of this research may help the educators in the institutions similar to the one involved in the research to better meet the needs of female students in non- traditional careers.

PAYMENT FOR PARTICIPATION

There will be no any reimbursements, remuneration or other compensation that will be provided to the participants in this study.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Your true name will be replaced by pseudonym so as to protect your identity and any information that may show your identity will not be reported. All collected information will be securely stored in the locked file cabinets and computers will be used only to store coded information about the participants. Two years after finalizing data collection all material data will be shredded and audio files erased. No information about you as a participant will be disclosed to the third party.

At all times (till they are destroyed) you will have right to review the audio recordings with your interviews. Only the researcher and her supervisor will have access to these tapes. These documents will not be used for any other purpose except for this research and will be definitely destroyed two years after the data are collected.

Please note that the focus group is a group event. This means that while confidentiality of all the information given by the participants will be protected by the researchers themselves, this information will be heard by all the participants and therefore will not be strictly confidential.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. Please note that since a focus group is a group event, while participants are able to leave the study, they may not request that the audio recording be stopped, but may excuse themselves at any point. However, any information that has been record before their leave cannot be withdrawn.

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

SUBSEQUENT USE OF DATA
This data will be used in subsequent studies.

RIGHTS OF RESEARCH SUBJECTS
You may withdraw your consent at any time and discontinue participation without penalty. If you have questions regarding your rights as a research subject, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH SUBJECT
I understand the information provided for the study **Factors Impacting Female's Decision to Pursue Mathematics or Related Disciplines in Higher Education** as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____

Name of Subject

____________________________________ __________________

Signature of Subject Date

SIGNATURE OF INVESTIGATOR: These are the terms under which I will conduct research.

____________________________________ __________________

Signature of Investigator Date

Revised April 2009

APPENDIX B: Letter of Information

University of Windsor

LETTER OF INFORMATION FOR CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: **Factors Impacting Female's Decision to Pursue Mathematics- Related Careers: A Case Study Approach**

You are asked to participate in a research study conducted by Atinuke Adeyemi from the Faculty of Education at the University of Windsor for her Master's thesis project. If you have any questions or concerns about the research, please feel free to contact Atinuke Adeyemi at adeyemia@uwindsor.ca or her supervisor, Dr. Dragana Martinovic at dragana@uwindsor.ca or (519) 253-3000#3962.

PURPOSE OF THE STUDY
The study will examine the factors that impact female's decision to pursue mathematics or related disciplines in higher education. It seeks to reveal the dominant factors that affect the decisions as well as the obstacles encountered by undergraduate female students in mathematics or related disciplines.

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

a) You will be interviewed in depth through semi-structured, 45mins long, one-to-one interview that will be audio-recorded and transcribed for detailed analysis.
b) You will participate in one, about 45mins long, focus group interview that will involve six participants. The meeting will be audio-recorded and transcribed for detailed analysis.

POTENTIAL RISKS AND DISCOMFORTS
There are no known risks (including for example, physical, psychological, emotional, and financial) for the participants in this study. Before the focus group meeting, you will be asked to sign the confidentiality pledge to minimize social risks associated with group interview.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY
Participants could learn how to better adjust and address some of the obstacles that are involved in the pursuit of careers in mathematics or related discipline. Expected benefits of the study to society are that:

- By working with undergraduate females who overcame the obstacles (at least to the point to enroll into mathematics or related disciplines), other females can learn how to overcome such obstacles.
- It will further inform parents, teachers, counselors, and school administrators of better ways of increasing females' interest and willingness to pursue mathematics or related careers.
- The findings of this research may help the educators in the institutions similar to the one involved in the research to better meet the needs of female students in non-traditional careers.

PAYMENT FOR PARTICIPATION
There will be no any reimbursements, remuneration or other compensation that will be provided to the participants in this study.

CONFIDENTIALITY
Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Your true name will be replaced by pseudonym so as to protect your identity and any information that may show your identity will not be reported All collected information will be securely stored in the locked file cabinets and computers will be used only to store coded information about the participants. Two years after finalizing data collection all material data will be shredded and audio tapes erased.

No information about you as a participant will be disclosed to the third party.

At all times (till they are destroyed) you will have right to review the audio recordings with your interviews. Only the researcher and her supervisor will have access to these tapes. These documents will not be used for any other purpose except for this research and will be definitely destroyed two years after the data are collected.

The focus group is a group event. This means that while confidentiality of all the information given by the participants will be protected by the researchers themselves, this information will be heard by all the participants and therefore will not be strictly confidential.

PARTICIPATION AND WITHDRAWAL

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

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE SUBJECTS

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

SUBSEQUENT USE OF DATA

This data will be used in subsequent studies.

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. If you have questions regarding your rights as a research subject, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_______________________________________ ___________________

Signature of Investigator Date

Revised April 2009

APPENDIX C: Consent for Audio Taping of the Interview

University of Windsor

CONSENT FOR AUDIO TAPING OF THE INTERVIEW

Research Subject Name
(print):______________________________________

Title of the Project: **Factors Impacting Female's Decision to Pursue Mathematics-Related Careers: A Case Study pproach**

I consent to the audio-taping of interview.

I understand these are voluntary procedures and that I am free to withdraw at any time by requesting that the taping be stopped. I also understand that my name will not be revealed to anyone and that taping will be kept confidential. In the case that I withdraw from the interview my recoding will not be used in the research. Audio files will be kept on a CD filed by a number only and stored in a locked cabinet.

I understand that confidentiality will be respected and that the audio files will be for professional use only.

______________________________ ______________________

(Research Subject) (Date)

APPENDIX D: Consent for Audio Taping of the Focus Group Interview

University of Windsor

CONSENT FOR AUDIO TAPING OF THE FOCUS GROUP INTERVIEW

Research Subject Name (print):

____

Title of the Project: **Factors Impacting Female's Decision to Pursue Mathematics-Related Careers: A Case Study Approach**

I consent to the audio-taping of the focus group meeting.

I understand these are voluntary procedures and that I am free to withdraw at any time by requesting that the taping be stopped. I also understand that my name will not be revealed to anyone and that taping will be kept confidential. I understand that I can excuse myself at any point, but may not request that the audio recording be stopped, since this is a group event. Any information that has been record before I leave cannot be withdrawn.

Audio files will be kept on a CD filed by a number only and stored in a locked cabinet. I understand that confidentiality will be respected and that the audio file will be for professional use only.

____________________________ ______________________

(Research Subject) (Date)

APPENDIX E: Confidentiality Pledge

Confidentiality Pledge

For Project Entitled: Factors Impacting Female's Decision to Pursue Mathematics-Related Careers: A Case Study Approach

I understand that discussions held in this focus group are not public. I will respect the confidentiality of those discussions. I agree to not disclose any aspects of those discussions in whole or in part, so that the privacy of individuals or groups of individuals within the focus group may be upheld.

I agree to uphold this confidentiality pledge.

Signature of Participant: ____________________ Printed Name: ________________

APPENDIX F: Face-to-face Interview Questions

Sample Face-To-Face Interview Questions Developed From Dick and Rallis' (1991) Model of Career Choice

Students Aptitude:

1) What were/are your usual performances (grades) in mathematics?
    a. In elementary school
    b. In high school
    c. At the university.

Cultural Milieu

Educational level of parents/caretakers:

2) What is the highest educational level that your parents/caretakers obtained?
3) Generally situate the kind of work your parents/caretakers do for living?
    a. Examples of sector: Industry, Education, Financial sector,....
    b. Examples of type of work: Manual labor, teachers, social workers, health workers,...

Socializers:

4) How were you impacted by others (Family/Teachers/Peers) in your decision to pursue mathematics (or related discipline)? Please elaborate on each of the three groups.
5) Who (Family/Teachers/Peers) had the greatest impact on your career choice? In

which way did they impact you the most?

6) What did others (Family/Teachers/Peers) tell you as you were pursuing mathematics (or related discipline)? Please elaborate on the advice, concern or comment you have received from each of the three groups.
7) What are your parents' perceptions of mathematics?

Past Experiences:

8) What experiences contributed to your decision to pursue mathematics (or related disciplines)? Please describe in detail three most vivid such experiences.
9) How would you describe your feelings about mathematics? (i.e., how did you feel in high school when you were working on a math problem/attending the math classes?)
10) How would you describe your beliefs about mathematics? (i.e., its usefulness in general; usefulness in other subjects; mathematicians' place in society; difficulty; aesthetic value)
11) What was/is your favourite subject and why?
    a. In elementary school
    b. In high school
    c. At the university.
12) What was/is your least favourite subject and why?
    a. In elementary school
    b. In high school
    c. At the university.

Self –Concept and Career Values:

13) Why did you choose to pursue mathematics (or related discipline)?
14) What were the most important factors that impacted your decision to pursue mathematics (or related discipline)?
15) How do you see yourself as a mathematician/physicist?
16) Explain the difference in studying mathematics vs. physics.
17) Did you ever consider enrolling into the related discipline?

Obstacles:

18) What obstacles have you encountered in the pursuit of your chosen career?
19) How did you overcome the obstacles encountered in pursuing mathematics (or related discipline) as a career?
20) Did you ever consider quitting your studies? If, yes, why?
21) What kept you going on your chosen career path?
22) Considering your career choice, if you could have done anything differently, what would that be?
23) Do you intend to enrol for graduate program in mathematics or related discipline? If, yes, why? ; If not, why not?

APPENDIX G: Focus Group Questions

Sample Focus Group Interview Questions

1) Why do you think that so few females pursue mathematics-related disciplines? Do you think that this is a gender issue, societal issue, culture or some other issue?

2) What could be or should be done to change that? Do you see yourself as different from a norm? What contributed most to your career choice? Talent, supportive teacher, support from family, job availability, role models, and pay

3) How was your home environment in relation to math? (Did home-work with parents or siblings, received tutoring in grade school, parents encourage you to take part in math/science tournaments)

4) Do you perceive mathematics-related career as a male domain? If yes, why yes? If no, why not?

5) Could you elaborate on the aspects of your chosen career that you have found to be frustrating or difficult?

7) What advice would you give a female that is about to pursue career in mathematics-related disciplines?

8) What advice would you give a female that is about to quit pursuing career in mathematics-related disciplines?

VITA AUCTORIS

Atinuke Adeyemi completed her elementary and high schools in Nigeria. She graduated from University of Ibadan, where she received her Bachelor of Science in Mathematics. She worked in the banking industry before she immigrated to Canada. In Canada she received her Bachelor of Education degree from the University of Windsor in 2007 and a year later enrolled in the Master of Education Program in the same university. Her areas of research interest include gender differences and multi-cultural issues in mathematics education, and school-parents partnerships.