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WOMEN'S HIGH SCHOOL AND UNIVERSITY EXPERIENCES THAT INFLUENCE THE PURSUIT OF UNDERGRADUATE MATHEMATICS DEGREES

Jennifer Hall

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in partial fulfillment of the requirements
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Abstract

In Canada, women are underrepresented in undergraduate mathematics degree programs as fewer women than men enrol and many women drop out or change programs. To investigate this issue, the research question 'In what ways do women who were educated in Canada and who are nearing completion of undergraduate mathematics degrees feel they have been supported and challenged in their high school and university mathematics experiences?' was explored using semi-structured interviews with six women who enrolled in and persevered with undergraduate mathematics degree programs. Specifically, the influence of the participants' families, peers, formal educational experiences, and personal characteristics was explored, and the study describes challenges and supports experienced by these women. In particular, this study highlights how these women confront feeling 'othered', and the important role that supportive relationships with family members, peers, and educators play in meeting this challenge. The findings also highlighted the participants' preferences for applied mathematics.

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CHAPTER 1: INTRODUCTION

> In those languages that assign gender to words, the word *mathematics* is feminine, but *mathematician*, meaning the studier or doer of mathematics, is masculine. Herein lies the crux of the mathematical mystique. (Fox, 1980, p. 1, emphasis in original)

Background of the Problem

In the past few decades, great strides have been made in terms of equitable achievement and participation of males and females in the field of mathematics at both the elementary and secondary level in a wide variety of countries (See FIMS, SIMS, and TIMSS outcomes outlined in Hanna, 2003). However, at the post-secondary level in Canada, equitable participation in mathematics degree programs by women is greatly lacking, with little improvement being shown in the past thirty years in terms of enrolment and graduation rates (Gallada, 2001). The ratio of female to male enrolment in undergraduate degree programs in mathematics and related subject areas (information and computer science) has actually decreased from approximately 0.43:1 in the 1992/1993 school year to approximately 0.33:1 in the 2004/2005 school year (Statistics Canada, 2008a), as shown in Figure 1.

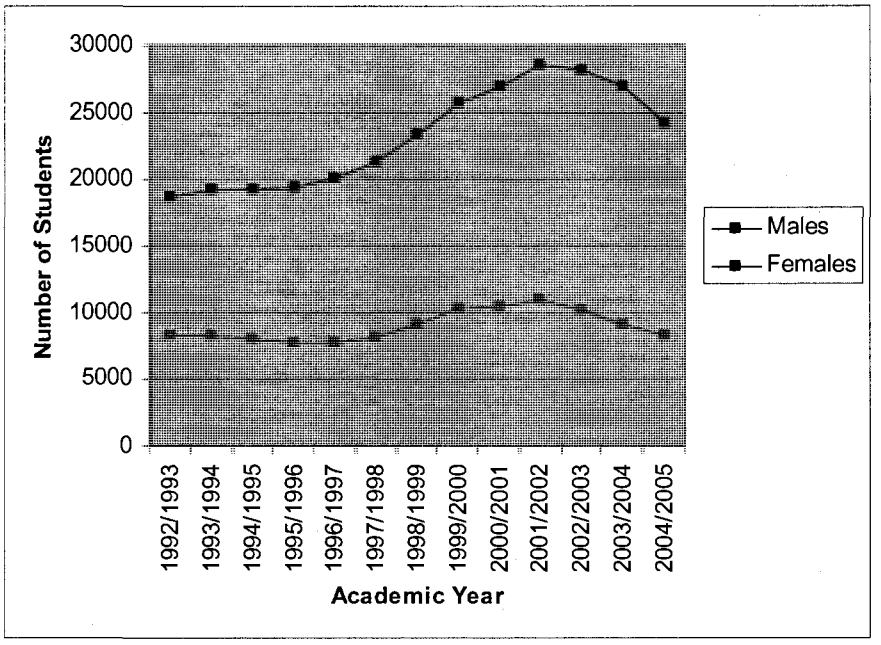

Figure 1. Number of students enrolled in bachelor degree programs in mathematics, computer and information sciences, by sex, by academic year, in Canada.

Similarly, the ratio of female to male graduation rates in these fields has also decreased, from approximately 0.5:1 in 1992 to 0.37:1 in 2004 (Statistics Canada, 2008b), as shown in Figure 2.

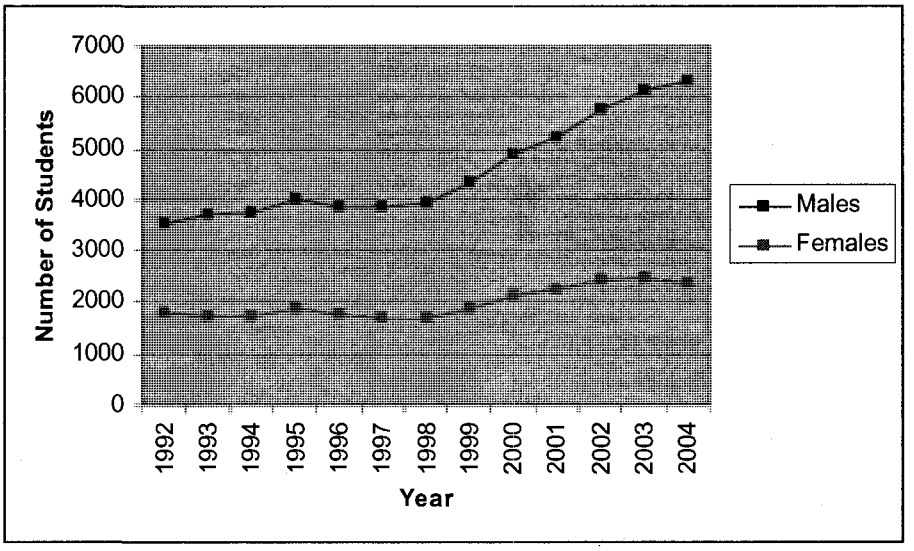

Figure 2. Number of bachelor degrees granted in mathematics, computer and information science, by sex, by year, in Canada.

These data stand in stark contrast to the statistic that approximately 60% of undergraduate students at Canadian universities are female, a trend that has remained stable for the past four years (Statistics Canada, 2008c). Furthermore, significant improvements have been made in other traditionally male-dominated university fields of study, such as medicine and business, to the point of the current equitable participation and graduation rates in many countries (Dworkin, 2001; Freeman, 2004).

Addressing the Problem

In my research, I examined a specific population that has had little previous attention in the research literature – females in upper years of undergraduate mathematics degree programs who have been educated in Canada for all levels of education. My study was guided by the following research question:

In what ways do women who were educated in Canada and who are nearing completion of undergraduate mathematics degrees feel they have been supported and challenged in their high school and university mathematics experiences?

I investigated this question with an exploratory framework of semi-structured interviews regarding the participants' personal characteristics and their experiences with the formal education system, family members, and peers.

Significance to the Field

This study contributes to the body of research regarding gender issues in mathematics by helping to further the understanding of the complex interplay of educational, social, and personal issues that affect women's decisions to select and pursue undergraduate mathematics degree programs. Although there are many existing studies

regarding gender issues in mathematics, Fennema (1996) reported that these studies typically have been conducted "using a traditional social science research perspective – that is, a positivist approach that has basically looked at overt behaviors" (p. 15). She further noted that "an understanding of gender and mathematics based on studies from this perspective is limited" (p. 16). Feminist scholars argue for research that allows female participants' voices to be heard and their perspectives to be explored (Campbell & Greenberg, 1993). Few studies have been conducted in Canada using qualitative methods that provide a more holistic view of the stories behind the university enrolment and graduation statistics. Furthermore, many of the existing studies relating to issues at the post-secondary level include the related subject areas of science, technology, and engineering rather than strictly focusing on issues specific to mathematics.

It is important to achieve equality in mathematics participation at the university level, and this study helps to garner a greater understanding of the current situation by providing insight into women's experiences. If equality at the undergraduate level is achieved, there will subsequently be more females available for higher degrees and academic positions in mathematics. Having more females in post-secondary mathematics may lead to expanded research directions and provide more female role models.

Personal Significance

The topic of my research is of particular personal interest as I completed an Honours B.Sc. degree with a double major in Applied Mathematics and Physiology in 2005. While my Physiology classes were fairly gender-balanced, females were clearly the minority in my Applied Mathematics classes. Furthermore, I only had one female mathematics professor throughout the course of my degree. Due to my concerns about the

gender imbalance, I became an executive member of a university mentoring program that attempts to decrease the female attrition rate from science and mathematics degree programs. I graduated as one of three females in an Applied Mathematics graduating class of approximately 100 students and have always questioned what personal and external factors contributed to my educational path.

Thesis Overview

Chapter 2 provides an overview of theoretical perspectives on gender issues in mathematics, and situates my theoretical views. In Chapter 3, related studies regarding enrolment and perseverance are reviewed. Chapter 4 outlines the methodology used in this study. In Chapter 5, analysis is provided in the form of individual participant profiles with respect to the four dimensions of the study: Family, Peers, Personal Characteristics, and the Formal Education System. Chapter 6 provides the analysis of the interview data across the six participants for each dimension. In Chapter 7, the research question is addressed by both dimensional and cross-dimensional findings. The thesis concludes in Chapter 8 with implications for education, a discussion of the contributions and limitations of the study, suggestions for future research directions, and concluding comments about the study.

CHAPTER 2: THEORETICAL PERSPECTIVES

In this chapter, I focus on the evolution of the ideas and theories surrounding women's relationship to mathematics and use these theories to situate my own perspective as well as to highlight current perspectives on gender and mathematics.

A variety of theories have evolved over time to explain gender differences in mathematics. I focus on two general themes that have been used to explain gender differences in participation and achievement: one explanation relates to biological differences, whereas the other relates to social and cultural factors. While I place these theories generally in a chronological order to provide a historical perspective, it is also important to understand that many theories overlap chronologically, and that many of the earlier theories and ideas are still held today by some individuals (e.g., Halpern, 1997; Summers, 2005).

Below, I separate my discussion into five sections. First, I present biological theories that attempted to explain differences between men and women in mathematics. Then, I describe a seminal study (Fennema & Sherman, 1977) that provided the transition from a focus on biology to a focus on society and culture. I next turn to a discussion of the relationship of society and culture to gender issues in mathematics. I then present current views regarding gender issues in mathematics education, and conclude the chapter by outlining the views with which I personally align myself.

Biological Differences

Throughout much of history, mathematics has been considered to be inherently foreign to the female mind (Hanna, 2003; Leder, 1992; Simon, 2000). Henrion (1997, p. xxiv) reported that, "First it was argued that their brains were too small, later that it would

compromise their reproductive capacities, still later that their hormones were not compatible with mathematical development". Issues surrounding women in mathematics and science were not a prevalent theme in research literature until the 1960s, when equality of access to education in mathematics and science for women became one of the predominant aims of the feminist movement (Hanna, 2003). Reports on the history of gender issues in mathematics (Hanna, 2003; Leder, 1992) note that much of the early research in this field attributed the inferior performance and underrepresentation of women in mathematics and science to innate biological factors. Several early studies (e.g., Benbow, 1988; Benbow & Stanley, 1980; Fruchter, 1954; Stafford, 1972) focused on biological explanations for differences between males and females in spatial perception and mathematical reasoning ability. For example, Stafford (1972) attributed differences in mathematics ability and spatial skills in male-female twins to a sex-linked recessive gene. However, other researchers questioned the biological focus and examined other issues that might affect females' experiences with mathematics. For instance, Fennema and Sherman (1977) found that when the number of prior mathematics courses taken and experience with spatial activities were controlled, no sex differences in spatial abilities were found.

Exploring Other Possibilities

Fennema and Sherman's study (1977) with more than 1200 Grade 9 to 12 students at four American high schools in different socioeconomic communities went beyond an examination of spatial skills to explore beliefs about mathematics, and the researchers found that many of these beliefs affected females' participation and achievement. The researchers found that females generally held the belief that mathematics is a male domain. The more the female students believed this stereotype, the lower their achievement in

mathematics. Females were also found to have lower mathematics confidence and to find mathematics less useful than males. However, Fennema and Sherman recognized that these beliefs were socially constructed and that social and cultural factors can influence mathematics achievement.

This study had a strong impact on the field of research into gender issues in mathematics education for three key reasons. First, the study was carefully designed and comprehensively analyzed; second, the study's focus related to tenets of liberal feminism, which has been a topic of debate from the 1970s to present; and third, the study introduced the Fennema-Sherman Mathematics Attitude scales, which acknowledge that attitudes are shaped by many factors (Leder, 2004). In fact, the article about this research (Fennema & Sherman, 1977) is among the most frequently cited publications in the mainstream journals of educational psychology (Walberg & Haertel, 1992). Thus, this article shaped future directions for research in gender and mathematics education.

Society and Culture

As research shifted from a focus on biological differences in mathematics ability to a focus on society and culture, there was also a change in terminology from 'sex differences' to 'gender differences'. This seemingly small change in wording represented a significant change as 'sex' is a biological term[1] whereas 'gender' refers to socially constructed roles or identities (Pryzgoda & Chrisler, 2000). Hence, differences are not seen as innate, but rather are linked to societal perceptions and thus are not immutable. Hanna (2003) provides the following useful summary:

> Most modern educational research on gender similarities and differences suggests no physical or intellectual barrier to the participation of women in mathematics... it is now generally accepted that women have been and continue to be

> underrepresented in these fields mainly because of social and cultural barriers that did not and still may not accord them equal opportunities. (p. 205)

The shift in research focused on examining how mathematics is viewed in society, how women's relationship with mathematics is viewed, and the implications of these views on gender equity issues in mathematics education. As such, research included examining social and cultural factors such as stereotypical identifications, media portrayals of women and mathematics, and parental and teacher expectations, views, and treatment of females in mathematics.

In general, mathematics tends to be viewed as a "logical, clinical, creative, objective, and complex pursuit" (Forgasz & Leder, 1996, p. 129). Traditionally, women have been perceived to be "less competent, less independent, less objective, and less logical than men" (Broverman, Vogel, Broverman, Clarkson, & Rosenkrantz, 1972, p. 75), so they have not been seen to align with the study of mathematics. Historically, the importance afforded to different subject areas has been linked to the notions of women's competence with the 'status' subject of the era. Burton (1986) drew a parallel between the high status given to learning languages in the 19th century and the high status of mathematics in the 20th century; in the 19th century, women were perceived as incompetent with languages, whereas in the 20th century, women were perceived as incompetent with mathematics. Similarly, Cohoon and Aspray (2006) discussed how changes over time in women's participation in 'masculine' fields refute biological explanations, stating:

> We reject the idea that biological gender differences explain the situation, noting the variance in time as the most obvious counterexample. One possible explanation is that the causes are so numerous and deep-seated in our institutions that society is not willing to make the changes that would produce gender equity. (p. ix)

Even in more recent years, mathematics has still been stereotyped as a male domain (Boswell, 1985; Fox, Brody, & Tobin, 1985; Mendick, 2005). Females are bombarded by

the media, parents, teachers, and other individuals with the message that mathematics is difficult for women, women perform inferiorly, and mathematics achievement is simply less important for women (Damarin, 1993). The impact of parental support at home has been shown to be a factor in gender differences in mathematics. Hanna, Kündiger, and Larouche (1990) compared outcomes from the Second International Mathematics Study (SIMS) for students in the final year of secondary school in fifteen countries in Europe, North America, and Asia. They found that there were no significant gender differences in achievement when students had high levels of support at home, but substantial differences when support at home was low or lacking altogether. This finding suggests that societal stereotypes regarding mathematics can be counter-balanced by family support.

However, pervasive societal views can significantly influence students' beliefs about gender roles and mathematics, both at the elementary and high school level. Forgasz and Leder (1996), two of the world's leading researchers in the field of gender issues in mathematics, administered a survey to nearly 200 Grade 9 students in Australia to learn about their gender role attitudes toward stereotypically gendered subject areas. The authors found that males considered mathematics to be 'masculine' whereas both sexes considered English to be 'feminine'. Similarly, males considered males to be better at mathematics whereas both sexes considered females to be better at English. These attitudes can detrimentally affect females' choice of and success in mathematics as a field of study. Related, in Fennema and Sherman's (1977) earlier, large-scale study, findings indicated that girls who viewed mathematics as a 'masculine' field had lower mathematics achievement. A more recent study by Lupart, Cannon, and Telfer (2004) used questionnaires with over 1400 Grade 7 and 10 students in Alberta to investigate the students' perceptions of academic achievement, interests, values, and future life choices.

The authors found that, even though girls have a better attitude toward learning for learning's sake, boys have much better attitudes toward and interest in mathematics. Clearly, society's views of women in mathematics affect students' perspectives on gender roles in mathematics, which can have far-reaching implications for students' educational choices.

Current Views

Recent research has focused on how views of mathematics as a discipline affect the ways mathematics is taught; this may account for gender differences, rather than the attributions and motivations of girls themselves. Several researchers have found unequal treatment of male and female students in mathematics classes, such as teachers calling on boys more often or asking them harder questions (Jones, 1989; Karp, 1991; Sadker & Sadker, 1985, 1994; Serbin & O'Leary, 1975), which disproves earlier biological arguments regarding spatial skills that posited that boys and girls had 'identical' educational experiences if they were in the same classes.

When examining Benbow and Stanley's (1980) biological explanation for gender differences in mathematics, a group of scientists (Egelman, Alper, Leibowitz, Beckwith, Levine, & Leeds, 1981) found, "an underlying fallacy... largely responsible for the unwarranted publicity in the popular media... is the notion that if a trait is under genetic control, the expression of that trait is immutable" (p. 116). Egelman and his colleagues (1981) outlined the importance of the environment on the expression of traits that are under genetic control. By using wheat, a very simple organism, the scientists showed how changing the environment resulted in a completely different outcome. Thus, even if one believes there is a genetic basis to differences in the mathematics capacities of males and

females, the expression of these abilities can be significantly altered by different learning environments.

Hence, many researchers have asserted that teaching should be connected to different ways of learning, and that those ways of learning may be connected to gender (Becker, 1995; Belenky, Clinchy, Goldberger, & Tarule, 1986; Gilligan, 1982). It is important to note that these gendered differences in ways of learning are attributed to differences in socialization rather than innate biological characteristics. Recent research has focused on how females learn mathematics, and a variety of different scenarios of classroom experiences have been investigated, including single-sex classes, mentoring, particular pedagogical practices in co-educational classrooms, and intervention programs such as summer math camps (e.g., Becker, 2001; Boaler, 1997; Campbell, 1995; Freeman, 2004; Goodell & Parker, 2001; Kerr & Kurpuis, 2004).

Boaler (1997) described how girls' underachievement and lack of participation can be attributed to the structured, traditionalist manner in which mathematics is often taught. Researchers have found that in a traditionalist classroom, girls tend to exhibit rule-following behaviours (Karp & Shakeshaft, 1997; Scott-Hodgetts, 1986) and excel at rote learning (Ridley & Novack, 1983; Schmittau, 1996). However, merely memorizing procedures is not adequate preparation for higher-level mathematics that may require students to engage in solving problems in unfamiliar contexts. Further, the competitive setting of the traditional classroom does not provide a safe space in which to take the necessary risks to engage in meaningful problem solving (Boaler, 1997).

Boaler (1997) found that in an open, connected environment that uses co-operative learning, females are more comfortable to engage in meaningful mathematics exploration. Her three-year longitudinal study in the United Kingdom followed over 250 students from

Year 9 (age 13) to Year 11 (age 16) at a traditionalist school and a project-based school with similar socioeconomic compositions in order to compare the experiences of students in these two different mathematics learning environments. Boaler's study incorporated both qualitative and quantitative methods, such as lesson observations, interviews with teachers and students, questionnaires, and document analysis, and used a continuous process of interaction, triangulation, and reanalysis. She found much greater strides in females' attitudes, conceptual understanding, and achievement in the latter. Furthermore, no significant differences in any of these measures were found between boys and girls in the project-based school. Boaler concluded that only by changing the system can the greatest improvements in gender equity be realized. This view parallels the thinking of those with a feminist perspective who have advocated for more variety in assessments, cooperative grouping, problem solving, and inquiry methods that employ real-world contexts as a way to connect more women to mathematics (Morrow & Morrow, 1995).

However, some contend that the issue of women in mathematics has been solved and gender equity has been achieved. For instance, while a full chapter (Leder, 1992) in the *Handbook of Research on Mathematics Teaching and Learning* (Grouws, 1992) discussed gender issues, the topic does not even explicitly appear in the table of contents in more recent handbooks (English, 2002; Lester, 2007). In fact, some research has turned to focus on boys in mathematics as there are some recent trends that suggest there is a low enrolment of boys in secondary mathematics classes, and there is a perceived bias as more boys are placed in special education classes in mathematics (Kleinfeld, 1998). This shift may detract from continuing efforts to promote females' increased participation and achievement in mathematics, and as reported by Forgasz and Leder (2001),

> Coupland and Wood (1998) [researchers who had community members examine Sydney, Australia newspaper articles regarding girls' improved performance in mathematics] were shocked to realize that people thought there was something to be concerned about now that girls were doing better than boys, while for years the status quo of boys doing better was simply accepted as the natural order of things... very few reports actually said anything congratulatory about the females' performance! (p. 352)

While the past twenty-five years have brought considerable progress for females in mathematics at the elementary and secondary levels (Campbell, 1995; Hanna, 2003; Kleinfeld, 1998), there is still significant work to be done in order to change societal perceptions surrounding females and mathematics.

Personal Views

Although I have presented the evolution from biological explanations to socio-cultural explanations to provide perspective, I personally view gender issues as connected to social and cultural factors, which is embedded in both my research question and the manner in which I conducted my research. Furthermore, I align myself with current researchers (e.g., Boaler, 1997; Morrow & Morrow, 1995) who believe that teaching practices need to change in order to ensure more meaningful, successful, and positive mathematics experiences for both females and males. I share the opinion of feminist researchers (e.g., Becker, 1995; Belenky et al., 1986; Gilligan, 1982; Whitten & Burciaga, 2001) who believe that instructional practices need to include a greater focus on conceptual understanding and connecting mathematics to women's lives rather than a focus on the memorization and rule-following behaviours that are too often associated with mathematics teaching and learning. Furthermore, similar to some feminist researchers (e.g., Boaler, 1997; Burton, 1995; Whitten & Burciaga, 2001), I believe that mathematics classrooms

need to become supportive, inquiry-based learning communities where female students' voices are heard, and a variety of approaches to doing mathematics are valued.

Conclusions

This chapter summarized the evolution of perspectives on gender issues in mathematics education. These theoretical perspectives began with a biological focus, presuming that differences in mathematics ability were innate and sex-linked. However, a seminal piece of research (Fennema & Sherman, 1977) questioned these biological explanations, and from that point, research began to focus on how society and culture can affect achievement in and attitudes toward mathematics. Recent research has examined the manner in which mathematics is taught, and explored notions of teaching in gender-connected ways. Although some current researchers still align themselves with biological explanations for gender differences in mathematics and others contend the 'gender problem' is solved, I believe there is still much work to be done to ensure equity in this domain, particularly at the post-secondary level. I align myself with current feminist researchers who believe that teaching practices and mathematics learning environments need to change in order to ensure more meaningful mathematics experiences for all students. It is with this theoretical lens that I explored my research question.

CHAPTER 3: REVIEW OF THE LITERATURE

In this chapter, I provide an overview of literature related to my research. These studies were conducted in nations with similar populations to my own study. First, I outline studies that examined influences, both positive and negative, on women's choice of mathematics as a field of study at the university level. Then, I describe research about perseverance of females in mathematics degree programs at the university level. I conclude the chapter by summarizing the main themes found in the related literature, and outlining how my study is related to the previous research literature.

Choosing to Study Mathematics

Research has been conducted, both in Canada and internationally, that examined factors that affect women's choice of mathematics as an undergraduate field of study. In particular, females' mathematics experiences at the high school level are frequently a factor in determining whether they choose to enrol in mathematics at a university level. Thus, studies about the choice of mathematics as a field of study at the undergraduate level tend to examine females' experiences with and attitudes toward mathematics at the high school level.

Several studies suggest that female high school students do not have positive perceptions of the field of mathematics and therefore elect not to study it, which may explain the low enrolments in mathematics at the university level. For instance, researchers investigating students' attitudes toward mathematics and science in high school found that more males than females tend to have more positive attitudes toward these subject areas (Forgasz & Leder, 1996; Lupart, Cannon, & Telfer, 2004; Weinburgh, 1995). Less positive attitudes of females toward mathematics and science have also been shown to correlate

with lower achievement in these subject areas (Fennema & Sherman, 1977; Weinburgh, 1995), which decreases their chances of acceptance to university mathematics programs. Even when outperforming males in mandatory high school mathematics courses, women still tend to drop mathematics as soon as they have the option (Freeman, 2004; Karp & Shakeshaft, 1997; Stewart, 1998).

Similar findings about high school students' attitudes toward mathematics appear in the questionnaires that accompany large-scale provincial, national, and international studies of mathematics achievement. For example, in the United States, McGraw, Lubienski, and Strutchens (2006) conducted an analysis of questionnaire data from the National Assessment of Educational Progress (NAEP) survey of Grade 4, 8, and 12 students from 1990 to 2003. They found that female students were less likely than male students to indicate that they liked mathematics or to consider themselves to be proficient in the subject, although males and females reported equal levels of understanding in class. In Ontario, similar results were found in the data from the questionnaire that accompanies the Grade 9 provincial mathematics assessment, which is conducted annually by the Education Quality and Accountability Office (EQAO). These data show consistently that more males than females agreed with the following statements: 'I like mathematics' and 'I am good at mathematics' (EQAO, 2005a, 2005b, 2006a, 2006b, 2007a, 2007b).

Other studies have also found that female students at the high school level tend to lack confidence in their abilities and show anxiety toward mathematics (Damarin, 1993; Fennema & Sherman, 1977; Richardson & Suinn, 1972). Mathematics anxiety is described by Richardson and Suinn (1972) as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). When mathematics is a stress-inducing

activity, it leads to avoidance of the subject area and poor performance (Bowd & Brady, 2003; Tobias, 1993), both of which decrease the possibility of studying mathematics at the university level.

Conversely, other research posits that females are opting out of mathematics for different reasons. Recent findings (Lubinski & Benbow, 2006) have suggested that women are self-selecting away from mathematics-related fields even when they are very skilled in the subject area. In 1971, the Study of Mathematically Precocious Youth (SMPY) was initiated by Julian C. Stanley at Johns Hopkins University, aimed at following mathematically and intellectually gifted adolescents for 50 years. The study began with over 2000 participants and has since expanded to over 5000 participants. The participants in the first four cohorts of the study were selected when they were between the ages of 12 and 14, and they comprise over 80% of the total number of participants in the study. Upon examining 35 years of SMPY data, Lubinski and Benbow (2006), who have led the study since 1991, found that the mathematically-gifted women from the first four cohorts tended to select fields of study that relate to organic materials or beings, such as medicine, humanities, and biology. Conversely, the males in the first four cohorts tended to prefer to work with inorganic materials, and were more likely than the mathematically-gifted women to go into fields such as engineering or physical sciences. Interestingly, the majority of the female study participants also had very strong verbal abilities, which was not the case for many of the males in the study. Thus, the researchers purported that, due to their wider range of skills, women had more choices for fields of study and careers, so thus opted out of the 'hard' sciences whereas men did not have that option due to their narrower range of skills.

However, Walkerdine (1997) noted that girls' 'choices' are heavily influenced by societal pressures and stereotypes: "It is not the case that there are no choices, but those choices are heavily circumscribed and shot through with conscious and unconscious emotions, fantasies, defences" (p. 171). Also, Shaw (1995) stated, regarding the continuing male dominance in mathematics fields even after decades of feminist interventions, "The most striking feature of subject choice is that the freer it is, the more gendered it is" (p. 107). The increased number of choices of fields of study and careers now available to women, particularly since the women's movement, may actually be counter-productive as the women tend to 'choose' fields that are seen as feminine, due to societal pressures and influences. Indeed, Pinker (2008) reports that in countries that are more progressive, provide equal opportunities for men and women, and have family-friendly policies, there is more occupational segregation along traditional gender roles.

Related, there is a pervasive stereotypical belief that mathematics is a solitary field that does not have much human interaction, which may deter females from studying it at the university level. Morrow and Morrow (1995) had similar findings to those of Lubinski and Benbow (2006), regarding females' preference to work with organic matter and beings. Morrow and Morrow host the SummerMath camp, now in its 27th year, at Mount Holyoke University, which provides a unique mathematics experience for females at the high school level. Each year, 100 young women from diverse ethnic, cultural, geographic, and academic backgrounds attend the six-week residential camp. The Morrows structure the camp's activities around a feminist framework based on *Women's Ways of Knowing* (Belenky et al., 1986), and find great strides in the participants' attitudes towards mathematics. However, Morrow and Morrow (1995) have often heard young women in their program say such statements as "I can do math, and it's even fun sometimes, but I

want to choose a career that will allow me to do something useful with my life. I want to work with/for people." (p. 25). Another study found that women were not interested in pursuing mathematics as a career because they viewed mathematics and science careers as less interesting because such careers appear to have little interpersonal involvement and few intrinsic rewards (Morgan, Isaac, & Sansone, 2001). Persistent stereotypical notions of the field of mathematics may dissuade female students from enrolling in such studies beyond the high school level.

While the above studies point to factors that may inhibit females from choosing mathematics as a field of study at the undergraduate level, studies of those females who did select mathematics-related programs, such as engineering, physics, and mathematics, provide insight into the factors that prompt such a choice. Gill's study (2000) of 13 first- and second-year female students from four Canadian universities used in-depth individual interviews to focus on women's decisions to pursue mathematics-related subjects in university. She examined three types of dimensions (intrapersonal, interpersonal, and contextual) and found that the women were most heavily influenced by intrapersonal factors, such as passion about and skill in the subject area. Interpersonal factors such as supportive relationships with teachers, parents, and peers were also significant to these women's selection of university fields of study. In terms of contextual factors, special educational or after-school programs and opportunities for group work were shown to be positively linked to the choice of a mathematics-related degree program.

Moreover, recent research has suggested that external limitations on students' selections of courses of study may help to promote women's participation in stereotypically 'masculine' fields at the post-secondary level. Charles and Bradley (2006) found that, in countries where governmental and educational system regulations ensure that all students

are educated in science, mathematics, and information technology during secondary education, there is a much greater gender balance in participation in these fields in tertiary education. Essentially, prescriptive outside practices may help to ensure gender balances in fields that are typically male-dominated. The authors found that, "Girls may be less prone to 'like' math or regard themselves as competent in math when a wide array of more 'gender-appropriate' options present themselves" (p. 195).

Persevering in Mathematics

Several studies have examined females' perseverance in or attrition from mathematics-related degree programs, and identified a wide variety of factors that promote or inhibit perseverance. I first address factors that relate to attrition from these mathematics-related fields, and then turn to factors that promote perseverance in these fields.

Reasons identified for attrition from mathematics-related fields include poor interactions with faculty, feelings of being invisible or not fitting in, a low proportion of females in the program, and a loss of interest in the subject area. Several studies pointed to faculty interactions and poor pedagogical practices as problematic (Herzig, 2004; Sax, 1994; Seymour, 1995). Faculty interactions were noted to be a key theme in Herzig's (2004) interviews with six women who left graduate-level mathematics programs at an American university. The primary reasons cited by the participants for their attrition were a lack of quality relationships with faculty members and a lack of feeling of community. The women felt that faculty members were patronizing or ignored them, plus did not offer moral or academic support or counselling. Seymour (1995) conducted over 600 hours of interviews with 460 undergraduate students at 12 American universities who left science,

mathematics, and engineering majors and those who persevered with these majors, and she found poor pedagogical practices were a significant concern. Also, a lack of faculty encouragement was viewed as blatant discouragement by the female participants in this study, and was particularly troublesome to them.

Studies also point to women's feelings of not fitting in (Damarin, 2000; Herzig, 2004; Rodd & Bartholomew, 2006). Herzig (2004) noted that the women in her study felt that they did not belong at the mathematics department, which one participant described as "the old white guys' club" (p. 385). This is similar to feelings of being invisible reported by the female students in undergraduate mathematics degree programs who participated in Rodd and Bartholomew's study (2006). An interesting finding by Damarin (2000) was that females in mathematics fields are seen as 'doubly marked', on the margins of both the 'female' and 'mathematician' categories but fitting into neither. They are viewed as less than female and less than a mathematician due to their belonging to the 'other' group and as such, have difficulty with social positioning. Correspondingly, Henrion (1997, p. 67, emphasis in original) found that, within the mathematics community:

> ...if women are seen too much as *women*, if they are identified with traits associated with being female such as physical attractiveness, marriage, or motherhood, they are less likely to be taken seriously as *mathematicians*. As a result, many women mathematicians feel the need to downplay these aspects of their lives.

Other factors related to attrition have been recognized, such as loss of interest in the subject, an interest in another subject, and a feeling of being overwhelmed with the pace and demands of the curriculum (Seymour, 1995). Interestingly, Seymour found that the issues that caused students to drop out or change from science, mathematics, and engineering fields also caused discontent among students who persevered. What accounted for the perseverance or attrition in these cases was the students' different attitudes and

coping strategies. There were no significant differences in terms of high school preparation or university grades between those students who persevered in science, mathematics, and engineering fields and those who did not.

Conversely, a positive university experience, particularly in terms of supportive relationships with faculty and encouraging teaching practices, has been shown to lead to perseverance of female students (Gavin, 1996; Seymour, 1995). Other research has shown that a 'critical mass' of other female students and faculty is vital for women persevering in traditionally male-dominated fields; women's-only universities and those with a substantial number of female faculty members tend to graduate a disproportionately large number of female doctoral students in mathematics (Frazier-Kouassi et al., 1992; Jackson, 1992; Sharpe, 1992). Similarly, Mastekaasa and Smeby (2008) found that the probability of women dropping out was much lower in female-dominated programs than in gender-balanced or male-dominated programs.

Another external factor identified by research that promotes perseverance of female university students is the support of significant others such as peers and parents. Some studies show that having highly educated parents and strong parental support are positive influences for perseverance (Gavin, 1996; Blair, 1991). Blair's (1991) interviews with 58 female 'persisters' and 33 female 'withdrawals' in undergraduate mathematics programs at three Alberta universities found that persisters received more encouragement and support regarding mathematics and non-traditional careers.

In the related field of engineering, Abri (2006) examined attrition and retention at the undergraduate level. She conducted interviews with eight women who were currently undergraduate students in engineering or had completed an undergraduate engineering degree at an American university. She found that the women strongly expressed a desire

for relevancy in the curriculum, so that the topics studied seemed real-world applicable. Abri also found that the participants in her study valued professors who related to the students and, conversely, they were frustrated by professors who were poor communicators and who were disorganized.

Zeldin and Pajares (2000) interviewed 15 women who were educated in the United States and who had successful mathematical, scientific, and technological careers about their academic and career choices. The researchers found that family was particularly important to these women's choice of fields; two-thirds of the women had a family member in a related field, and they were all supported in their interest in science, mathematics, and technology from an early age. All participants spoke of influential teachers, both male and female, who made a particular impact on their academic paths. The women perceived these teachers to be both enthusiastic about the subject matter and supportive of students. Several of the women also noted that they had supportive peer communities that involved mathematics, science, or technology. Notably, all the women in the study recalled encountering obstacles in their academic and career paths, but overcoming them based on their strong belief systems in themselves.

My pilot study (Hall, 2006) with women who graduated from engineering, physics, and mathematics undergraduate degree programs at Canadian universities examined factors that positively impacted their perseverance in these male-dominated fields of study. Through the use of semi-structured individual interviews, three key themes emerged that appeared to support the women in their undergraduate degree experiences. First, the women had strong, independent personalities; second, they had a great love of and skill for their subject area; and third, they received social support from peers.

Other studies also highlighted the importance of certain personality traits, such as competitive attitudes, determination, coping strategies, superior abilities, pride and belief in abilities, and serious academic attitudes, which tend to lead to perseverance in mathematics-related programs (Gavin, 1996; Rodd & Bartholomew, 2006; Seymour, 1995; Zhao, Carini, & Kuh, 2005). Gavin (1996) found that the female mathematics students placed high academic demands on themselves. Rodd and Bartholomew's (2006) interviews with female undergraduates in mathematics showed that these women had very positive early identities of being 'special' and 'chosen' as they were mathematically-talented girls. Furthermore, the women in the study were found to be more 'elite' than men in their degree program, as they were particularly high achieving and committed to their studies.

Summary

The aforementioned studies have shown that there is a wide variety of factors that influence female students' enrolment and perseverance in mathematics-related fields of study at the university level. Sociological factors, such as personal characteristics and the impact of peers, family, and educators, have been noted to play a key role in women's enrolment and perseverance in mathematics.

In terms of factors that may contribute to a lack of women selecting mathematics for university study, several small- and large-scale studies have found that females at the high school level often have negative attitudes toward mathematics (Fennema & Sherman, 1977; Forgasz & Leder, 1996; Lupart, Cannon, & Telfer, 2004; McGraw, Lubienski, & Strutchens, 2006; Weinburgh, 1995) and a lack of confidence in their abilities (Damarin, 1993; Fennema & Sherman, 1977; Richardson & Suinn, 1972). Recent American research has also suggested that females are self-selecting away from mathematics due to an interest in fields that relate to organic materials (Lubinski & Benbow, 2006). Furthermore, societal

stereotypes, such as the notion that mathematics is a field that lacks human interaction, may turn female students away from the field (Morgan, Isaac, & Sansone, 2001; Morrow & Morrow, 1995).

Conversely, studies regarding females' choice of mathematics-related fields of study at the university level point to the importance of supportive family members and teachers, passion for and skill in the subject area, and specialized educational opportunities (Gill, 2000). Another factor that may positively impact the choice of such a field of study is the mandatory enrolment in mathematics-related fields at the high school level (Charles & Bradley, 2006).

When discussing women's perseverance in mathematics-related fields of study at the university level, several factors have been found to hinder such persistence, such as a negative university experience with regards to unsupportive faculty members and poor teaching (Herzig, 2004; Sax, 1994; Seymour, 1995). Other studies pointed to women's feelings of not fitting in (Damarin, 2000; Herzig, 2004; Rodd & Bartholomew, 2006). Some students also leave mathematics-related fields due to a loss of interest in the subject area or a feeling of being overwhelmed by the academic demands (Seymour, 1995).

Alternately, having a positive educational experience with supportive faculty members and quality teaching is linked to perseverance in mathematics-related fields (Gavin, 1996; Seymour, 1995; Zeldin & Pajares, 2000). Further, having a large cohort of female peers in the program is also a support for perseverance (Frazier-Kouassi et al., 1992; Jackson, 1992; Mastekaasa & Smeby, 2008; Sharpe, 1992). Studies have also noted the positive impact of supportive relationships with family members and peers (Blair, 1991; Gavin, 1996; Hall, 2006; Zeldin & Pajares, 2000). Finally, certain 'supportive' personal characteristics, such as competitive attitudes, determination, and serious academic

attitudes have been shown to lead to women's perseverance in mathematics-related fields (Gavin, 1996; Hall, 2006; Rodd & Bartholomew, 2006; Seymour, 1995; Zhao, Carini, & Kuh, 2005).

These closely related studies have been very useful in informing my current research, as they highlighted key factors that influence, both positively and negatively, women's enrolment and perseverance in mathematics and related fields. My current research examined the following four dimensions with regard to women's enrolment and perseverance in undergraduate mathematics degree programs: Family, Peers, Personal Characteristics, and the Formal Education System. Several studies have shown the importance of each of these four factors: Family (e.g., Blair, 1991; Gavin, 1996; Gill, 2000); Peers (e.g., Frazier-Kouassi et al., 1992; Hall, 2006; Jackson, 1992); Personal Characteristics (e.g., Rodd & Bartholomew, 2006; Seymour, 1995; Zhao, Carini, & Kuh, 2005); and the Formal Education System (e.g., Gill, 2000; Herzig, 2004; Sax, 1994).

However, even studies similar to my own have differed significantly in important facets, such as educational level of participants (e.g., Gill, 2000; Herzig, 1996; Rodd & Bartholomew, 2006), sex of participants (i.e., including both male and female participants) (e.g., Seymour, 1995), subject area of study of participants (e.g., Abri, 2006; Gill, 2000; Seymour, 1995), geographic location (e.g., Gavin, 1996; Herzig, 2004; Rodd & Bartholomew, 2006; Seymour, 1995), university type (e.g., Gavin, 1996), and dimensions studied (e.g., Blair, 1991; Gill, 2000; Rodd & Bartholomew, 2006). Few studies related to women's enrolment and perseverance in mathematics and related fields at the undergraduate level have been conducted in Canada. Of the existing Canadian studies on this specific issue, very few specifically focused on mathematics and used qualitative methods to obtain a more holistic understanding of women's experiences.

Thus, my study differs from the existing studies in two key areas. First, my study examines the combination of these four factors, which have not been examined all together in prior studies. Exploring this combination of factors using a qualitative framework allows for a more holistic understanding of the participants' mathematics experiences. Second, my study is conducted with a unique population that has not been featured in the previous research literature – female students who are currently enrolled in upper years of undergraduate mathematics degree programs at a Canadian university, and who have been educated in Canada for all levels of education (i.e., elementary, secondary, and post-secondary). The findings from my research into sociological and personal factors that affected the mathematics-related experiences of these women will contribute greatly to the body of Canadian research in this area of study.

CHAPTER 4: METHODOLOGY

This chapter provides an overview of the methodology used in this study. I begin by reiterating my research question to provide context. This is followed by a justification for the methodological framework and a description of the data collection instrument. I then proceed by providing an overview of my background as an educational researcher. Next, I outline the recruitment strategies used and provide a profile of each participant involved in the study. I conclude the chapter by describing the data collection and analysis methods.

Research Question

The design of my study and data collection instrument were guided by the following research question:

In what ways do women who were educated in Canada and who are nearing completion of undergraduate mathematics degrees feel they have been supported and challenged in their high school and university mathematics studies?

Rationale for Methodological Framework

Based on my research question, a qualitative study was most appropriate as I wanted to learn how women perceived their mathematics experiences at the secondary and post-secondary level. Qualitative research "assumes that there are multiple realities… It is a highly subjective phenomenon in need of interpreting rather than measuring" (Merriam, 1988, p. 17). This type of research framework allows for investigation of the individual women's stories behind the aggregate-level enrolment and graduation statistics. Qualitative research also allows for researchers to "democratize the research process by enabling the voices of the people as research participants to be heard" (Oakley, 2000, p. 11).

I wanted to gain a better understanding of the lived experiences of my participants, so it was imperative that I had face-to-face contact with them in order to explore their stories. Since I was interested in participants' perceptions of their past and present experiences with mathematics, interviews were the best format in which to gather these data. I considered both focus group and individual interviews. However, there are too many variables, based on social contexts, in a focus group interview that may alter the results. Hollander (2004) reports that focus group interviews "do not reliably tell us what individuals think or feel" (p. 628). Since I was interested in learning about each participant's experiences, perceptions, and feelings, individual interviews were the most suitable selection for my research; they allow one to "enter into the other person's perspective" (Merriam, 1988, p. 72).

One-on-one interviews aligned very well with my research question as I was interested in each participant's story and how she interpreted it. I wanted to understand "the lived experience of other people and the meaning that they make of that experience" (Seidman, 2006, p. 9). Specifically, I used a semi-structured protocol in order to ensure reliability among interviews, but with the freedom to explore other issues or topics that arose. Semi-structured interviews allow for exploration of issues in an in-depth manner as participants' answers can be followed up (Creswell, 2005). Furthermore, I felt that it was important to hold these interviews face-to-face in order to observe the participants' body language and facial expressions.

As participants were recalling their experiences from high school and earlier, the reporting of these events may be slightly altered from the way the events actually occurred. However, the manner in which each participant recalled events and how she felt is equally, if not more, important than factual accuracy in this study. I believe that the interview

process is "not simply about the giving and receiving of information but at least as much about speaking identities into being, solidifying them and constantly reconstituting them through the stories we tell ourselves and each other" (Epstein & Johnston, 1998, p. 105).

Interview Protocol

The interview protocol (Appendix A) for my study consisted of three sections: 1) Identification data, 2) Instructions for the interviewer, and 3) Interview questions.

The identification data consisted of two sections: interview details, such as date, time, and location; and participant details, such as name, academic program, and contact information. This section allowed for a simple manner in which to collect and organize details regarding participant identification and interview context for future reference.

Instructions for the interviewer were included to maintain reliability in the interview delivery. Reliability, "the consistency of scores obtained – how consistent they are for each individual from one administration of an instrument to another and from one set of items to another" (Fraenkel & Wallen, 2003, p. 165), is essential to ensure consistency and quality in research. For instance, this section reminded the interviewer to thank the participant for participating, describe the interview process and the study, and assure the participant of confidentiality and anonymity. Further to the written instructions, reliability was ensured as I was the only interviewer, so the same presence was provided to all participants.

The eight open-ended questions with related follow-up questions in the interview protocol covered each participant's mathematics experiences in high school and university with regard to the influence of the following four dimensions: the Formal Education System, Family, Peers, and Personal Characteristics. These dimensions were selected as

they were shown in similar studies to have a significant impact on women's experiences in mathematics. A few additional questions were added as follow-up questions to the eight main open-ended questions as the interviews progressed. Specifically, the questions added were: 'Why do you like mathematics?', 'What is the approximate ratio of males to females in your mathematics classes? Has this changed over the course of your degree?', and 'What is the approximate ratio of male to female mathematics professors that have taught you?' These additional questions arose by happenstance in earlier interviews and I felt they were important to include, so I formally added them to the interview protocol for later interviews.

Specifically, the first two questions on the interview protocol inquired about the participant's current university program and her choice of this program, in order to ease into the interview with simple, ice-breaker-type questions. It is important to use such a method in order to build rapport with participants, which is fundamental to the tone and outcome of the interview (Creswell, 1998; Seidman, 2006). Each of the remaining questions (#3 to 8) included several follow-up questions that I could potentially ask to obtain further information. Questions #3 and 4 asked about the participant's high school and university educational experiences (Formal Education System dimension). Previous research literature has shown that specialized educational experiences and relationships with teachers have significant impacts on women's decisions to enrol and persist in mathematics (Becker, 1990, 1996; Gavin, 1996; Gill, 2000; Herzig, 2004; Rodd & Bartholomew, 2006). Question #5 inquired about the role of the participant's family, both parents and siblings (Family dimension). The impact of family members, particularly parents, has also been shown consistently to be significant in women's choice of and perseverance in mathematics (Becker, 1990; Gavin, 1996; Gill, 2000; Rodd &

Bartholomew, 2006). Questions #6 and 7 asked about the impact of peers in high school and university (Peer dimension). This topic is most frequently seen in the literature in terms of gender-role attitudes at the high school level (Fennema & Sherman, 1977; Forgasz & Leder, 1996; Lupart, Cannon, & Telfer, 2004), but some direct impacts have also been noted (Gill, 2000; Hall, 2006). Finally, Question #8 inquired about personal characteristics of the participant that may have impacted her mathematics experiences (Personal Characteristics dimension). Several studies have examined the characteristics of females in the field of mathematics and tend to show similar results, such as the women being competitive, having serious academic attitudes, having great passion for their subject area, and being proud of their superior mathematics abilities (Becker, 1990; Gavin, 1996; Gill, 2000; Hall, 2006; Rodd & Bartholomew, 2006; Zhao, Carini, & Kuh, 2005).

Researcher's Background

In this study, my similar educational background to the participants was advantageous in helping me to develop bonds with them and to gain an insider's perspective. I believe the participants opened up to me more so than they would have with an 'outsider', be it a male or non-mathematician. Feminist researchers (DeVault, 1990; Lather, 1988) have found that female participants tend to open up to female researchers easily. However, my similarities to my participants could be construed as a limitation as I may have affected the participants' responses. To combat this, I only shared my educational background with the participants prior to the interview, so I believe that I was able to elicit more honest and unbiased responses and gain insight into my participants' lives. However, if a participant asked about my views on women in mathematics at the

conclusion of the interview, I freely shared my opinions at that point, as it obviously could not affect the participant's prior responses.

When conducting qualitative research, the researcher should be fully qualified to undertake the tasks associated with such a study. I was qualified to carry out this study due to the skills I attained from conducting a pilot study of a similar nature (Hall, 2006). This pilot study consisted of semi-structured one-on-one face-to-face interviews with women who had completed mathematics-related degrees, such as engineering, physics, and mathematics, in order to learn what factors had contributed to their perseverance in their degrees. During the course of my pilot study, I completed the Research Ethics Board application, conducted interviews, transcribed audio files, analyzed data, and wrote a comprehensive report on my findings. Furthermore, my interview protocol and consent form from the pilot study served as initial templates for my interview protocol (Appendix A) and consent form (Appendix B) for my thesis research.

Recruitment Strategies

The three requirements for participation in this study were that participants were female, were enrolled in third or fourth year of an undergraduate Mathematics degree program, and were educated in Canada for all levels of education. The last requirement was included as this study was examining experiences in the Canadian educational system. Participants for this study were recruited in a variety of ways. In March of 2008, I contacted the administrator in the Department of Mathematics and Statistics at the University of Ottawa, who agreed to send a mass email on my behalf to students enrolled in third or fourth year mathematics courses. I provided the text for this email, which contained a listing of the participant requirements, an overview of the study, and my email

address as a contact. Three participants were recruited through this initial email. The administrator also agreed to print and post my recruitment posters in the Department of Mathematics and Statistics building.

I also personally emailed each professor who was teaching a third or four year mathematics course during the semester in which the interviews occurred, asking if I could do a brief presentation about my research to try to recruit volunteers from their classes. From the 11 professors contacted (who taught 12 courses, and of whom 10 were male), I received five replies; of these five professors, three did not have female students in their classes who satisfied the criteria of the study. I made recruitment presentations about my research in two classes; interestingly, when I mentioned my requirement of completing all their education in Canada, nearly all the Asian women noted that they did not meet this requirement. A few women who emailed to inquire further about the study also were disqualified by this requirement. I recruited one participant through the class presentations.

By mid-April, I had interviewed four women, all of whom had informed their female colleagues about the study, upon my request. However, due to a lack of response, I again contacted the administrator in the Department of Mathematics and Statistics, who agreed to again send out another mass email to the aforementioned students. The timing of my recruitment was problematic as it was near the end of the academic year, so students were focused on exams. Thus, the mass email was sent out in the last week of April, after most students were finished exams, with the hope that they now would have sufficient free time to volunteer for the study. From this email, two further participants were recruited, one of whom noted that one of my prior participants had also talked to her about the study. One of these participants was a graduate student, but I decided to allow her to participate due to the difficulty I was having in recruiting participants and the fact that she was still

immersed in the mathematics culture at the university level; further, this participant met all of the other requirements of the study.

Upon being contacted by potential participants via email, I double-checked that they met the study's requirements, and then arranged a time for an interview, providing the participants with several options to allow them to best fit their schedule.

Participants

Six women participated in this research. They are referred to henceforth by the following pseudonyms: Allison, Brooke, Chantal, Dana, Elise, and Felicity. All women were between 20 and 22 years of age at the time of the interviews, and with the exception of Elise (who was in the second year of her master's program), the participants were all in the third or fourth year of their undergraduate studies at the University of Ottawa.

The University of Ottawa is an officially bilingual university, with degree programs offered in both English and French. Five of the six participants were enrolled in the Francophone sector for their undergraduate studies. However, as was noted by all of these participants, in small departments such as the Department of Mathematics and Statistics, there are often very few students in the Francophone sector. Thus, Francophone students often have no choice but to take their mathematics classes in English. The participants noted that this was particularly the case in upper-year undergraduate courses. Elise, the master's student participating in the study, noted that all her graduate-level mathematics courses were taught in English, as these courses include graduate students from Carleton University, an English-language university in Ottawa, due to low enrolment.

Allison

Allison is a fourth year student with a specialization in Mathematics and a concentration in English, in the Francophone sector. As such, approximately 60% of her courses are in mathematics with the remaining 40% coming from the Department of English. She grew up in a Northern Ontario town and moved to her current location when she was in Grade 9. She was enrolled in regular-stream classes in her French co-educational public high school and consistently was a top student in many subject areas. Allison took advantage of the opportunity to participate in Canada-wide mathematics contests in high school. She plans to attend a Faculty of Education next year to become a high school Mathematics and English teacher.

Brooke

Brooke is a fourth year student with a double major in Biology and Mathematics, in the Anglophone sector. She began her university studies in Biology at a university in Western Canada, but transferred to the University of Ottawa in third year; at this point, she also added Mathematics as a second major. Thus, she will require five years to complete her degree. Brooke attended regular-stream classes in her co-educational English public high school, and does not recall any enrichment opportunities or special programs for mathematics during her elementary or secondary education. Brooke originally wanted to become a veterinarian, but during her university studies, she changed her career plans. She now hopes to attend a master's program in Forensics and then work for one of Canada's intelligence agencies.

Chantal

Chantal is a third year student with a concentration in Mathematics, in the Francophone sector. Over the course of her degree, approximately 90% of her classes have

been in mathematics. She attended an all-girls French high school and was enrolled in a specialized International program, which consisted of more demanding and varied coursework, plus a focus on community service. Upon completing high school, she attended a collège d'enseignement général et professionnel (CEGEP) for Pure Science (CEGEP translates to 'college of general and vocational education' in English; CEGEPs are post-secondary institutions in Quebec that are required prior to students beginning university). Chantal plans to complete a bachelor's degree in Statistics with a minor in Economics upon completion of her Mathematics degree. She hopes to work in a statistics-related field.

Dana

Dana is a third year student with a double specialization in Mathematics and Economics in the Francophone sector. She changed to this program in second year, after beginning in a Biopharmaceutical degree program. Approximately two-thirds of her classes are in mathematics. She attended a special arts school in the province of Quebec for Grades 1 to 6, but she was enrolled in French co-educational public schools once she moved to Eastern Ontario in Grade 7. After the demanding schedule of the arts school, she found the work in Grades 7 to 12 to not require much effort to do well. Upon completing her degree, Dana hopes to work as an actuary.

Elise

Elise is in the second year of her master's degree program in Mathematics; she is currently working on her thesis, after completing three classes and two reading courses last year. She began her undergraduate degree in a General Science program in the Francophone sector, and dropped one science each year (Biology, Physics, and then Chemistry), resulting in her degree in Mathematics. Elise attended a French public co-

educational high school, and was enrolled in the International program (as described in Chantal's profile). Notably, Elise was 16 when she began university (due to a move away from the Quebec high school system), and she learned to speak English at this time in order to be able to take English-language mathematics courses. Upon completing her master's degree in Mathematics, Elise will begin work in a statistics-related job at a government agency, plus take night courses to complete an undergraduate degree in Psychology.

Felicity

Felicity is a fourth year student in an Honours Mathematics degree program, in the Francophone sector. She began in a combined Mathematics and Science program, but dropped Science during her second year of studies. Felicity was enrolled in an enriched program from Grade 4 to 7, until her family moved across town to an area where this program was not offered. She then attended a regular-stream elementary school for Grades 7 and 8, where she found mathematics very easy. Felicity attended an arts-focused co-educational French public high school and was enrolled in an enriched program. She has applied to master's degree programs in Mathematics at two Canadian universities, and hopes to either work as a university mathematics professor or in the business world.

Data Collection

Data for this study were collected via a single semi-structured interview for each of the six participants. The number of participants was initially supposed to be eight, as suggested by my thesis committee, but due to difficulties in obtaining participants, it was agreed by my thesis supervisor that six was a sufficient number of interviews to collect the required data.

Each interview was conducted by the researcher, using the interview protocol (Appendix A), and audio-taped with a digital recorder in order to allow for transcription. Interviews were conducted between March and May of 2008 at the Faculty of Education building on the University of Ottawa campus, which was convenient for participants due to its proximity to the Department of Mathematics and Statistics building. Interviews ranged from approximately 40 minutes to two hours in duration (mean duration: 1:17:49).

In order to maintain a conversational tone and rapport with the participants during the interviews, I did not take any notes, as I felt it would be distracting and would make the participants feel as though they were being 'studied'. However, if I noticed anything significant during the interview, such as noteworthy facial expressions or gestures (e.g., eyes filling with tears), I made notes immediately after the participant left. The interviews were conducted in a relaxed, conversational nature, which including having spontaneous off-topic chats with the participants during the interviews. Bogden and Biklen (1990) highlight the importance of "building a relationship, getting to know each other, and putting the subject at ease" in interviews with participants who are strangers (p. 96). I believe that I increased the participants' willingness to share their mathematics experiences, particularly those that were negative, as we developed a rapport on another level than the content of the interview questions itself.

As previously described, as the interviews progressed, a few additional follow-up questions were added to the interview protocol, as these arose spontaneously during earlier interviews and I felt they were important to include in order to better understand the participants and their experiences. Often, due to the conversational nature of the interviews, the order of the questions on the interview protocol was not followed, although the

questions were all covered. In the event that I missed a question during an interview or needed more clarification, I emailed the participant to ask for this information.

Furthermore, upon completion of the transcription of the interview data, participants performed a member check, wherein "the researcher solicits informants' views of the credibility of the findings and interpretations" (Creswell, 1998, p. 202). Participants were given the choice to receive their entire verbatim transcript or a summary of their transcript data, in order to be considerate of the amount of time they had already volunteered for the study. The participants were evenly split in their choices of file type on which to perform the member check (three asked for the entire transcript; three asked for the transcript summary).

Data Analysis

Data analysis began by transcribing all interviews verbatim, including pauses and relevant non-speech sounds (e.g., laughter). The transcripts provided 174 single-spaced pages of data (28, 33, 17, 31, 42, and 23 pages respectively for each of the interviews). As aforementioned, participants were given the option of receiving the full transcript or a summary via email to check for accuracy; regardless of the participant's choice, I still created a summary for each interview, for my own use. Then, I created two 'fact tables', which summarized the factual information regarding the participants' families and educational experiences.

Next, I re-read the transcripts several times and initiated my analysis by highlighting, in six different colours, the sections of the interviews that aligned with the following categories:

1) Formal Education System, 2) Family, 3) Peers, 4) Personal Characteristics, 5) Questions about the Research, and 6) Other. Further to the colour-coded highlighting of categories, margin notes were made that briefly described what each highlighted section discussed. The first four of these categories are the dimensions of the study. Upon further examination of the 'Questions about the Research' and 'Other' categories, I decided that they did not contain sufficient information that was relevant to the study in order to analyze the data separately. Some of the transcript data that initially were grouped in these two categories were later moved to one of the four dimension categories if they were relevant.

Then, from the highlighted sections of each participant's transcript, I extracted quotations and placed them in separate word processing files for each dimension; that is, each participant had four files assigned to them – one for each dimension (Family, Peers, Personal Characteristics, and the Formal Education System). This resulted in 24 separate files in total. Then, I further examined each word processing file to select the most relevant quotations from each dimension, and created a portrait for each participant, in order to share her story with regard to each dimension. I used each participant's own words as much as possible in order to better include a sense of her individual voice. These portraits do not simply provide facts about each of the dimensions; rather, they also include a clear indication of each participant's feelings regarding various individuals and events. This dimensional analysis for each participant is found in Chapter 5.

I then proceeded to analyze the data within each of the four dimensions across the six participants. For each dimension, I first found sub-topics that were common to all participants. For instance, within the Family dimension, sub-topics included parents' education, parents' careers, and parents' feelings about mathematics. I then created tables that summarized the findings for the sub-topics within each dimension and examined the

data within each sub-topic across the six participants (See Figure 3 for an example of a partial table).

	Allison	Brooke	Chantal	Dana	Elise	Felicity
Elementary mathematics experiences						
High school mathematics experiences						
Transition to university						
…						

Figure 3. Example of partial table summarizing trends in sub-topics in the Formal Education System dimension.

Upon examining the summary tables for the six participants within each dimension, I wrote a comprehensive summary of the findings (See Chapter 6). Finally, I conducted a further level of analysis as I noticed three broad themes that related to several dimensions. These themes related to the importance of supportive relationships, the preference of all participants for applied mathematics, and issues surrounding notions of 'othering'. These themes are discussed in Chapter 7.

Summary

The methodology of the study was driven by a qualitative framework. As the study's purpose was to learn about the lived experiences of women who are 'success stories' in mathematics, data collection via individual face-to-face interviews was appropriate. These interviews explored four dimensions that have been previously shown in the research literature to be significant in women's enrolment and perseverance in mathematics and related fields: the participants' families, peers, and personal characteristics, and their experiences in the formal education system. Brief profiles of the

six participants provided initial insight into the women involved in this research. The chapter concluded with detailed descriptions of the data collection and data analysis methods, both of which maintained the study's focus on highlighting the voices and stories of the participants. As an educational researcher, I brought to this study the skills I attained from conducting a pilot study of a similar nature. Further, as a female with a mathematics degree, I was able to obtain an insider's view into the participants' lives.

CHAPTER 5: DIMENSIONAL ANALYSIS BY PARTICIPANT

In this chapter, I describe the mathematics experiences and stories shared by each participant during her single-session interview. Each participant's experiences are grouped by the four dimensions examined by the study: Family, Peers, Personal Characteristics, and the Formal Education System. If it is appropriate, based on the interview data, each dimension is further divided by sub-headings (e.g., 'Formal Education System' is divided by the level of schooling, such as 'High School' and 'University').

ALLISON

Allison is a fourth year student with a specialization in Mathematics and a concentration in English, in the Francophone sector.

Family

Allison is the second-youngest child in a family of four (two boys, two girls). She lives in a nearby town with her parents and younger brother. Her parents both finished their formal education at the high school level, which Allison described as "the norm back then, unless, you know, you were – lots of money, well-educated, whatever."[2] Her mother works as an office administrator, and her father works as a purchasing officer. Allison feels that her father's job is "a low-level – he makes good money and, if he's happy with it, I'm happy, but it's not a power job, if you get me."

In her family, Allison feels that the girls are expected to do well in school whereas similar expectations are not made of the boys. For instance, when she failed one math course at university, her father was very upset with her, but he did not seem that displeased when her younger brother failed several courses.

> He [her brother] fails, and it's just like 'I don't know'. [...] and when I failed one of my classes, my dad – he wasn't upset because he doesn't get angry, but you could tell he thought, 'Wait a minute – you failed? Why did you fail? How come you failed?' I failed; I feel bad enough as it is. Whereas my brother failed... and wait a minute... something seems to be different. It's not fair.

Allison's perception of a lack of fairness in the way she and her brother are treated is clearly very bothersome to her. Furthermore, she feels as though the boys in the family do not put much effort into schoolwork, whereas the girls are "really, really, really good at school". Similarly, Allison feels that males and females do very different jobs in her household. Her mother tends to do all the stereotypically 'female' tasks; Allison is expected to do these tasks if her mother is not available.

> [...] if somebody's sick, she's the nurturer; she's taking care of them. If she is sick, or she is not there because she's gone off to work or whatever, I take over. It's really that in our household. The women are the nurturers; the men are... lazy.

She further expressed her displeasure at the unfair nature of the household task break-down: "It's not necessarily 'Woman – make dinner' because he [her father] does help out, but there is an expectation of us doing it, of the female parts of the family doing it, which really sucks from my point of view." The one non-gender-stereotypical role that her mother takes on is to look after the household finances. Allison also noted that her extended family members have very traditional gender-role beliefs, which annoys her.

> [...] the extended family, they're all manly-men and women... Ugh! I really don't like the extended family. [Laughter][...] you know: 'Me man. Me strong. Me smart. You go cook.' I mean, I've hated that attitude, but I've never seen it in math.

Interestingly, Allison feels that her extended family members' stereotypical viewpoints do not extend to mathematics. In fact, she questioned the purpose of the study as she didn't really 'see' the gender issues in mathematics. She attributes part of this outlook to the fact that her mother had "raised us that male, female, we're equal". Notably, Allison did not mention anything similar about her father.

Growing up, Allison was a high-achieving math student. She suggested that receiving awards and doing well in math may have been a way to get attention in her large family: "I don't know if it's a child of four, where I wanted my attention, which could be it. [Laughter] [...] It just made me feel good." If she had problems with her math homework, she would often go to her older sister, eight years her senior, for help. The children in the family tended to sit together to do their homework.

Due to her parents' educational backgrounds, she did not go to her parents for help with homework once she began doing more difficult mathematics in high school. She described an incident when she went to her father for help with her Grade 9 mathematics homework.

> He likes to help me, and he likes me going to ask him questions. It was the last time I went because he went all over the place. He did all sorts of calculations and his calculations were right, but he didn't have the thinking process to go from there to there... he went all over there and came back to the point we were at – he never went to where we were going.

She feels that her father really does like math, but that "he's not very good at it". Conversely, she doesn't feel that her mother likes math very much. However, she doesn't feel that "they affected my love of math, but, I mean, their attitudes probably affected my love of school. It's not – it wasn't specific; it was more general."

When it came time for Allison to select a university to attend, she decided on the University of Ottawa so that she could live at home. She felt this was important not only financially, but to provide her with a sense of familiarity during the transition between high school and university. She noted that her parents were not surprised with her choice of subject of study due to her very high grades and her long-standing desire to be a teacher: "It was always expected that I go to university, that I become a teacher [...] So, there was no surprise."

During her time in university, Allison decided to take a sign language course from a nearby college. This decision prompted a very adverse reaction from her father.

> My father actually objected to me taking the sign language course. [...] I thought that was weird. [...] it wasn't a complete shock because he's not much on education [...] he wants you to do it, but it's not a driving force. When I wanted to take the sign language course, he asked, 'Why are you doing that?' [...] especially because it didn't count [...] I think at this point, he kind of wants me to get it done with.

This reaction is very telling of her father's attitude toward education – basically, if it doesn't have to do with her degree and subsequent career, it appears that he feels that it is superfluous. Conversely, Allison pointed out that her mother has a very different attitude: "My mom said, 'Go to university. Get your degree. Set yourself up for a good life.' You know, because your parents want you to do better." She feels that her mom wants her to "do well to feel good about herself" and be "happy in her job and her home".

Peers

High School

In high school, Allison found that her close friends consisted of a small group of males and females with diverse interests. Most of her friends from high school are now attending either college or university in a wide variety of fields of study; she is the only one who is studying mathematics. During high school, Allison found that she was considered "the brain" in her group of friends, with regard to mathematics as well as many other subject areas, but this label was not negative: "My guy friends were not very good in school. [Laughter] At all! [...] my really close friends [...] might have appreciated the fact that I was so good because I could help them [...] but it was never an issue."

However, outside her group of close friends, Allison found that she was treated very differently by the male and female students at her high school. Generally speaking, she felt that she got along well with the males: "[...] the guys were great. [...] I could get

along with any of them, and I was always the pal, and they could always come see me if they needed help or whatever." Conversely, she found that many of the female students were hard to deal with, and she described them as "Barbie-ish". Allison felt that she did not fit in with these girls as she wasn't appearance-focused nor did she drink, smoke, or like to go to parties. They tended to either tease her or ignore her, which she found very hard to deal with; she attributed this treatment to the fact that she was a strong student.

> You know, little jokes, little taunts [...] some of the ones that didn't do as well or didn't apply themselves as well seemed a little meaner to me, seemed a little more – you know, 'You think you're so much smarter than me'. It's not that I think that; I happen to be better. [Laughter] [...] It's not my fault that you're not sitting down and learning the stuff – you're going to a party or whatever. I mean, that was the harder part. But again, within my group of friends, it was never an issue.

One particular incident that Allison recalled that encapsulates the ethos of the school was a school yearbook vote for the student who was most likely to live at home with his or her parents the longest. Allison received the second-highest number of votes, and remembers that the 'winner' was another female who was also a strong student in mathematics and the sciences. Allison did not see how being intelligent would correspond with 'winning' such a category.

> ALLISON: [...] I happen to notice that it was smart girls that happen to 'stay home the longest'. I'm like, 'Why?' I mean, you would think, you know, being smart, I would get out.
>
> JENNIFER: Yeah, get out there and conquer the world.
>
> ALLISON: I mean, I'm still living at home, but I'm making good money and I'm going to get a good job as soon as I get out. So, I mean, there was a lot of stereotypical... you know... the girl – the 'smart girl' thing.

University

When Allison began university, she found it was hard to make friends in her program since she had to commute to the university from out of town, and relied on her

parents and brother for rides. Thus, she did not have much free time outside of class to meet new people. She tends to work on assignments by herself for the same reason. Occasionally, she will work with her peers when assignments are particularly difficult, but she stated that this occurrence was "not all that regular – once every two weeks or once a month or whatever." She recalled only one time where she met with a classmate on a social level.

Although she does not consider herself to be very close to her classmates in her mathematics courses, Allison finds that she is much more similar to them than the 'Barbie girls' in her high school. She noted that the women in mathematics tend to be serious about their work, which relieved Allison, as she had previously been involved with group projects and assignments where the workload was not shared evenly. Allison also feels that the other women in mathematics are very accepting, and she finds that she can speak openly and fits in with them.

> They're not as judgmental about everything else outside of the Math program. They're not judgmental about clothes and make-up and hair – I mean, sure, we're girls and we talk about it, and you know, we'll have comments and whatever, but it's never an issue. [...] You're more accepted for who you are and for what you do compared to outside. [...] Whereas in the Math program, it's a lot more – I can say whatever I want, I can do whatever I want, and nobody's surprised. Nobody acts any differently.

She finds that the women in the mathematics program tend to 'stick together' in a group, regardless of their outward appearance or lifestyle, something she did not see happen in her high school. She does not find this same collegiality with the females in her English classes, so she questions whether it is related to the fact that there are so few women in mathematics.

> Obviously, there are girls in the program who have boyfriends and stuff – it's not that. But even those who do, and even the really pretty – not Barbie, but you could mistakenly think they're Barbie – even them, they're great, and they're never

> judgmental. It might be the fact there are so few of us. It might be the fact that we're a small-knit group. I don't know how boys deal with that. [...] the girls in the group are wonderful. It'd be great if there were more girls, but I'm just afraid, I don't know if we'd lose that.

Allison jokingly wondered if the "math gene takes out the cattiness", referring to the attitudes she's seen from women outside the mathematics department, such as those in her English classes and women at her part-time office job. Allison believes that mathematics, as a discipline, is "so universal; we accept anybody and therefore anybody is accepted", whereas she does not feel this is not the case in other departments, which tend to be more homogeneous.

Personal Characteristics

Allison described herself as someone who "hates to fail". She feels that this fear of failure, though sometimes an unhealthy attitude, has been one of the main factors responsible for her success in mathematics. Her fear of failure has resulted in her taking extra classes, 'just in case'.

> I did fail one or two Math classes, which really hit me. [...] I was just upset. I practically cried. It was terrible. From one of my classes, we have homework, and I just don't understand [...] it's very discouraging. It's not a very healthy attitude, like 'Oh God! I can't fail!' But at the same time, it does push me because I will not fail. [...] I need one class for the summer term. As long as I pass my classes, and so far it looks good. But, as long as it goes well, I need one class. But I'm taking two, in case something happens.

Another characteristic that Allison attributed to her success is her independent nature; however, she sees how this too can be harmful in terms of not seeking help. She described how she enjoys working and spending time alone: "I'm not a social butterfly. [...] It goes a bit with the being independent thing. [...] the fact that I'm happy to stay home and read and do my homework, that helped a lot too."

Allison finds that, while she is very organized, she also procrastinates "like crazy". She believes that her procrastination has worsened since she began university. Particularly, she tends to use other subjects to procrastinate for classes she dislikes.

> I've picked up some bad habits from I don't know where. Again, in high school, it was sort of… you know, I got home, I did the homework, and I understood everything. […] whereas here, especially the […] stuff that I really don't like, I do push it off. It's a horrible – I mean, I'm telling myself it's a horrible thing to do while I'm doing it. [Laughter] I really, really like reading, and I'm reading and I'm like, 'I should be doing my Math homework. I should be doing my Math homework.'

While Allison described herself as an independent worker, she does not like to learn mathematics on her own or from a textbook. She finds she understands mathematics much better when a professor is there to explain the concepts.

> […] when it comes to the math part, I cannot learn math by reading. I really need that personal touch where the professor's explaining it. […] sometimes he's using the exact words from the book, but I prefer having him there with me, and explaining it to me […] it goes so much better. […] I'm very independent in my work, but not very independent in my studying of it, in my learning of it. […] I really need to be in every class and take all my notes.

Finally, Allison noted that she does not have a strong memory for mathematics concepts, theorems, and formulas as they lack a storyline, whereas she does not have the same problem in her English classes.

> I'm not very good at memorizing it. […] In English, it's fine because I feel if it's a story, I can retain it. […] And retaining the story helps me to retain the details, whereas in math, it's not – it's a little bit story-like in the sense that this goes to this, which explains this, which therefore is this… so, I mean, some of those simple theorems and stuff, I get that, and I can do it and I can follow it. But when it's like, 'we're doing this, and we're using this theorem, and we're using this theorem, and we're using this theorem', it's no longer straight, linear; it's all of a sudden going, you know, beyond the box, never mind outside the box.

Education

Elementary School

Allison did not recall any opportunities for enrichment in mathematics in her elementary school.[3] However, she noted that she was always placed in split-grade classes (e.g., Grade 5/6) and would end up doing the higher grade's work, particularly in mathematics, where she felt that her work "seemed too simple; it seemed too easy." She recalled an experience when she was in Grade 5 in a split Grade 5/6 class where she ended up doing both grades' work during special mathematics exercises that were given at the end of each week, as she was bored with only doing the Grade 5 work.

Allison was consistently a top student in mathematics and other subjects during elementary school. She noted that she thrived on competition at this level, and she recalled that "from primary, elementary, high school, most of my competition has been boys." She found that she was particularly competitive with other students in mathematics as she perceived it as more objective in terms of marks. Allison described how the reasons behind her drive to do well in mathematics have changed since elementary school.

> Competing was a big thing too… being the best in the class, and I really like that feeling. I don't get that feeling much anymore. [Laughter] […] As I said, little pond, big pond, but once I got here, it was more like, 'I got the answer'. It's not 'I got more answers than her'; it's 'I got my answer and that's enough'.

High School

Allison attended a French co-educational public high school that had approximately 400 students. Even with the small size of her high school, she found that some of her classes had more than 30 students. Upon the suggestion of her Grade 9 teacher, who saw that she had an affinity for mathematics, Allison participated in the Canadian Mathematics Competition. She participated in it each year of high school, placing among the top

competitors in all of Canada. She appreciated how the awards for her high placements honoured her work in mathematics, a subject in which she feels students do not often receive public recognition.

> [...] the first year, [...] I got a certificate or something, and the other years, I got a medal, which was great because it's a way to acknowledge the work that I did too. That's another thing too – I mean, how are you going to praise a student for mixing chemicals or reading a book... whereas in math, it was: you did the work, I see you did the work, and you did it well.

Allison really enjoyed working with the female teacher who coached the students for the Canadian Mathematics Competition and also taught Allison in class. She described the positive attributes of this teacher as follows:

> She is so bubbly. [Laughter] I love her. [...] she really made it fun for everybody. [...] she's got a huge smile all the time... if you got it right, she's like 'Yes!' You could see she was... just a spectacular teacher. I think she would have been like that in any subject; in math though, it just showed even more because she loved it so much.

Allison also mentioned one male teacher who she also thought was a good teacher, although he differed quite substantially from her favourite female mathematics teacher in temperament and teaching style.

> [...] he was a lot more sedate. [...] he was very serious. He has a very sharp wit, where he's sort of insulting you [Laughter] without necessarily obviously insulting you or stuff. He took the math a lot more seriously, but you could still see that he liked it. He enjoyed doing his problems.

Allison recalled one instance where she had what she considered an unqualified teacher teaching her mathematics class. Allison found that students would end up going to her for help with their questions rather than asking the teacher.

> She was horrible – she 'happened' to get her teaching degree. She wasn't a math teacher. [...] She had an accounting thing, and she was teaching math, right... She was horrible. I remember students actually lining up at my desk for me to answer their questions because she couldn't answer them.

University

When Allison began university, she did not have difficulties adjusting to the significant increase in class sizes. She described herself as a "very independent student", but she stated that she will go get help from professors when she needs it. Allison did not know anyone in her classes when she began university, but she feels that this may have actually benefited her in-class attentiveness to the professor.

> I'm listening to the teacher and I'm doing my thing, being a good student; I didn't really miss anybody, you know, next to me, or around me. And again, sitting in front, I don't look in the back. [...] Having no friends in the program either [...] made it more natural to be, you know, one in 150, because I didn't know anybody, so what else was I going to do but sit there and listen?

However, she felt that she was behind the other students in terms of her content knowledge in mathematics when she started university. This is due to an experience in her Grade 12 Calculus course, where the teacher left out an entire unit of the course. Allison has found that her university professors in first year assumed that students had seen this material, so it was rushed through and not explained. Allison did not feel comfortable asking about this material in her large first year classes, but when she went to see the professors one-on-one, she found that "they've always been very willing to take the time".

Allison's mathematics courses were so large in first and second year that they had to be held in auditoriums. However, in third and fourth year, when the students in the classes were strictly mathematics majors, she found that "it got really cut down". Her classes now generally contain between 10 and 30 students. She perceives that there have been more males than females in her mathematics classes for all four years of her degree, although she generally sits at the front with a small group of other female students, so she does not often notice the other people in her classes. This perceived gender imbalance in

her mathematics classes has never been a problem for Allison, as she feels she has been treated equally by the male students.

> I've never felt it was an issue [...] I've never had any of them hit on me or be, you know, extremely superior because they're male or anything. [...] they've all been really great and we're just students. [...] there's never been any, you know, 'coddle them because they're girls' or you know, 'treat them differently because...'

Allison has only had two female mathematics professors over the course of her four year degree, but she does not recall any inequitable treatment of the male and female students by any of her professors.

Allison described two mathematics professors who she thought to be exceptionally good. The first professor is one about whom she claimed, "It doesn't matter who you talk to, male, female, third year, second year, first year – [professor's name] will come out in every single conversation you do. He's really one of the good ones." She finds that his manner of teaching is "very straightforward, very logical", and she appreciates his organized, ordered explanations of mathematical concepts. Although Allison finds the second professor not nearly as well organized as the first one ("He's really bad at giving notes and all that."), she finds that he is very supportive of students and believes in them. She explained how after she failed a class, this professor allowed her to take another class that required, as a prerequisite, the class she had failed: "He was willing to sign off on me taking that other class because he knows I've seen the material. [...] when I did have problems, I could go see him."

On the other hand, she has had one professor whom she finds is neither supportive of students nor clear in his explanations of the mathematics material.

> ALLISON: He's one of those that you can't go see him. [...] I think they force him to have office hours. [Laughter]
>
> JENNIFER: He would prefer if you didn't go. [Laughter]

> ALLISON: Exactly, because the few times I've gone to see him at the end of class or I've asked a question in class – I even went to his office once… he seemed very 'you should know this'. Well, obviously I don't – that's why I'm here […] because I don't understand and I would like you to explain it to me… and grudgingly, he's like 'na na' and then he explains it the exact same way.

Reflecting on her degree at the end of her fourth year, Allison feels that she has been fairly happy with her university experience. She does wish that she had more space in her schedule for electives, particularly in the social sciences and languages. She also finds that she has not enjoyed the required mathematics courses that are very theoretical in nature.

> […] there were so many required classes […] where it's proving these theorems of, you know…[…] when you're trying to prove stuff and theorize things about four dimensions, it's like 'Dude – no offense, but I'm more practical; I'm more hands-on than this'. So, I mean, the number of […] required classes that are theoretical, it bothered me a bit.

Allison is in the Francophone sector, but she finds that she has had to take nearly all her upper-year mathematics courses in English, due to the low enrollment of Francophone students. She noted that some of her professors in English-language mathematics courses would allow her to submit homework in French, but this was to the discretion of individual professors. Allison feels more comfortable doing mathematics in French, as she finds that she sometimes will not understand what a professor is talking about because of the use of English mathematics terminology.

Career Aspirations and Further Educational Plans

Allison hopes to become a high school mathematics and English teacher, a career she has aspired to since she was in the first grade. She plans to begin her studies at a Faculty of Education this fall. She feels that teaching at the high school level is a good fit for her as she likes the mathematics and English curriculum content at that level, plus the

fact that students will already have a background in those subject areas. She wants "more the difficulty of thinking and not the difficulty of helping them apply".

Allison stated that she is not interested in further education in mathematics as she feels it will become too theoretical and will move away from the types of mathematics that she enjoys.

> I really like playing with the numbers and applying and figuring stuff out, which is why I like the probabilities. It's still simple math; it's the thinking of how to do it and how to make it work and stuff. But if I went further in the math, it would have to become theoretical.

She would, however, consider doing graduate studies in English as she feels the work would not become as theoretical as mathematics. She potentially would be interested in becoming a university English professor at some point.

View of Mathematics

Allison enjoys mathematics for several reasons, and describes herself as "fascinated" with numbers. She likes "the way it works, how it always adds up… there's always an answer". She recalled an instance where she struggled with a difficult mathematics problem, and then was elated when she finally was able to get the answer.

> I said, 'Oh my God! The answer is right! Yes!'[…] Then, one of my old teachers was passing by, and asked, 'Allison, what's going on?' And I said, 'Oh my God! I got it right!' and he was all excited, and I said, 'This is why we're in math because there is an answer, and we can find it.'

Interestingly, she chose to study English for essentially the opposite reason – her perception that "there was no answer – there is never an answer". She enjoys the critical thinking, reading, and imagining in her English courses. She loves being able to read the same work as someone else and "take from it all these different things".

Summary of Allison's Mathematics Experiences

In Figure 4, a summary of the supports and challenges experienced by Allison, with each dimension denoted by a different colour, is presented. The items in the left circle, such as 'Determination' and 'Participation in mathematics contests', were supports for Allison. The items in the right circle, such as 'Female peers in high school' and 'Procrastination', were challenges for Allison. The items in the intersection of the two circles, such as 'Father' and 'Fear of failure', were both supports and challenges for Allison.

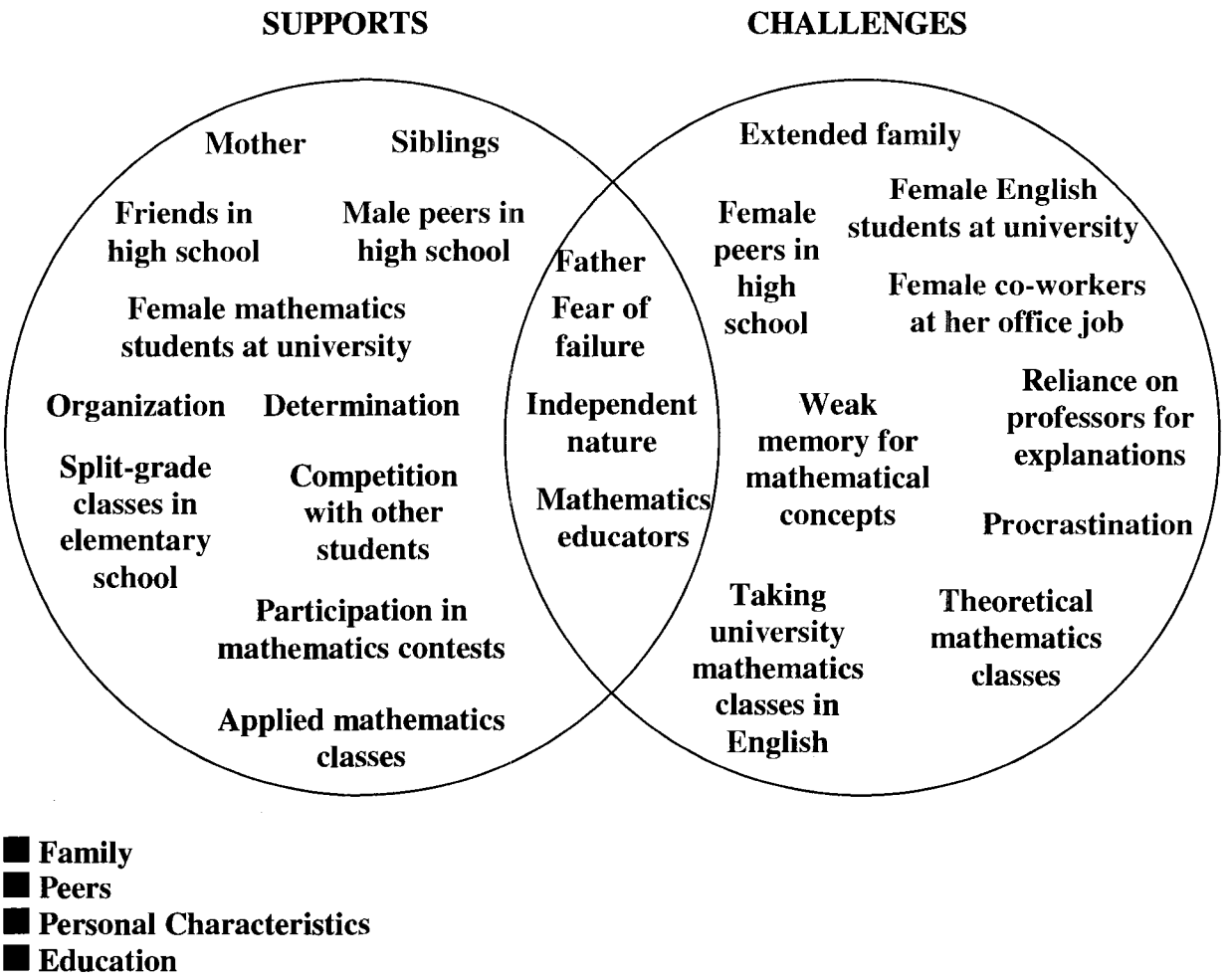

Figure 4. Summary of supports and challenges for Allison.

BROOKE

Brooke is a fourth year student with a double major in Biology and Mathematics, in the Anglophone sector.

Family

Brooke's family consists of her mother, father, and one brother, three years her senior. Her mother has a Biology degree, and currently works in human resources. Her father has both an Economics degree and a Theology degree. He has been a priest for the past 20 years, but he previously was a businessman. Brooke noted that her parents "both needed math and they both used math in their degrees and in their lives".[4] With regards to her interest in mathematics, Brooke feels that "They've been pretty nurturing in that aspect. They've been pretty accommodating for anything I want."

Brooke's interview provided evidence that parents have been very supportive of her love of mathematics, which was apparent at a very young age. She described how her mother would create fun mathematics resources and games for her, when she was a child.

> [...] my parents went out for dinner with some friends of theirs and everything, and I was bored, so my mom would write me a little booklet of math questions for me to do. I've always loved it! [...] I'd set up things, I'd put price tags on everything around the house, and my mom would have to buy it and I'd have to add it all up.

Brooke's parents would also allow her to attend her older brother's tutoring sessions, where the tutor would provide her with questions that were three grades above her level. Upon being questioned about how her brother felt about his younger sister tagging along to his tutoring sessions, Brooke stated: "[...] he knew that I was academically better than he was, but he didn't really care because he didn't really care about school." She also noted that the tutor was careful to assign her different questions from her brother so there was no direct comparison.

Another formative experience for Brooke was spending the majority of her pre-school time with her father as her mother was working long hours at a hospital. She feels that this time spent with her father increased her exposure to 'masculine' activities.

> [...] before I started school, I'd follow my dad around a lot. He'd take me on his trips and stuff like that. So, I probably had more of an attachment with my father at that time. [...] So, I probably did more of the guy stuff, I guess, because I hung out with him for the first five years of my life.

This exposure to activities that fall into stereotypically 'masculine' categories continued as Brooke was growing up. She attributed part of her exposure to 'masculine' activities to the fact that her brother was focused on computers whereas she "kind of wanted to do a little bit of everything". In their household, Brooke finds that her mother does most of the cooking, but her parents usually do the other chores together. Interestingly, her father is responsible for sewing, a stereotypically 'feminine' task, a skill learned from his own father, who was a tailor. Brooke noted that household chores for the children were always evenly distributed.

Brooke's childhood experiences were very different from most children, as she was a priest's daughter: "You learn a lot of things quicker than other kids would. But... in regards to certain things, I feel like I was quite naïve." Being in the spotlight in her small town was also significant to Brooke's childhood.

> [...] it's like you're famous, just because everybody in parish knows you, so they've known you since you were two [...] and you grew up in that atmosphere and everybody knows you, and if you do one thing – everybody knows everything about your life. And if you do something different or something wrong or something – you know, if you get a speeding ticket, God forbid. [Laughter] Everybody knows about it and everybody talks about it.

However, she felt that both she and her brother dealt well with the pressure of being in the public eye, and have avoided becoming the stereotypical priest's children: either very rebellious or very pious. With regard to the two extreme stereotypes, Brooke stated that,

"my brother and I have a pretty good balance between the two of them." However, when Brooke moved to Ottawa in her third year of university (after living at home with her parents prior), she felt relieved by her newfound anonymity: "When I came here, it was kind of nice because I'd go somewhere and nobody knew me, and I could walk around and be one of the crowd."

When Brooke decided to change her career plans from wanting to become a veterinarian, and add Mathematics as a second major to her Biology degree, she found her family very supportive of this change. She feels that they will be content with whatever career path she ends up choosing, as long as she is satisfied.

Brooke's relationship with her brother is particularly important to her. She currently lives with him, plus considers him one of her closest friends, more so than anyone she's met at university. Brooke took a semester off university this year so she could spend time travelling in Europe with her brother during his time off from his foreign military appointment. After debating with herself prior to making the decision to take time away from her studies, she realized that this educational sacrifice was worth it.

> [...] this is my one and probably only opportunity to go, and probably my last time to go with my brother because by the time, you know, if we end up having another opportunity, he'll probably be married by that time and... [...] We're not kids anymore, so I was like, 'Screw it! I'll take the semester off and work.'

Brooke is very close to her entire family and feels that they have been helpful and nurturing with all her experiences growing up, both in mathematics and otherwise: "They've been a pretty good family actually."

Peers

High School

Brooke found that she got along with "everybody in high school", and was friends with people from diverse groups, such as the 'jocks', 'popular people', and 'punks'. Her close group of friends included students who played in the school band and were in mathematics classes with Brooke, particularly the very small senior mathematics classes. From her group of close friends, Brooke recalled that everyone went to university for similar fields of study: "I think more than half of them were Engineers. [...] The other half was probably Science. I don't think anybody did any kind of Social Science or Arts or anything like that." However, she was the only one who went into Mathematics.

University

Brooke currently lives with her brother on an army base, so that has affected her social interactions, as all her peers are male. Although she feels that she has a good balance between 'masculine' and 'feminine' activities in her life, she found it tough to be around 'army guys', who she feels "have a different mind structure than a lot of females, that's for sure". As the only female on base, she felt she basically had two options in order to cope socially with the situation.

> [...] it was either, you know, you were the promiscuous female on base, or you were one of the guys... so, of course, I chose to be one of the guys! [Laughter] [...] Not a hard decision. [Laughter] [...] I took on a kind of tomboyish, kind of 'kick back with one of the guys' kind of thing when I moved here. [...] I grew up doing a balance between doing guy things and girl things. But when I moved out here, it was kind of a shock, gender-wise.

When a soldier's girlfriend moved onto the base, Brooke enjoyed the opportunity for 'girl talk', which she found to be "completely different" than talking with the guys on base. Brooke usually spends her social time with her brother and his friends from the army rather

than peers from her mathematics classes or extra-curricular activities. In terms of her peers from her mathematics classes, she described her relationship with them as follows: "I'm [...] friendly to a lot of people, but I don't have a lot of really close friends."

As Brooke is taking a double major in Biology and Mathematics, and takes all of her electives in Psychology, she has been around the female students in these three fields sufficiently long enough to notice substantial differences. Brooke finds that "Math majors are more geeks than Bio majors. [Laughter] I hate to say it, but I'm in it so I can say that." Also, she notices that Biology majors and Mathematics majors tend to complete undergraduate degrees in their fields for different reasons. Brooke feels that the Biology majors usually have "a greater purpose", such as medical school or veterinarian school, and the Biology degree simply acts as a stepping stone. However, she believes that the Mathematics majors "are doing it because they enjoy math. [...] Math is their priority; math is their goal." She also notices that 'math people' tend to notice patterns in the world and think in a different manner. Brooke feels that the women in Psychology are different from those in either Biology or Mathematics. She considers women in Psychology to be 'Valley Girls', and does not feel that she fits in with those women. However, she does not feel that she fits in with the females in Mathematics either as they are much more introverted than she is, particularly women in lower-year courses.

> The girls in my math class seem very quiet. [...] I've tried to strike up a conversation with some of them, but they've just – they're all kind of very in on themselves. [...] I don't mind asking them for notes or whatever, but a lot of the girls in my math classes seem to be a little more shy. Especially – I'm taking a second year math class right now and those girls especially seem to be especially in on themselves and just like... it's me against everybody else.

Brooke feels that she fits in best with the women in Biology, as she feels they are more serious about their studies than the Psychology students, but more outgoing than the Mathematics students.

> They're pretty friendly, Biology students [...] I don't think they're as quiet and closed in as the Math girls are, but they're all the ones who are trying to get into vet school or med school or whatever, so they're serious about their studies but at the same time, they're fairly laid-back [...] I'm probably more Bio – not oriented, but that kind of personality, I guess. [...] Yeah, because I'm not as introverted as the girls in Math and I'm not as Valley Girl as the girls in Psych. [Laughter] [...] To put it bluntly. [Laughter]

Notably, Brooke remarked that the male students in her mathematics classes are very different from the female students – more outgoing and friendly.

> The guys are like typical university, you know, college guys. They're pretty loud and they're excited about lots of things. They're pretty nerdish, a couple of them. You get the nerdish kind of guys, but you get that in any class. [...] The Math guys, they don't mind talking. I probably talk to more guys in my Math classes than girls, just because they seem to be a little more friendly. They seem to be willing to talk about things. [...] The guys don't mind helping out or anything like that, but the girls are like, 'Well, you can see this if you want'. They're very shy about it.

Personal Characteristics

Brooke feels that one of the most helpful characteristics during her educational pathway is her determination, although she noted that she only perseveres to a reasonable point.

> I don't give up very easily. But there is a point that I'll say, 'Screw it! I'm not doing it anymore!' But I try to get through it as much as I can. I'm pretty strong willed, pretty stubborn when it comes to a lot of stuff.

Her stubborn nature is also beneficial in that she won't let anyone tell her what she can or cannot do; indeed, she is more driven to do something if someone tells her she can't do it. Brooke shared the following experience from one of her psychology classes:

> [...] And it's funny because psych professors always ask, 'Who's a Psych major? Who's another major?' And if you tell them you're a Math major, they'll say, 'I don't think you're going to get this very well. I don't think you're going to do very

> well in this class.'[...] And I'm always like, 'Why?' And they'll say, 'Because you have to do a different kind of abstract thinking.' I was like, 'Have you ever done a Math major? Because there's lots of abstract thinking!' [...] as soon as someone says 'You can't do it', it makes me want to do it even more. [...] It's probably like a lot of people, but I've always been like that. So, if my Psych professor says, 'You're probably not going to get this very well', I'll be like, 'I'll just show you how well I can do!'

She believes that her tomboyish nature has also helped her along her pathway in a stereotypically 'masculine' field of study. She feels her balance of "guy stuff and girl stuff" has helped her avoid the stereotypes such as 'guys are better at math'; Brooke doesn't think that she's ever "fallen into a certain stereotype".

Another characteristic that Brooke feels has contributed to her success is her ability to "go with the flow". She described how she changed her career pathway as follows:

> When I first started university, I was going to do four years of Biology and four years of vet school and I was going to be a vet and that was it. But you know, things happen and things change, and you just kind of go with the flow and take it one day at a time – but if it doesn't work out, then it doesn't work out.

Conversely, Brooke feels that her competitive streak has been somewhat detrimental to her success, especially during the transition from being a top student at high school to an 'average' student at university.

> At first, it was probably my competitive streak, because I was always – you're in high school, of course you're an A average all the time, and then you come to university and you end up being average for a while, and you're like 'What is this?' [...] You're more competitive, but at the same time, you have to learn how to work with people instead of competing with them all the time. So, that was probably... it took me a while.

Related, she finds it hard to work in groups because she doesn't want to look stupid or hold the group back. During her first couple of years at university, she found it very difficult to ask a question or go to a professor for help. However, she does not have a problem with either of these actions anymore.

> I'm not a big fan of group projects. Even group studying – if you don't get it and everybody else does, you feel embarrassed about it. So, I think that's probably – it took me a long time to maybe ask people for help. [...] And that was probably the biggest thing. It took me a long time to go visit a professor and ask them for help. I didn't do that my first year; I wouldn't go up – I don't know why. Maybe I was shy, maybe I was embarrassed. Now, I don't really have a problem. I'll go up and ask. But it took a while to get over that. [...] But now, I'm just like 'Whatever'; if you think I'm stupid, you think I'm stupid. I don't care. [Laughter]

Education

High School

Brooke attended an English public co-educational high school in a small town in Western Canada, with a graduating class size of approximately 100 students. She did not remember there being any enrichment programs, mathematics contests, or other such special opportunities at her high school. She described her Grade 12 Calculus class as being a memorable experience.

> [...] we were all friends, and we could all work through it together. It just made it that much more enjoyable, you know? And of course, the one-on-one relationship with the teacher is that much greater because you have 12 students in the class. So, that was a lot of fun. And – whereas all the other classes are – people are taking the bare minimum to get into university where we took as much as we could, you know, to get better prepared. We were all the students who wanted to go to university and wanted to do well, whereas everybody else was just like, 'I just need to get out of high school!'

Brooke recalled one high school mathematics teacher who had trouble getting her point across to students.

> She knew what she was talking about, for sure, but it was just hard to get her point across and for us to realize what she was talking about. But she wasn't a bad teacher at all; you could just tell that there was that little bit of difference where she just couldn't get it across as well as she wanted to.

University

Brooke completed her first two years of university in Western Canada. She began in a Biology degree program, with career aspirations of becoming a veterinarian. Brooke

found the transition between her small high school and the large first year classes at university to be "a big culture shock". She did not feel adequately prepared for such a large change, but eventually adapted and found study methods that worked for her.

> High school is kind of a joke compared to university, really. So, it was kind of intense to see 500 students in your class and you end up just being a number; you're not a student any more. So, it's kind of a shock, but you adjust to it and you kind of figure out your own specific studying methods and how you're supposed to get along with everybody… so, you find your group of people that you can study with and hang out with. The first year, first semester was kind of a shock because going from 12 to 500 is a big difference, but at the same time, it was all very exciting because it was all new, and it worked out eventually.

Brooke found that she didn't ask questions in her large first year classes at university as she felt intimidated, but she noted that "fortunately, I didn't really need to", as she understood the material in her courses. She is, however, willing to go to a professor if she has questions. In general, Brooke prefers to work on homework and study on her own, as opposed to working with classmates. She feels she is "pretty independent when it comes to that kind of stuff".

As Brooke progressed though her Biology degree, she became increasingly disenfranchised with the university she was attending in Western Canada. She felt that it was very disorganized, and that international students were getting priorities over Canadian students. Furthermore, she was not given the opportunity to take courses that aligned with her degree.

> I was a Biology major and the only classes they were offering me or letting me take were computers or math, and I was like, 'This isn't helping me with my degree!' […] it was just really frustrating. I couldn't register for any of my courses or whatever.

Brooke had talked to her older brother about her displeasure with the university, and he suggested that she move to Ottawa, where he lived, and attend university there. Brooke applied, was accepted, and began her third year of her undergraduate degree at the

University of Ottawa. At this point, she also added Mathematics as a second major. She explained her reasoning behind this choice as such:

> I wanted a back-up option and I've always enjoyed math, so I thought math would be a good idea. There are lots more jobs you can get with a Math degree as opposed to a Biology degree, unless – really, the only thing you can do with bio is go into grad studies or go into med school or vet school. You can't really go into the government or anything like that, whereas in math, there's a lot more programs you can do with math.

At this point, nearing the completion of her second year studying at the University of Ottawa, Brooke is very happy that she changed universities: "I really like this university. [...] it flowed so much better than [the previous university]."

Brooke has found that her class sizes have decreased every year, from a few hundred students in her first year classes to approximately 50 students in her third and fourth year classes. She has also noticed that the proportion of male students in her mathematics classes has increased as she has progressed through her degree. She noted that the proportion of females is "usually between 30 and 45 percent, unless it's the stats class and then it's probably 50-50." Brooke also mentioned that she has only had one female professor in mathematics, and that was in a statistics course. Conversely, in her biology classes, she feels that approximately two-thirds of the professors are male; in her psychology classes, she believes that it is "probably an even mixture".

Brooke has found that her mathematics professors are "a completely different breed of people". She finds that they are extremely intelligent and have a lot of eccentricities. She described one of her professors as being "this hippie professor who comes in, and he's like, you can tell that he's probably not married and he works on math proofs all the time in his free time." She said that she "gets a kick out of them", and she thinks that they are "a lot of fun". However, Brooke finds that some of her professors have trouble getting their point

across, which she attributes to their being "just so smart". She finds that these types of professors "just whip through the board, writing everything down, and you ask them a question, and they just look at you like, 'Why don't you understand this? This is easy!'". She has also been frustrated by professors who do not speak English clearly.

Career Aspirations and Further Educational Plans

Upon completion of her degree, Brooke is hoping to attend a foreign university to attain a master's degree in Forensics. She then hopes to work for one of Canada's intelligence agencies. However, she has also considered further studies in other fields. Since she has taken so many electives in Psychology, she is considering doing a second undergraduate degree in that subject area. She also noted that she has considered doing a master's degree in Mathematics: "I don't know what I would do it in yet, but I've considered it, for sure."

View of Mathematics

Brooke recalled that she has always loved mathematics, ever since she was very young. She remembers her mother making up mathematics games and activities for her, and she would attend her older brother's mathematics tutoring sessions for fun. She has always found that math just 'clicked' more for her than other subjects, even closely related ones such as physics.

> I've always enjoyed that kind of stuff. [...] I like solving problems, I like the challenge of it – it's not just rote memorization of something; it's something you can apply to other things. But the funny thing is that I've never liked physics. [Laughter] [...] That's really strange, but it just – math just seemed to make much more sense. I don't know what it is. I've always just really enjoyed it – it's just a lot of fun.

Her interest in applied types of mathematics is apparent in her favourite university mathematics courses.

> I've taken a lot of stats classes for some reason. [Laughter] Apparently I like stats. But I like discrete math – it's a lot of fun with the probabilities and stuff like that - they're interesting. Algebra is pretty fun too, but not the proofs. I'm not a big fan of proofs. [...] I think it is more those abstract math classes where I'm like, 'What's the point of this? This is definitely something I'm not ever going to use.'

Summary of Brooke's Mathematics Experiences

In Figure 5, a summary of the supports and challenges experienced by Brooke, with each dimension denoted by a different colour, is presented. The items in the left circle, such as 'Close relationship with her brother' and 'Parents' nurturing of her mathematics interest', were supports for Brooke. The items in the right circle, such as 'Female mathematics students at university' and 'University attended in Western Canada', were challenges for Brooke. The items in the intersection of the two circles, 'Living on army base' and 'Mathematics educators', were both supports and challenges for Brooke.

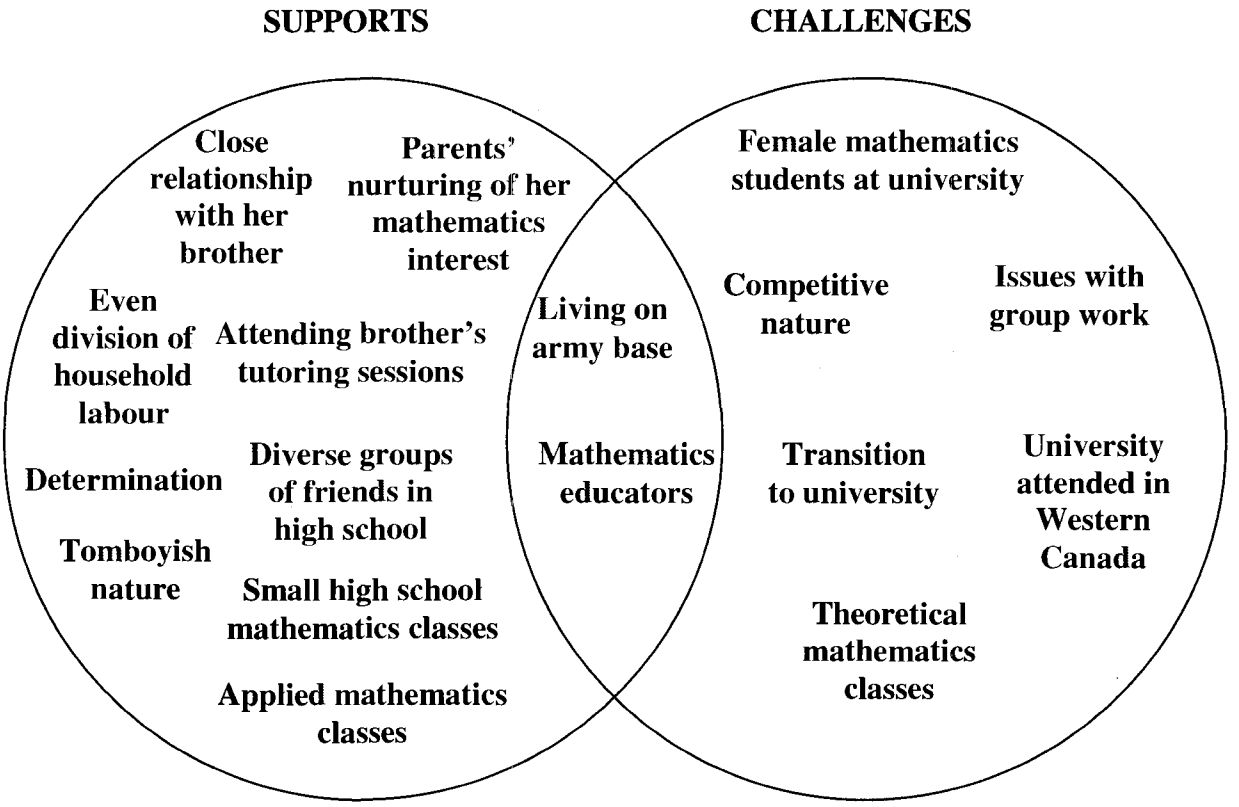

Figure 5. Summary of supports and challenges for Brooke.

CHANTAL

Chantal is a third year student with a concentration in Mathematics, in the Francophone sector.

Family

Chantal's family consists of her parents and two older sisters; she lives at home with her parents, but her sisters have moved away from home. Her parents immigrated to Canada from Haiti, which has a culture described by Chantal as: "The woman – not wears the pants – but she's more… I don't know. It's more matriarchal."[5] Her parents completed the majority of their education in Haiti. Chantal's mother attained her college diploma in Nursing when they moved to Canada, and currently works as a nurse. Her father has a high school education, and works as a driver at an embassy. Her older sisters were educated and work in mathematics-related fields: one is an accountant and the other has a degree in Finance and works in human resources. Chantal acknowledged the impact that her sisters had on her educational pathway.

> JENNIFER: So, when you were growing up, did you find you really looked up to your sisters?
>
> CHANTAL: Yeah, I think I did, yeah. I really followed in their footsteps until I got to CEGEP because they did Sciences Humaines […] And I went into Science. But still, pretty much followed them… I went to the University of Ottawa; she went to the University of Ottawa too.

Growing up, Chantal recalled that her father would help her with her homework, particularly her mathematics homework; she feels he "is pretty good at it". However, she does not feel that her mother uses mathematics very much nor did she have an impact on Chantal's views of the subject. Due to her parents' education being mostly outside of Canada, Chantal found that they sometimes could not help her with mathematics

homework. So, she would turn to her older sisters, aunt, or uncle for assistance. Nobody in Chantal's extended family is in mathematics-related fields, but her aunt and uncle "were strong in it" so they could assist her.

When Chantal decided to begin her university degree in Mathematics after taking Pure Science in CEGEP (a post-secondary institution in Quebec required prior to beginning university), her parents were surprised by her choice of field of study. However, Chantal noted that they supported any choice she made: "My parents were actually surprised. They thought I would go into computers. [...] but they never put any restrictions, so it's pretty loose." Chantal attributed her parents' lack of stereotypical gender-role attitudes (regarding various topics, such as fields of study and household tasks) to their upbringing in Haiti, a matriarchal culture where "anyone does anything".

Peers

High School

Chantal attended an all-girls French public high school where the students were required to wear uniforms. She found that her grade cohort was pretty close: "There were still cliques, but it wasn't – well, some people did get picked on. [Laughter] Yeah, it happens, but not as much [as at schools without uniforms]." She found that she liked everyone, and was well-liked by her peers, so she "didn't have any problems." Chantal's group of close friends included girls who were from a variety of different cultures, and who were involved with the school's competitive dance team.

Her friends from high school have gone into very diverse fields. At CEGEP, only one of Chantal's friends was in Pure Science with her; the rest were in various social sciences. Similarly, at the university level, she is the only one of her high school friends who is studying Mathematics; her friends are mostly studying in social science fields.

Chantal has stayed in close contact with her friends from high school, and would be more apt to get together with them for social outings rather than friends from university.

University

In university, Chantal has made a couple of close friends from her mathematics classes, but mostly spends her time with them in academic endeavours.

> JENNIFER: [...] in terms of people in your classes now, do you get together with them to work on projects and assignments or study, things like that?
>
> CHANTAL: Yeah, we do a lot. We see each other almost every day. [Laughter] And we have breaks at the same time because usually we have the same classes, the same schedule – so, we have breaks together and then class and then another break together and then class, so we're always together.
>
> JENNIFER: Okay, so you'd just say, 'Okay, in this break, we're going to study whatever, or work on such-and-such an assignment'.
>
> CHANTAL: Yeah, or sometimes we'll just go our separate ways, but we always meet up right before class, yeah.

When comparing herself to the other women in her mathematics classes, she feels that they are similar to her in the manner in which they think and the fact that they are all determined individuals.

> [...] the way that we think... the way we approach things, I guess. [...] we're more – I guess if I compare it to my friends, we're all different, but I think in the way we approach things, like problems and stuff like that. But yeah [...] we don't give up. We'll still try to figure it out and work at it.

The main difference that Chantal has noticed between her and the other women in mathematics is that they tend to take more sciences, whereas she takes arts, for electives.

Personal Characteristics

The key characteristic that Chantal attributed to her success in her various mathematics experiences is her determination. She described how she will persevere

regardless of difficult situations: "I think not giving up even though it was hard or I didn't do as good as I thought I would, to keep going… that has helped me a lot."

On the other hand, Chantal admitted that she procrastinates quite a bit, which has "not helped", but she has been working on improving on this problem. Another detrimental quality Chantal described is her tendency to doubt herself and her abilities, which leads to her doing poorly at school. However, Chantal explained how she is able to get herself out of this cycle of negativity.

> CHANTAL: I noticed that as soon as I doubt myself, I'm not doing good […] immediately. And I know it's because I wasn't sure of myself and I wasn't confident enough. When I'm confident, I'm okay. So yeah.
>
> JENNIFER: So what do you do then if you notice, 'Oh no – I'm getting myself in the cycle of not feeling good about it' – so then, what do you do to get out of that?
>
> CHANTAL: I try to tell myself – I'll have a fresh start. I'll say, 'Forget about it; that happened, but it's the past, so keep going. Try to do the best as you can now'.
>
> JENNIFER: Do you find that tends to work?
>
> CHANTAL: Yeah. And I try, if I have negative thoughts, I try to switch it to positive.

Education

High School and CEGEP

Chantal attended an all-girls French public high school in Quebec, where she was enrolled in the International program, for which a test was required for entrance. This program included a wider variety of courses and a focus on community service. Chantal described how the program was more challenging than the regular-stream classes: "It's an enriched program […] more classes and it's more demanding". She found that her high school was very supportive of students, in that one period per day was set aside for 'recuperation', where students could go see teachers individually for assistance. Chantal

noted that students could choose to attend this period or that the teacher could request that they attend, if they were having difficulties in the class; in the latter case, Chantal felt that the students were "very followed".

Chantal recalled that her high school science teacher impacted her choice of Pure Science as a field of study at CEGEP. Chantal noted that this teacher was "really, really, really passionate". Chantal feels that good teachers "put themselves in the shoes of the students and try and make them to understand it on their own instead of just giving them the answer", and she believes that her science teacher did just that. Chantal also recalled having good mathematics teachers in high school, though none of them had the impact of her science teacher.

Chantal took Pure Science at CEGEP, which included courses in biology, mathematics, chemistry, physics, French, English, and philosophy. Her classes generally had between 30 and 40 students in them. She did not recall any exceptional teachers or experiences during her time at CEGEP.

University

When it came time for Chantal to attend university, she had trouble deciding on a course of study. The guidance counsellor at her CEGEP suggested that she take an arts degree as it would allow her more freedom to choose classes; thus, Chantal decided to take a B.A. in Mathematics. She described her reasoning as follows: "I went with Math – well, because I did Science and I like math, so I said, 'Why not?'" Chantal will graduate this year, and feels happy with her choice of program.

Chantal is in the Francophone sector, but she has noticed that her classes have been offered more often in English as she has progressed through her degree. Chantal only applied to the University of Ottawa (as opposed to Carleton University, an English-

language institution in Ottawa) as it is a bilingual institution, and she wanted to do her Mathematics degree in French. She noted that she was initially afraid of taking mathematics classes in English, but she has now become used to the differences, including terminology.

Chantal has found that her mathematics professors have mostly been "very good". She noted that they not only were good at conveying the subject matter, but they also were helpful with out-of-class matters: "[…] usually what they say would be true, not just in math, but in your university experience also, they had some good tips." She has also had a few teachers who did not explain the mathematics concepts very clearly: "[…] they'll just write the formula and it's like, 'Plug it in and find it' – no really, no explanation."

Over the course of her degree, Chantal's classes have not changed drastically in size, primarily due to the fact that there were very few students initially in the Francophone sector of the mathematics program. In first year, Chantal noted that all her classes had approximately 50 students in them; now, her French-language mathematics classes have "like 10 at the most" whereas she has some upper-year English-language mathematics classes that have had waiting lists and class sizes over 50 students.

In terms of the gender balance in her classes, Chantal has not noticed a consistent pattern in terms of the ratio of male to female students. She stated that her statistics courses generally have more females than males in them. However, she noted that the cohort of French mathematics students is so small that these changes are not that significant. Chantal recalled having two female mathematics professors over the course of her degree, compared to six male mathematics professors.

Chantal generally does not ask questions in class, but feels that she is more willing to ask questions when her classes are smaller. She explained why she doesn't often ask questions in class as follows:

> I think normally in classes, sometimes usually when it's in the morning, I'm just tired and I'll just take notes and try to figure it out. Because usually I'll have a question, but then I can figure it out on my own, so I don't really ask it in class. [Laughter] I usually don't ask that many questions during class – sometimes I just don't follow and then I'll go over it again and I'll 'Oh!'. I'll understand.

If she doesn't understand something in class, Chantal tends to ask a classmate for help first; if the classmate cannot assist her, they will go to the professor together to get help. Chantal finds that she often will work on assignments and homework with her mathematics classmates.

Career Aspirations and Further Educational Plans

After Chantal graduates from her Mathematics degree this year, she plans to begin a second undergraduate degree in Statistics, with a minor in Economics. Since she has already taken many of the required courses for the Statistics degree program, she believes that she will be able to finish "in almost a year or a year and a half, so it'll be fast". She is hoping to work in a statistics-related field when she graduates from her second degree. Chantal noted that she would be potentially interested in doing a master's degree in Mathematics, but that she would like to spend some time working first.

View of Mathematics

Chantal has found that the more mathematics she takes at the university level, the more she has become engaged with the subject area.

> [...] it's pretty cool what you can do with it, actually. The stuff they do, I'm always like, 'Oh really? I didn't know that!' Because at first, I thought it was just going to be numbers and calculations, but it – the more I get into it, the more I like it.

She also noted that statistics is her favourite type of mathematics, and that she finds that she struggles with more theoretical types of mathematics: "I like it more applied".

Summary of Chantal's Mathematics Experiences

In Figure 6, a summary of the supports and challenges experienced by Chantal, with each dimension denoted by a different colour, is presented. The items in the left circle, such as 'Parents' non-gender-stereotypical attitudes toward education or careers' and 'Determination', were supports for Chantal. The items in the right circle, such as 'Doubt in mathematical abilities' and 'Early morning timing of university mathematics classes', were challenges for Chantal. Located in the intersection of the two circles, 'Mathematics educators' were both a support and challenge for Chantal.

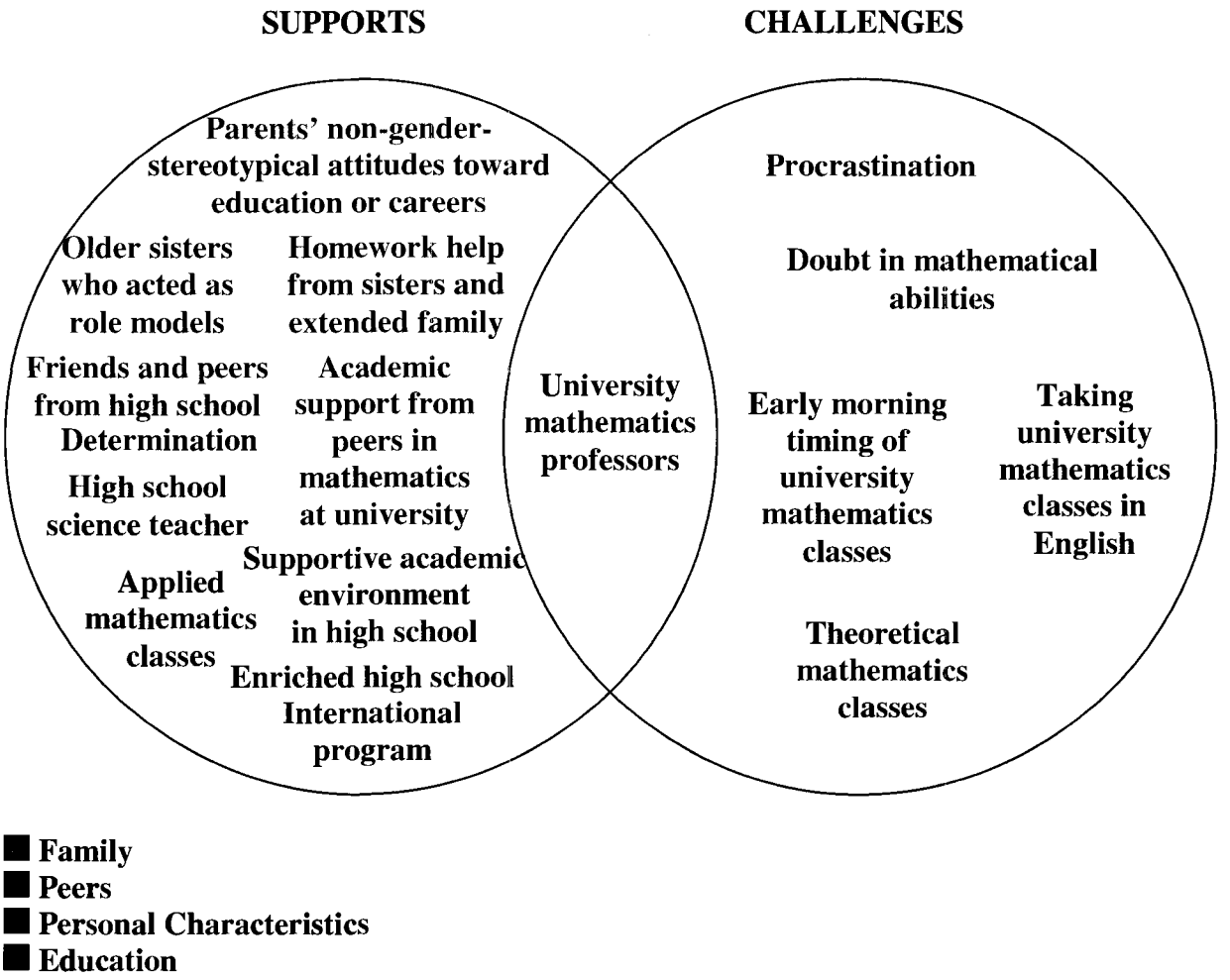

Figure 6. Summary of supports and challenges for Chantal.

DANA

Dana is a third year student with a double specialization in Mathematics and Economics in the Francophone sector.

Family

Dana is the oldest child in a family consisting of her parents and younger brother. Her family immigrated to Canada from Morocco in 1990. Her mother has a Kinesiology degree, and works as a high school biology and dance teacher. Since she taught biology at Dana's high school, Dana avoided the subject area completely. Her father has two master's degrees, one in Mathematics and one in Science, and is a high school mathematics and science teacher. Dana noted that her parents "both had finished their degrees in Morocco, but then when they came here, they went back to university."[6] Her parents divorced three years ago, and her father now lives nearby. Dana lived at home until this year, when she got a job that required that she live on campus. She described how she remains in close contact with her family via the telephone.

> I don't go see them that often, or as often as I thought I would even though it's right there. I definitely talk to them almost every day-ish. I talk to my mom almost every day. I talk to my dad three, four times a week. And… I don't go that often though. I'll see them once a month or something, once every two months, even though it's right there.

Regarding helping her younger brother with mathematics, Dana noted that "when I go home, I definitely help him with his homework. Every single time I've gone back home, I'll sit down with him."

Growing up, Dana's parents were very proactive in ensuring she did her homework. She mentioned how her father would check over her essays and help her with mathematics problems. She felt that in one way, "homework was brutal", but she was glad to always

have it completed when the teacher asked for it. Importantly, Dana's father would never do the work for her, even though he was very involved.

> DANA: It was good. But he would never give me the answer though. He would say, 'This is wrong' and then he'd send me back and try to figure it out. I've definitely spent hours and hours and hours on one number for one stupid thing and he wouldn't tell me what it is and I had to figure it out.
>
> JENNIFER: Would he give you hints or would he just…?
>
> DANA: Yeah, after a while, if I said, 'I don't know! I don't know!' […] He'd say, 'Okay'. But it was good.

She believes that her father is "really good in math" and has "always liked math, for sure", but does not think that her mother feels similarly about the subject: "I don't think it's my mom's favourite thing, for sure. She doesn't mind it, but […] it's not something she's passionate about, for sure."

In fact, Dana's mother wanted her to become a doctor, which Dana believes may be partly responsible for her choice of a Biopharmaceutical degree program when she began university. However, when she decided to change to a Mathematics and Economics degree program in second year, Dana no longer was thinking of how her parents felt about her choices, although they were supportive of her decision.

> I think I kind of just realized after that that it was really that I had to do something for me. It wasn't about what my parents think anymore. I realized I'm doing this. I'm doing this every day. I'm doing this every single day. And it – I think I really just did something for me. It wasn't about how my parents felt about it or anything like that. I realized that I need to do something that I want to do and that I'm good at doing and that I'm going to enjoy myself even a little bit, doing it. They were both kind of like, 'If you think that's what you need to do, that's what you need to do.'

She believes that in general, her parents have become more relaxed and less conservative over time, including with regard to gender-role attitudes, which she attributes to their working in Canadian high schools.

> I think my parents have evolved. They've changed over time. They used to be very conservative. But I think now, just because they both work in high schools and they're just more exposed to everyday teenagers and stuff like that, they've definitely let go of a couple things and just become more open, I guess, to even accepting and considering new things and stuff like that, I guess.

Peers

High School

Dana found that her friends in high school were interested in a wide variety of subject areas, but not mathematics. In fact, she reports that most of her friends "think math is gross. [...] They don't like it. They don't want to hear about it." She only recalled a couple of male friends who were also interested in mathematics when she was in high school. Dana liked to compete against one of her male friends in mathematics classes, which would result in her receiving her "best grades because we were in competition with each other". Upon graduating, her friends entered a variety of fields at both the college and university level. She noted that a few of her friends began in Engineering or Physics degree programs, but they changed to other fields of study. She is the only one is in a Mathematics degree program.

Dana has remained in touch with just a couple of friends from high school, although, as she described, "all the people from my high school, like 80%" attend the University of Ottawa. When she sees her friends from high school and tells them she's changed programs from Biopharmaceutical studies to Mathematics, she receives the following type of response:

> They think I'm nuts. [...] They're kind of just like, 'Oh. Why?' That's usually the question I get after people ask, 'What program are you in?' They're kind of like, 'Math-math?' They'll have that like, 'Math? Like, math? You're in math classes?' I'm like, 'Yes.' And they're like, 'Why?' 'Because I like it.' No, they think – I don't know... they just don't get it. Most of them would never do that, so... they're glad – if they have one math class to take in first year, they're glad it's over and they never have to do that again.

University

In university, Dana has made friends who are in a wide variety of academic programs, only one of whom is in Mathematics. She notes that she connects with her closest friends "on a different level than just school." She finds that most of her classmates in Mathematics are acquaintances, except one other female student.

> I have one girl who I'm really good friends with, but I'm in all my classes with her also. That's how I met her. But I'm definitely good friends with her; it's not just because of that. She's in the exact same program as me, so it's nice. We'll go and do assignments together, and I'll call her and she'll call me. We'll help each other out.

Dana has a few classmates from her mathematics classes she feels comfortable going to with her questions, but they generally are the only students with whom she is in contact. She finds that the students in Mathematics tend to not be very helpful or social, which makes her feel uncomfortable around them.

> I find Math students are kind of just... 'I worked really, really hard on this to get it, so it's mine and I'm not going to pass it to you.' [...] I don't know. It's weird. They're kind of like, 'I worked my ass off to get this done, so you know what? Now it's your turn. You go and work.' So, I don't know. I don't feel that comfortable. I find that people are not as open, not as social kind of thing.

Dana does not feel that she fits in well with the other female students in Mathematics, nor does she fit the stereotypes about Mathematics majors. In fact, when she tells people she is in Mathematics, they often reply "Are you serious?" Dana explained that she has had several people assume she is in another program, which she surmises may be based on the way she looks.[7] She finds that the female students in her mathematics classes are very intelligent and driven, but almost to the point of being overly focused on mathematics, to the detriment of other areas of their lives. She believes that the other students have become more 'intense' as they progressed through the program. Dana, on the

other hand, places more value on being a well-rounded individual than being the top student in the class.

> JENNIFER: If you were to describe the girls in your math classes in a few words, generally, how would you describe them?
>
> DANA: Not super-social. Quiet. [...] But usually they're super-smart. [...] They don't... I find that all their energy is put on that though, all of it. They don't usually do anything else.
>
> JENNIFER: Oh, okay. So, they're not very well-rounded?
>
> DANA: No. I find that that's all they'll do. They won't care about anything else. They won't do anything else. That'll be the only thing that they'll do, and I don't really believe in that. I would rather do a lot of things intensively and enjoy myself now – maybe do a little bit not as good at school, but live every day. [...] I think I put more value on people and right now today, and just – I like doing so many different things though that sometimes it's hard also. I don't know. I find it... the older I get, and the deeper I get into my program, it's like the more intense people get, but... I don't know. It's like some of them have something to prove...

However, Dana finds that the women in Economics are "a lot more relaxed" than the women in Mathematics, which she attributes to her view that the Economics program is easier. She describes the intelligence of the females in Economics as "random... all over", whereas she describes the women in Mathematics as "smarter than the average person in class". However, she finds that this academic success in Mathematics comes at a price that she is not willing to pay.

> I find that people in my program – like, they won't care about their parents, for example. They're not going to put any time on... I don't know. They're just really stuck on one thing, and it's just like nothing else matters.

Personal Characteristics

Dana describes herself as someone who both enjoys working with others and by herself. She enjoys the challenge of working on problems and the satisfaction derived from solving them by herself. Dana also feels that her ability to work quickly, particularly under pressure and time constraints, has contributed to her success: "I get more done three hours,

four, five hours, the night before something is due than I could have possibly done three days before that." However, she noted that the primary reason she finds herself in these 'last minute' situations is due to her lacking time-management skills.

Dana believes that her marks are lower than they could be due to her over-confidence in her understanding and preparation for examinations and tests, as well as her love of socializing, which takes time away from her studying and schoolwork.

> I think I go into stuff over-confident sometimes because I know I've been doing good in something, so I'll just assume I'm gonna do good in something else and not necessarily put the amount of time in that I should have. I always – it's really weird because I won't put that much work into stuff and I'll get a 70, 75, but then I think about it and I'm like, 'Wait – if I would have just studied properly, I could have got a 90-something'. [...] sometimes I'll just be like, 'Oh, whatever'. I'll just take it, but sometimes maybe I should be more like, 'You know what? I'm gonna just go for what I can actually get.' I need to push myself a little harder. I definitely – I love socializing. I love hanging out. [...] That definitely takes a lot of time out of school. [...] which is not necessarily good, not good at all...

She further elaborated that she needs to work on finding a better balance between her love of socialization and her love of spending time alone; when she finds this balance, she believes she will do better with her academics.

Finally, Dana feels that the time of day during which mathematics classes tend to be held, the morning, is detrimental to her learning and understanding as she is not a 'morning person'. She feels frustrated by the lack of choices for class times: "I work better at night and all my classes are in the morning, so that's not working out for me. Yeah, I'm very productive in the late afternoon and nighttime." She noted that she usually just copies the notes during class time, and then has to try to figure them out later on her own, as she is not alert during the morning.

Education

Elementary School

Dana attended a special arts-focused public elementary school in Quebec from Grade 1 to Grade 6. The school day at this institution was divided in half – music, visual art, and dance for the first half of the day, and all the other subject areas in the second half of the day. Reflecting on how compacted her school day was, Dana noted that the students at her school had to "learn to work really fast, really well, type of thing, and listen really well and take directives really well".

When Dana's family moved to Ontario, she began Grade 7 in a regular-stream French public elementary school. She found that her schoolwork was "super easy", after having to learn the curriculum content at such a rapid pace from Grade 1 to 6. In fact, she referred to her intermediate school years in the following way: "Grade 7, 8, 9 was just kind of a joke".

High School

Dana attended a French public co-educational high school that she felt was very 'ordinary': "There was nothing really special going on when I was there. [...] It wasn't the worst high school, but it wasn't the best either." She estimated that each grade had approximately 200 students, with class sizes typically ranging between 20 and 30 students. She recalled having the opportunity to participate in the Canadian Mathematics Contest each year, but only taking part in the contest once. Dana stated that she "didn't go the extra mile". Dana took all three Grade 12 university-preparation mathematics courses, but found that she disliked the Data Management course: "I just find that I have to work so much harder for stats and probabilities because it's not always logic."

Dana recalled that her "best, best" high school teacher was one of her mathematics teachers who had been teaching for several years. Dana was taught by this teacher for two different mathematics courses; even when Dana was in another teacher's class, she would go back to this teacher for assistance. Dana described the positive attributes of this teacher as follows:

> She explained so well. She motivated you, everything, everything. My best grades were always in her class, for sure. [...] And she did her degree in Math, obviously, so she was passionate about it. It wasn't just – I had other teachers after who were okay, but she loved math, yeah. She was amazing.

University

Dana began her university studies in a Biopharmaceutical degree program; however, upon reflection, she could not fully explain her reasoning behind the choice of that field of study.

> I think I didn't really, really know what I wanted to get into [...] I think the state of mind I was in when I picked my first year was more of where do I want to be where I finish, without realizing you have to go through it for four years.

Dana did mention that her mother, a high school biology teacher, may have influenced this decision as she wanted Dana to become a doctor.

Dana found the transition between high school and university to be 'brutal'. She found that the early morning times of her classes did not mesh well with her typical sleeping patterns. She also was not used to putting in the amount of work required to do well in challenging university classes.

> [...] to be honest, I wasn't used to making that much effort to learn something. I was kind of just used to [...] not putting that much time and effort into schoolwork and still doing [...] good. But then, I came here and that just doesn't work.

However, when she failed her first year Calculus class, it was "a huge reality check". She realized that she would need to put more effort into studying in order to do well

academically, which is exactly what she did; Dana noted that she "did really, really good" in second year.

After completing first year, Dana realized that her Biopharmaceutical degree program was not a good fit for her. At this point, she switched to a double major in Mathematics and Economics. Changing her degree program was a decision Dana made for herself rather than worrying about what her parents might think, as she realized that she was the one going through the program on a daily basis, and she needed to enjoy herself and excel in what she was doing. Dana noted that she will likely take five years, instead of the usual four, to complete her degree, due to this change of programs. She does not feel that she needs to put equal amounts of work into her two majors to do equally well in them.

> I think my Economics classes are pretty easy, to be honest. I spend most of my time on my Math. And I'll study for my Economics like two days before the exam [Laughter] and I'll do fine, compared to every day for Math.

Dana is in the Francophone sector, and she has found that most of her classes so far have been in French. However, she noted that her "books are all in English". Dana finds that, even though she is fully bilingual, it takes her longer to read and understand the English text, due to all the specialized mathematics terminology.

Dana's classes in first year had approximately 400 students, but they now range in size from fewer than 10 students to approximately 30 students, both in economics and in mathematics. She did not find the change from her much smaller high school classes to her large first year university classes to be that much of a problem, although she prefers smaller classes.

> I definitely learn better if it's a small class just because I find you can put more focus on the teacher. There's not so many things disturbing you, getting your attention left and right. I get disturbed really – if anything moves, I'll turn around.

Although she noticed that her classes have decreased in size overall, Dana has found that the number of female students has decreased more rapidly than the number of male students; she estimated that 25% of the students in her classes are female. She also noted that she has never had a female professor or teaching assistant.

Dana has had one mathematics professor who she believed was "really, really good". She finds that he explains mathematics concepts fully and is very knowledgeable about the subject matter. Dana described how this professor makes a full set of notes for the class, independent of the textbook, which she finds "amazing because then you know you have everything you need to study for his exam". She also enjoys his style of interacting with the class.

> He comes in class and he's loud. He's there. You can't not pay attention to him. [...] you can tell that he actually enjoys what he's doing, that type of thing. He explains very, very clearly. He never, ever just assumes that you know something. [...] He'll make jokes once in a while. He'll talk about his daughter, his son. He just makes it more personal, I think.

On the other hand, Dana has experienced a few teachers who were difficult to learn from and deal with, for a variety of reasons. For instance, she noted that she has had professors who "get it really well and they can apply it really well", but they have problems trying to communicate the material to the class. Another professor was teaching a French-language mathematics class, but he was, according to Dana, "clearly English", so she often could not understand what he was trying to say. Yet another issue she has encountered is professors who frequently make negative comments, which make the students feel inadequate. Dana provided examples of such comments from two professors.

> We're just trying to keep up with him and then every ten, fifteen minutes, he'll be like, 'We'll just leave it... and this is easy... and this is easy'. And he'll say, 'This is easy' or 'This is simple; you guys should get this' every fifteen minutes.

> I know my [course name] teacher thought we all were stupid. He told us once in a while. [...] He'd ask us a question and [...] we should have gotten it, but we didn't... and he was like, 'You should all go out and be shot'.

Dana has found most of her mathematics courses to be on the same level in terms of her interest in the content; when she liked a class particularly well, she attributed it to the professor rather than the mathematical content itself. She has, however, had one particularly difficult class in terms of the type and amount of content. Dana described this class as follows:

> The amount of stuff in that class is ridiculous that you need to learn. And it's all brand, brand, brand, brand new stuff that you haven't seen before, stuff you've never seen before, and there's so much of it. [...] It's basically you retake anything and everything you've ever assumed was true. Like, any theorem or anything that just seems really obvious, but you just can't assume that anymore. You need to start proving everything. Anything and everything needs to be proved before you can use it.

If Dana finds that she does not understand what is happening in class, she tends to first ask her classmates for assistance; she noted that "we usually just figure it out eventually". She does not recall going to see a professor with any questions this school year. Dana stated that, if she had a question during class, she would be willing to ask her questions in front of the other students: "I'm not super shy or anything."

Dana shared that this school year has been particularly difficult for her. She had three jobs, one of which required that she move to live on campus two weeks before the school year started, and found that this simply took up too much of her time. Her marks suffered substantially from the lack of study time.

> I've never done so bad at school as last semester... and it sucks because it's all about time management. If I would have just had more time... I pretty much didn't have time to study. [...] It was a lot of changes at once. I moved out of home, I still had too many jobs, and I had school. So, it was the perfect combination to fail. [...] Way too many things. Too many changes. [...] I don't regret it, but [...] I find that was a big price to pay to learn a lesson.

Dana has since quit one of her three jobs, and feels that she now has a much better balance to her schedule.

Career Aspirations and Further Educational Plans

Once Dana completes her degree, she hopes to become an actuary. This career requires that she pass five tests before she can begin working and 20 tests before she receives her actuary certificate. She plans to begin studying this summer and hopes to complete two tests before she graduates. Dana feels that being an actuary will be an interesting job as it combines mathematics with several other fields; this relates to her choice of a double major rather than a degree solely in Mathematics.

> I like the fact that it was a lot of math, but [...] you need a lot of knowledge in everything to do that job. It's not just math, math, math, math, math. Like, I love math, but I don't want to just do that. I want to be able to use other things that I know and other things that I like doing, stuff like that. That's also why I did a double bachelor. I didn't want to do just a Math degree. Umm... just because you need to know about politics, you need to know about economics, you need to know about what's going on around the world... just... yeah. You need to be able to do a lot of stuff and understand a lot of things.

View of Mathematics

Dana noted that she has "always liked" mathematics; she found that she didn't need to put much effort into her mathematics classes in order to achieve top grades. She stated that it simply "made more sense" to her than other subject areas. For instance, she noted that she has always struggled with spelling, but that she's "always liked numbers better". Dana described how she likes the objective nature and the challenge of mathematics.

> I think I just like the challenge, I guess. Just the fact that you know there is an answer; it's there. You just have to find it. [...] It's not like writing a paper and you have to come up with stuff and it can be right or wrong. [...] I think I enjoy myself more if I'm doing something and I can't figure it out right away. [...] I'll spend hours and hours trying to figure it out and eventually get it, then... I don't know. It's rewarding. And you know it's there – if you quit, it's because you quit. There is an answer.

She also expressed how she feels the negative stereotypes attributed to mathematics are deterring others from studying it, and she noted how much she enjoys doing the hands-on practice that is required in mathematics.

> [...] they have this conception of it, but if you can get past that and just get yourself to do it and get into it, I think anybody – there would be so much more girls, but I think there's just this whole idea that math is hard and gross. It is – but it's just more time-consuming than hard, I think. [...] I think that's why I like it, actually, because you're not just memorizing things. I think I'd hate to do that.

Summary of Dana's Mathematics Experiences

In Figure 7, a summary of the supports and challenges experienced by Dana, with each dimension denoted by a different colour, is presented. The items in the left circle, such as 'Father's love of and skill for mathematics' and 'Enjoyment of problem-solving', were supports for Dana. The items in the right circle, such as 'Female mathematics students at university' and 'Balancing schoolwork and socializing', were challenges for Dana. Located in the intersection of the two circles, 'University mathematics professors' were both a support and challenge for Dana.

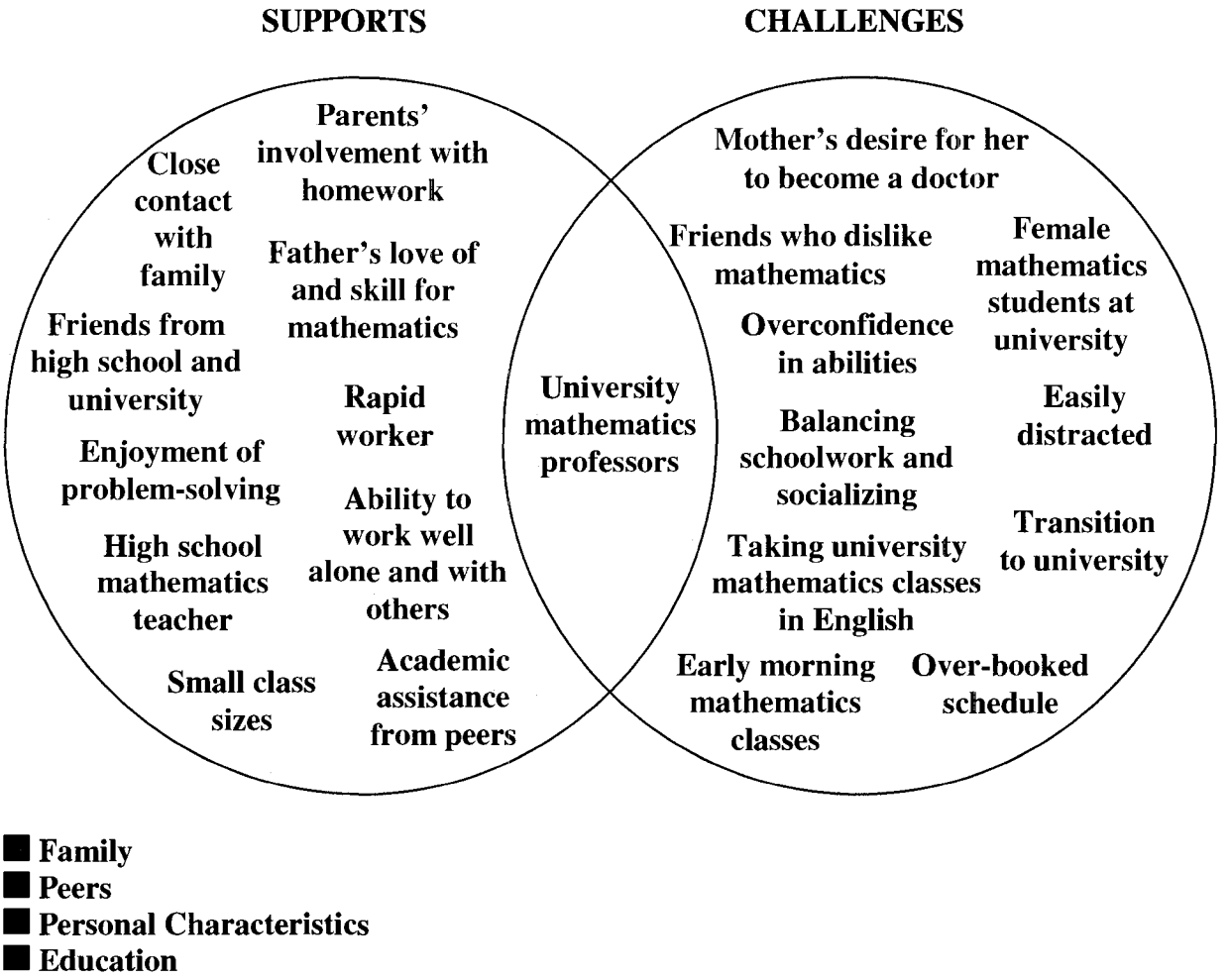

Figure 7. Summary of supports and challenges for Dana.

ELISE

Elise is in the second year of her master's degree program in Mathematics. She also holds an undergraduate degree in Mathematics from the Francophone sector.

Family

Elise's family structure has gone through many changes over the course of her lifetime. When Elise was born, she, her father, and her mother lived in Quebec. Her father worked for a government agency as a computer specialist, plus was a gemologist. He did not have any university education. He passed away when Elise was six years old. Her mother has secretarial training, but she has worked her way through the ranks at a government agency and is now a computer specialist. Elise has a sister who is 12 years old and is very involved with horseback riding. Her mother remarried when Elise was 15 years old and the family moved to Ontario soon thereafter. Her stepfather took some university courses in Sociology, but he did not finish his degree; he has the same job as her mother, at the same government agency. Elise lived at home with her parents and sister for the duration of her undergraduate degree, but she has since lived with her boyfriend.

When Elise was in elementary school, she struggled with mathematics. She tried to go to her mother for help, but found that her "mom is really no good".[8] However, her mother found her assistance elsewhere: Elise's uncle, a construction worker, was able to help her with fractions and other mathematics topics that she called "the worst parts" of the elementary school curriculum.

Elise's family's move to Ontario when her mother remarried was a very significant turning point in Elise's life. Due to their new location, Elise would have had to take three buses to get to the CEGEP she was supposed to attend in Quebec. She did not want to have

to do that, so, upon her parents' pushing, she enrolled at the University of Ottawa at the age of 16. Elise described how upsetting this decision was for her:

> ELISE: [...] my parents didn't really give me a choice, so that's why I started at 16 at the University of Ottawa because it's the only university that accepts Quebec students.
> [...]
>
> JENNIFER: [...] have you been pretty happy with your experience here?
>
> ELISE: Yes, I am. My mother's always – because I was really pissed off when they forced me to do that. [...] And it was a huge deal, and now she's always saying how she was right to do that and I do so well... and she was right! But I still think I should have had the choice, but it did work out pretty well. I guess I was so nervous that I – I just thought I couldn't do it because I was so young. Everybody was two years older than me and they had so much more experience, so I felt I had to catch up, so I was working so hard.

She finds it particularly frustrating that her mother still thinks that she was right to push Elise to begin university at such a young age. Elise does not agree with her mother's decision, even though Elise was a very successful student. However, by second year, after catching up with her classmates through summer courses and lots of hard work, Elise noted: "I knew I was supposed to be there."

Her family is very proud of Elise, as she is the first one ever to attend university (including her extended family). Her mother and stepfather are very supportive of her choice of field of study, but they do not understand what she does.

> For them, it's like, 'Oh, you're in university. Do what you want.' [...] For them, as long as you're at a university, it'll all be good. My mom never went, so for her, it was like, 'My girl – my daughter is a student at Ottawa U. It's so amazing!' For her, it could have been Physics. It could have been Math. She doesn't even know the difference. [...] to this day, she doesn't know what I do. [...] She doesn't really want to know. [Laughter] She's just very proud of me.

Her other extended family members have no experience with university so, "for them, it's all... new and they are just proud but they don't understand. They're just proud".

However, when Elise decided to not continue on to do her Ph.D. in Mathematics, her parents were quite surprised by her decision. Similar to her mother's feelings about enrolling Elise in university at such a young age, her mother seemed to think that because Elise did well academically, she was happy with what she was doing.

> That was a shock because I had been talking about it forever. They were like [...] 'Why are you not doing it? You have the scholarships.' For them, it was not logical. [...] So, it took a while for them to understand that it was just not what I wanted to do. It was something that I was good at, but I didn't want to do.

However, once Elise began preparing for the statistics-related job she will begin this fall at a government agency, her parents saw that she was serious about having a career and working hard. Elise noted that "they were encouraging with the job... now it's fine".

Interestingly, Elise's parents do not have similar educational expectations for her younger sister, even though she too is a strong student. Her sister horseback rides at a ranch nearly every day for several hours, and her parents think that she'll have her own ranch when she grows up. They do not expect her to go to university, which they explicitly articulate to her. This really bothers Elise.

> ELISE: And I don't like how they say that! Because she hears that and I'm afraid she's just going for that because that's what's expected of her. And I'm like, 'No! You can be a veterinarian. You can go to school in that!'
>
> JENNIFER: Yeah, exactly. Or even something like Business to learn how to manage a ranch.
>
> ELISE: Exactly. That's what one of my friends did. I told her that once. I was like, 'You know mom says that, but you have so many options. I don't want her to pressure you into doing something. You can always have a completely different job and still have horseback riding on the side. Don't limit yourself. You're too young.' And she's like, 'I know. I know. I'm thinking about it. I don't know yet.' For me, it's important that she knows that anything is good – that she goes to university or not – just that she does something that she wants. But my parents don't see it that way. They like to decide for us. She's like, 'Well, you are a university person. You had to go. She's not.' I was like, 'What does that mean?'

Elise feels as though she was pigeon-holed as the 'student' in the family, partly due to her more serious, disciplined demeanor, while her parents assume her sister is a not the 'university type' as she is more of a comic and likes to joke around. Elise tries to provide another outlook to her sister, other than what their parents are touting; she doesn't want to force her sister to go to university, but Elise wants her to keep her options open.

In terms of her parents' gender-role attitudes, Elise finds that household tasks are divided along traditional lines between her mother and stepfather. However, with regard to educational choices and careers, Elise feels they are much more liberal: "I don't think that gender really matters to them." Elise noted that, for her mother: "It can be a job that females do more or it can be a job that men do more, but if it's not paid well, that's what's going to worry her." Elise's mother wants her to reach her potential and work at a job that suits her capabilities and intellect.

Peers

High School

In high school, Elise was enrolled in the International program, which meant she was with the same group of 25 to 30 students for the entirety of high school (which is five years, in the Quebec system). She stated that many of the students in her cohort were "kind of theatre people [...] they needed a lot of attention". Also, she found that many students were conceited about the fact that they were in the International program, rather than the regular-stream classes, an attitude that she noted "even some teachers would encourage". Elise did not feel that she fit in with students with either of those characteristics, and described herself as follows: "I was a very calm person and I just wanted to do my stuff. And I didn't think I was better than anybody else." Elise was able to find a small group of

students in her program that felt and acted similarly to her, and she became close friends with them.

Elise is still in touch with her group of friends from high school, but she found it difficult when she was in an Ontario university and they were all together at a CEGEP in Quebec. She felt left out, even though they "always kept in touch" and would "meet on the weekends and stuff". None of her friends from high school went into Mathematics at university; in fact, they are all in social science or arts fields, as opposed to any of the sciences. Elise's friends really admire her for studying mathematics, but she does not feel she deserves their admiration because she finds the subject easy to master.

Elise feels she is a bit more mature than her same-age friends from high school, having begun and completed her undergraduate degree at university before them. She is now at a different stage in her life than her friends from high school. She described some of the differences between her friends from her master's degree program (and herself) and her high school friends as follows:

> Well, they're my age. [...] But they're in third year. And they're like, 'Oh my God! I have an exam! I have three exams!' [...] But for us, it's over. That part is over. And they still live with their parents to save money. And the graduate students that are my friends are all living on our own or with a boyfriend or whatever. And... it's a different kind of life. You're starting to think about a job. And we make more money.

Since her high school friends tend to lack money, she tends to do more costly social outings, such as trips, with her friends from her master's degree program. Besides the differences in maturity and lifestyle, Elise never 'mixes' her high school friends with her friends from her master's degree program due to the fact that her friends from high school speak French and her friends from university speak English. She is glad to have kept in touch with her high school friends as they provide her with a comfortable atmosphere.

> But sometimes, it's good to just speak French. To be with my friends who know me – they've known me for 10 years and they – I don't have to do anything. I can be myself. While the other ones, when you're not talking your own language, it's always a bit different. It's always a bit tiring and you don't say exactly what you want to say. You don't always find the right words. So, that's why I sometimes prefer doing stuff with them.

University

When Elise began university, she found it "scary, very scary" to go from her close-knit high school class to the auditoriums full of first year students. She felt very alone as she was the only one from her high school who went directly to university instead of attending CEGEP. To her, it seemed like the students from Ontario "all went from high school to university together, so most of them knew each other". Elise met a couple of students in her pre-university summer classes who had also come directly from (other) Quebec high schools, but she noted that they were not "the type of people I would normally hang out with", and she quickly grew annoyed with them. She ended up spending her long breaks between classes working on schoolwork or reading, all alone, which she found "really depressing".

In second year, Elise began making her own friends, and she felt that "it was fine from there". She is no longer in close contact with her girlfriends from her undergraduate degree program as they all went into the field of Education, rather than Mathematics, for further study. Her close friends now are the women she met during the two years of her master's degree program, particularly the other women in her office. Although she is younger than they are, she finds that she fits in well with them.

Elise described one of the other women in her office as being particularly similar to Elise, both in terms of a lack of self-confidence and a high anxiety level regarding academics, even though they are both excellent students.

> We always need to perform. We need to have the best mark and we get anxious – we get nervous, so nervous. We always think we're failing, but we're getting A+.[…] We're very similar like that, and just in life in general, we doubt ourselves a lot. Like, 'I don't think I can do this.' Low self-confidence. If you were to look at our resumes, you'd be like, 'Oh my God! I want this person!' but she's probably looking at it and saying, 'Ohh! Don't look at it!'

Elise feels that this lack of self-confidence is very common with all the women she knows in the graduate programs in Mathematics. Like her, Elise finds that the other women tend to be "really shy and quiet". However, she does not find the same characteristics in the male students in the graduate programs in Mathematics. She feels that they are much more outgoing and less stressed out. For instance, she described the differences between how men and women in the program tend to approach doing academic presentations as follows:

> They don't care if they understand or not. They're going to do their presentations, and if you're not happy, too bad. Pfft! But for me, if I do a presentation, I need to understand everything and be prepared for any question, while a guy, I think, from what I know, will be more relaxed and be like, 'Well, if I don't know the answer, I'll just say I don't know'. But for me, that's not an answer. That's not a possibility. I will not allow that. So, we're more nervous, more stressed out.

However, Elise feels that she differs from most of the other women in the graduate program in Mathematics as she is more concerned with her appearance and more interested in 'feminine' activities such as shopping. She finds that the women in her office, save the close friend described above (who is similar to Elise in terms of her attitudes toward appearance and shopping), will often wear pyjamas to the office and do not care about their appearance: "It's kind of cool to be […] in pyjamas doing math and being cool about it." However, she and her close friend will often dress up when they come to the office for 'no real reason'. Elise described how her friend wants to look nice "even though she's going to do math all day", a sentiment that Elise shares.

Personal Characteristics

Elise describes herself as someone who is very disciplined and task-oriented: "I like to have something specific that I have to do and I just do it, and I'm happy when it's done and when it's well done." She dislikes subject areas and tasks that are vague and subjective; conversely, she likes mathematics and sciences because "there was one answer and I was right; you were wrong". Related, she feels that her organized, rule-following tendencies have helped her in mathematics, even though they may be 'annoying' to peers during social activities, such as board games.

> But, I'm very serious. I like to – when we play a board game, we have to follow the rules; otherwise, I'm not happy. [...] Some of them say, 'It's just a game – let them have it' and I'm like, 'No! That's not how it's done.' [...] It's annoying to some people that I'm so organized and, you know, things have to be done a certain way. [...] But that helps in math. [...] You follow the rules and you have a proof. So, I think that helped me.

Elise finds that the challenge of mathematics is exciting for her, as long as it is not too large of a challenge. She noted that, in elementary school, mathematics was "too big of a challenge. I couldn't get through.", so she was discouraged. However, when she began to grasp mathematics better in high school, her love for challenges was nurtured: "I was having fun with it, and I was like, 'Give me more! Give me more challenge.' And I was the best student for the last two years of high school."

Elise describes how her tendency to focus on small details and formulas rather than the 'big picture' of what she's doing has been detrimental to her, something that she has finally been able to articulate and focus on improving during her master's thesis work. Her supervisor "works the big picture", so this has helped her to improve upon her working style. She still has to remind herself not to fall into her old habits.

> I always knew it was there, but he once told me exactly that, and I was like, 'Oh, that's true. I do exactly that.' I have to remind myself to take a step back and say,

> 'What are we doing exactly?' [...] Because it's easy to get lost in all the formulas, all the descriptions, there are so many models and... that it's easy to just apply the rules. [...] So, he's helping me so much – that's what made me choose him as my supervisor.

Elise also shared that she is afraid of failing or looking "dumb or stupid", which causes her to sometimes struggle with problems long beyond a reasonable time period, rather than ask someone for assistance. When she doesn't understand something immediately, she begins to question whether she even belongs in mathematics at all. Her supervisor has been helpful in getting her to realize that she should not have all the answers and that asking for help does not make one "dumb or stupid".

> I want to find the answer on my own and I don't need nobody's help. [...] I'm scared of asking for help because sometimes people look at you and they're like, 'What? You don't know that? You should know that!' Or, I'm just afraid of that. [...] So, sometimes I don't say anything when I should say something. And... that just takes me more time because then I have to work so hard to find the answer myself, and sometimes I just can't find it. So... and then I have to go back and ask the question and the – my supervisor or whoever says, 'Well, why didn't you ask that two weeks ago when we first started to talk about it?' [...] I'm like, 'Because I wanted to find it myself.' He'll say, 'No! You have to ask your questions. That's what I'm here for. That's what you're supposed to do. You're supposed to have questions. You're not supposed to understand everything at first.' He gets angry at me. But... it's just – I always want to understand everything right away. And when I don't, I start to feel like, 'Oh my God! Maybe I shouldn't be in Math. Maybe I shouldn't be here. I don't understand this and everybody seems to understand.'

Elise admitted that she needs to be more "gutsy" and that she should just "go for it", saying, "Who cares if you look dumb?"

Education

High School

After struggling with mathematics at the elementary school level, Elise found that she "starting getting it [...] having fun with it" when she got to high school. Elise shared an experience that occurred when she was in her final years of high school; she became

fascinated by the many ways one could solve a problem and would spend time trying to find alternative solutions, even though her teacher did not find it efficient or a logical thing to do.

Elise was enrolled in a special International program at her Quebec public co-educational high school. A test was required for entrance into this program, and the program included a broader range of classes, which were all enriched, plus a requirement of community service. Students would have to come up with a community service project and then implement it, after conducting fundraising. She felt that the purpose of the International program was to make the students "be open about people, the world".

Elise was with the same group of students over the course of her five years in high school, and she noted that the International students "would never mix and match with the rest", referring to students in the regular-stream classes. She found that some of her teachers and classmates in the International program were very elitist, and would say things like, "International is the best. We're so much better than the regular program." Elise did not agree with these sentiments, and hearing them made her uncomfortable. Elise noted that quite a few students either dropped out of the program or were kicked out because of low grades or a lack of participation in the community service projects.

Elise shared the fact that she was the top student in her grade for the last two years of high school. At her high school, certificates were given out to the student who had made the best effort and to the student who had received the best grades in each semester. Elise stated that she often would receive both awards, as her top grades came from the fact that she was "working so hard" because she "loved it". However, even though she was such a successful mathematics student, she was never asked to participate in the national mathematics competitions by her teachers: "It was always these two guys that went". Elise

was upset by this experience, even though she admitted that she was not solely focused on the mathematics competition: "I wasn't doing it to be the best. I was doing it because I loved it. [...] I didn't work hard all year to go to that contest." However, she felt vindicated when she ended up, in her role as a teaching assistant, marking these students' undergraduate mathematics exams.

University – Undergraduate Degree

Elise began university at the age of 16; she neither planned nor wanted to begin so young, but her mother remarried and the family moved to Ontario. It would have been very difficult logistically for Elise to travel to the CEGEP in Quebec that she was planning to attend, so she instead began her post-secondary studies at the University of Ottawa. However, Elise felt as though her parents were making the university decision for her, even though she did feel trapped by her situation.

> [...] they pretty much forced me to go to university. I didn't feel ready at that time. I thought I was too young. I didn't even know what I wanted to do, but... it was crazy – the bus ride would be crazy and I didn't want to do that either, so I was kind of stuck.

Elise felt as though she had to work extra hard in order to try to keep up with the other first year students, who were two years older than she was. She also had to take two mathematics courses the summer before she began university in order to catch up.

It was the experience of taking the summer mathematics courses that caused another major change in Elise's life – at the age of 16, she had to learn to speak, read, and write in English, as one of the summer mathematics courses was not offered in French. Elise taught herself English without any language classes or teachers. She described how she felt about overcoming this major obstacle, even with modifications to the course.

> I was afraid to start my second course in English. [...] To me, it was impossible. I was like, 'I can't do math in English at the university! It's way too much!' So, what

> they did is they gave me the book, which was in English [...] and they made me take the final exam, which they translated in French. So, I had to study on my own, and that didn't go that well. [...]

When Elise had to select her program of study for university, she recalled that she "hesitated between Psychology and Math at the beginning". She noted that, during high school, she had thought that she would do her degree in Psychology; however, she changed her mind, partly based on her perceptions of the two fields.

> I always thought, 'Well, psychology – anybody can do psychology'. When someone doesn't know what to do, they go into psychology and see what happens. So... I didn't want to do something easy. It happens that I love psychology, but it's easy, so... it's not as rewarding. [...] And I was good in math and people are not usually good in math. [...] I don't care about what people think that much, but it is a good feeling to know that you're one of the few who can do it.

So, Elise began in a General Science program in first year as she knew that was the area that interested her, even though she had not yet decided upon which field of science to study. After first year, she realized she did not like biology, so dropped it; she then dropped physics from her schedule, and by her third year, she decided that she also did not want to continue her studies in chemistry. Thus, Elise ended up in strictly a Mathematics degree, which she felt was a clear choice by third year.

> I could see that I preferred my math courses way more. It was natural to me to do math. While chemistry was fun, I really had to work my butt off. So, I pretty much figured out that I would do my master's in Math, so I might as well just drop the chemistry part. [Laughter] So, I changed programs again to do only math. So, that's how it happened.

Elise recalled that her classes in first year had "like 100, 200 students"; during her master's degree program, her mathematics classes were as small as three or four students, and never had more than 20 students, even though the students from Carleton University also take these classes. She found that her master's degree classes had more male than female students in them: "I was often the only girl." Elise estimated that her graduate-level

courses were approximately 20% female, compared to 40% in her undergraduate-level courses. She found that the females in her undergraduate mathematics degree "all wanted to go in Education". Elise was the only female student in her undergraduate classes who went on to graduate studies in mathematics.

As she progressed through her undergraduate degree, Elise had to take some of her other mathematics courses in English as the French-language mathematics courses were only offered sporadically. She noted that her first two years of her undergraduate mathematics courses were entirely in French-language classes and her last two years were entirely in English-language classes. She described how she felt about the lack of French-language courses at the University of Ottawa: "[...] they say it's a bilingual university, but it's not. I'm really annoyed with that because I came in thinking it was bilingual so I would be fine." Elise found the language barrier to be a challenge to her learning of mathematics; she would understand the mathematical expressions written on the chalkboard, but she would not understand what her professors were saying. She also noted that she sometimes would be confused by different notation in French and English mathematics terms: "I would get stuck on stupid things like that."

Elise described herself as a very hard worker, which helped her to overcome the language issues in her degree program. She recalled that she attended every group discussion session, and she would frequently go see professors for individual assistance during their office hours. Elise noted that she is much less likely to ask questions during or after class; in her large first year classes, this "never happened". She shared that she was "always one of the best students" in her classes, so she didn't ask classmates for help as she found they generally would not understand the material if she did not understand it. When

Elise went to see her professors for help, she would stay until she completely understood the mathematical concepts.

> Some of them want you to figure it out by yourself and will just give you hints, but won't give you the answer. Others would keep you in their office for hours. [...] It doesn't matter how they would respond to me; I would be there. I know I may be annoying or whatever, but you're going to explain this to me.

Elise described one professor from her undergraduate degree program who she thought was particularly helpful. This professor was willing to write a reference letter for Elise when she applied for a scholarship during her first year of studies, even though he did not know her. He was particularly impressed by her résumé and top marks, and began encouraging her to do her master's degree. This professor continued to encourage Elise, and informed the other mathematics professors what a proficient student she was. It is only when another professor commented on her reputation as a top student that Elise began to realize that she may be doing better than 'normal'.

> [...] apparently other teachers were talking about me, and I was really surprised about that because I didn't think people noticed me. I thought I was a normal student. I thought it was normal to get A+ all the time... and that's the first time I realized that maybe I'm different. Maybe I'm... good at what I'm doing. I'm doing this okay. I'm okay. So... I guess these teachers who... told me 'you're doing fine' made me feel better. Because you don't know how you're doing. [...] You don't talk about marks to other people and you have no clue. I always used to think I was the worst one in the class. That's how I assumed. I would start a class assuming I was the worst one, and always be surprised when I learned that, no, I was one of the top students. So... it was always good to get, you know, good feedback.

However, there was also a negative side to these compliments: Elise began to feel pressured to always perform and be the top student in her classes. In the third year of her studies, she began to experience anxiety and became very nervous before exams. Elise had one particularly negative experience with a professor who "made her realize that there's pressure". When she went to see her final exam from his class, the professor pointed out to Elise that she had not received the best mark in the class, and explicitly told her the name

and grade of the student who received the top mark. Even though Elise did not do as well on the final exam as she had hoped, she still ended up getting an A+ in the class. She reported that he said the following to her: "I'm very disappointed in you because everybody told me so many good things about you, and I find it disappointing, looking at your final – you could have done so much better. People actually beat you." She was really upset by this, and avoided the professor's classes ever since. Her reaction to his comments was "Why do I need to be perfect? It is still an A+!"

As Elise continued to perform exceptionally well in her classes, receiving all A+ final marks, she reported that more and more teachers encouraged and pushed her to go to graduate studies, saying such comments as, "You need to go to grad school. It would be a waste if you didn't. You have such good marks." Elise noted that she "never really questioned" her decision to apply to the master's program at the University of Ottawa; she did not even consider applying at any other universities. Her plan was to do her master's degree, then her Ph.D., then post-doctoral studies, and end up becoming a university mathematics professor. Reflecting now, she stated:

> I don't know why I didn't stop and think of the other options. [...] I think I just got excited about it because I was doing so well in math, and everybody was telling me, 'You need to keep going' that I never questioned if I liked it or not.

University – Master's Degree

Elise is now completing her second year of her master's degree in mathematics. In her first year, she took three classes and two reading courses; this year, she is strictly working on her thesis. She selected her thesis supervisor based not only on his field of study and expertise, but also on how responsive he was to her inquiries about becoming his master's student. She noted that "he seemed really interested", and sat and talked with her, whereas other professors she approached would simply give her articles to read about their

research. Elise feels her supervisor is excellent, and that he is very relaxed and flexible, which complements her structured, disciplined working style and decreases her anxieties.

Elise has found that she has liked graduate studies far more than undergraduate studies due to the increased autonomy.

> [...] you're so much – free. You can do whatever you want. I can come into the office at 10:00 and leave at 3:00 and nobody cares. Because you can work at home, you can work at your office, you can work at a coffee shop... and the thing is with research, you can't – sometimes you're just not in the mood. [...] While, where you're an undergrad and you need to study, well, you need to study. [...] But research is like... more like art... when you feel inspired. When you feel like, 'Oh! I have an idea – let's try to work on that', that's when you're productive.

Elise has enjoyed meeting and working with her office-mates at the university, four other female graduate students in Mathematics, although she finds that they sometimes distract her from working. If this happens, Elise will simply go elsewhere to work. She also feels that she has benefitted from the fact that all of her office-mates are unilingual English speakers. Elise is forced to practice her English every day, and her colleagues will correct her mistakes so that she can improve.

However, as Elise progressed through her master's degree, she began to question her planned educational pathway and career goal of becoming a mathematics professor. She saw how her boyfriend, a Mathematics Ph.D. graduate, and other Ph.D. graduates were having difficulty finding university teaching positions. Elise also realized that she did not want the demanding schedule of a university professor.

> ELISE: [...] I want a steady job. I want to do 9 to 5, 8 to 5, whatever, and go home and have nothing else to think about. [...] not think about my job all the time, and that's what research is all about. You're always thinking about it. And when you have a problem you can't solve, it's like...
>
> JENNIFER: It's just on your mind.
>
> ELISE: Yeah, all the time. And I don't want that. I want to be able to let go and have a nice weekend, and then go back to work on Monday.

Elise admitted that she mostly was interested in the research aspect of being a professor, and that she "hates teaching". She realized that research would be much more difficult without a supervisor's guidance. Elise knows that, to become a professor, she really needs to be passionate about her subject area, which she is not, even though she is very proficient.

> I don't love it. I do it. I'm good at it. I get it fast. But it doesn't mean I like doing it. Just because you're good, it doesn't mean... [...] I don't hate it; it's just not what I want to do.

Thus, Elise then decided not to do her Ph.D., and began to explore other career options.

Career Aspirations and Further Educational Plans

Elise has passed the required tests to work in a statistics-related field at a government agency. She found that she "started really liking" statistics when she was studying for her tests for the job. This experience caused her to reconsider her former feelings, as a mathematician, of "looking down" on statistics. Elise will begin her job this fall, and hopes that it will be a challenging: "I need to be busy and I need to see that I'm going somewhere, that I'm learning stuff." If she finds that this job is not a good fit for her, she will look for work elsewhere, but knows that she does always have the possibility of going back for her Ph.D. in Mathematics, or further education in another field of study.

While Elise is working at her new job, she will also be taking night courses to complete a second undergraduate degree in Psychology. She took all of her electives in this field, and only needs to complete a few more courses to have enough for a degree. Elise described her experiences in psychology classes and her feelings for the subject area as follows:

> [...] they would give us assignments or homework, just readings. You need to read this for next class. I'd be so happy that I'd go right home and read it and make notes. To me, it's like a hobby, something I do for fun. [...] It's no work at all for me. I read it and I'm so interested in it. I like talking about it with people. I'll say,

> 'Did you know they did research about this and apparently blah, blah, blah this happens?' Just the way of thinking and understanding people better, understanding me better…

Elise noted that she would potentially consider completing a Ph.D. in Psychology.

View of Mathematics

Elise likes mathematics as she feels that it comes 'naturally' and easily to her. She likes the feeling of being one of the 'select few' who are able to do well at mathematics at a high level of study. Elise also enjoys problem-solving, as is evidenced by her experience in high school, solving a single problem many ways.

With regard to her master's degree experience, she has enjoyed other aspects of mathematics:

> […] the challenge. In my research, I do stuff that's never been done before… That I'm trying to prove something that I don't even know if it's true or not… I like typing my thesis. You can see how it looks professional. It looks like an article that I read. That's exciting.

She has found that, upon hearing that she is doing a master's degree in Mathematics, people make comments such as, "Oh my God! How do you do it? Math! I can't do math!" Elise admitted that these comments make her feel good about herself and that these viewpoints were "maybe one of the motivations" for choosing to study mathematics at university.

Summary of Elise's Mathematics Experiences

In Figure 8, a summary of the supports and challenges experienced by Elise, with each dimension denoted by a different colour, is presented. The items in the left circle, such as 'Disciplined and task-oriented nature' and 'Thesis supervisor', were supports for Elise. The items in the right circle, such as 'Mother's pushing to begin university at age 16' and 'Lack of self-confidence in mathematics abilities', were challenges for Elise. The items in

the intersection of the two circles, 'University mathematics professors' and 'Being encouraged to do her master's degree', were both supports and challenges for Elise.

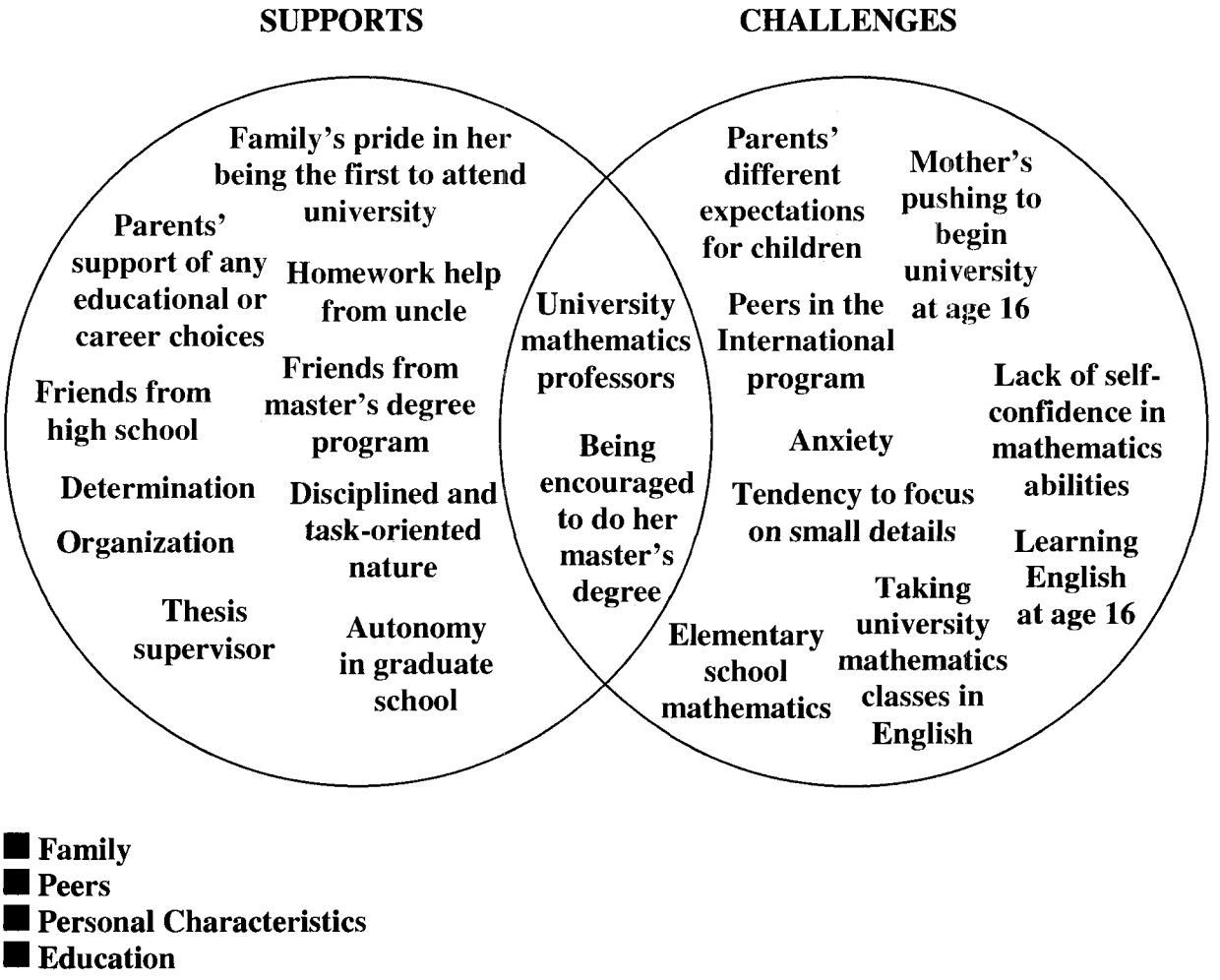

Figure 8. Summary of supports and challenges for Elise.

FELICITY

Felicity is a fourth year student in an Honours Mathematics degree program, in the Francophone sector.

Family

Felicity's family consists of her parents, two older sisters, an older brother, and a younger sister. Felicity lives at home; she selected the University of Ottawa so she could remain living with her family. Her family immigrated to Canada from Lebanon in the early 1990s. Her father began his university studies in Mathematics and Physics, but ended up doing a Law degree due his involvement in the Lebanese military. Felicity noted that "it was not because he wanted to be a lawyer, type of thing, but so he could get a higher rank".[9] Felicity's father now drives a taxi cab; she noted that his status as a lawyer "went away when he came here". Her mother has her high school education, and is self-employed as a daycare provider. Felicity's siblings, who span a 10-year age gap, are in a variety of fields: her one older sister is a medical doctor, the other older sister has a degree in Political Science and Economics, and her older brother has degrees in Computer Science and Mathematics. Her younger sister is interested in physiotherapy.

Growing up, Felicity would work on her mathematics homework with her brother and father. She found that, "It was fun. You can just picture us at the kitchen table, trying to figure something out." Although her father did not complete his degree in Mathematics, she found that he was able to help her with homework until she was in first year university. She described his relationship with mathematics thusly:

> It was more of a hobby for him. He just always wants to come see what I'm doing. [...] [Laughter] 'Explain to me this.' And I'm like, 'It's going to take forever'. [Laughter] Because he's missing all the basics. But he's cute that way. He's always really interested in what I'm doing, which is nice.

She feels that she gets her love of mathematics from her father, as she feels he "loves math". He would push her to strive with mathematics. She attributes him with some of her skill sets in mathematics: "I can't even remember the last time I used a calculator because of him." Her mother does not have the same feeling toward mathematics: "She more tried to push me towards Engineering. She said, 'You know it has math.' [...] She didn't see where Math could give me employment." However, now that Felicity has the goal of becoming a professor, "they're good with that. [...] the main thing was just employment."

Felicity believes that what she calls the 'Arab mentality', as well as her parents' experiences as immigrants, has strongly impacted her parents' opinions regarding career paths and choices of fields of study. She described the 'Arab mentality' as follows:

> FELICITY: It's also the Arab mentality – we have a joke in the Arab community that Arab parents will always push Engineering, Medicine, or Law.
>
> JENNIFER: Oh, okay. [Laughter]
>
> FELICITY: Those are your options; pick... or Pharmacy. [Laughter]
>
> JENNIFER: [Laughter] But besides that...
>
> FELICITY: Besides that, you're not going to make any money. [Laughter] I guess it's also... where we come from... because of the immigration, you're clearly not as – like, they had a harder time with jobs and stuff like that, so they want us to be comfortable. I get where they're coming from, but...

At one point, Felicity's parents did push medical school as a career choice for her: "It was basically a year or two of me arguing that I'm not going into med school; leave me alone, type of thing." She even got to the point of applying to medical school, but withdrew her application. Although she does well in the sciences, she feels "that you really have to love it" to pursue it further, particularly the demanding career of medicine; she saw this first-hand when her sister was training to become a doctor. When Felicity decided to pursue

mathematics further rather than medicine, she found that her parents "didn't persist. So, it was nice."

The 'Arab mentality' also impacts the interactions in her household. She feels that her brother has not had to contribute to the housework very much. Felicity also noted that she prefers to do stereotypically masculine tasks.

> JENNIFER: So, how did your brother find it, being the only boy?
>
> FELICITY: I think he enjoyed it because he never had to lift a finger. [Laughter] [...] Especially the Arab mentality. He sits and 'Food'. 'Okay.' No, he's very spoiled, very spoiled.
>
> JENNIFER: So, do you find in your house that it's very much that the girls do all the housework and the guys do the stereotypical tasks like yard work and garbage and shoveling?
>
> FELICITY: Basically. Although I end up doing a lot of the guy work. I'm kind of like the second guy. [Laughter] [...] Which I don't mind...

Peers

High School

Felicity described herself as a 'floater' in high school, as she would hang out with different groups of people on different days. Since she attended an arts high school, she found that "not that many were into science". Of her closest friends from high school, some are currently working in arts fields, some are travelling, and some are enrolled in university; none of her friends are enrolled in Mathematics degree programs.

University

In her first two years of university, Felicity found that she had a more diverse group of friends, from science fields outside of mathematics. However, as classes became more specialized in third and fourth year, she found herself making friends with students from the Mathematics degree program. She has become particularly close with a group of male

Mathematics students, and gets together with them frequently, both for academic purposes, such as studying and working on assignments, and social outings. Besides this group of friends, she is very close with several people from her church, having grown up with them.

Felicity is quite involved with her church and other extra-curricular activities, such as those related to the local Lebanese community. She feels that having a balance of academics and extra-curricular activities is vital to her well-being, but she does not sense that this is the case with the other women in the Mathematics degree program, who she finds have an almost singular focus on mathematics.

> FELICITY: [...] although I love math and everything, it's not my – I have other things that take almost as much weight, outside of school. I have a lot of social activities, like extra-curriculars and stuff, which most of their extra-curriculars somehow come back to... either teaching or math. [...] Mine don't. [...] I don't give schoolwork as much time as they do, if that makes sense, which is a bad thing for me sometimes. But I can't do only that.
>
> JENNIFER: School all the time.
>
> FELICITY: I need the other side. Whereas they could do school all the time, I'd go crazy. Even during exams, I find myself getting together with friends and stuff, and they're like, 'You're crazy'. But I can't.

However, Felicity feels that she and the other women in mathematics are similar in the sense that they are all very organized and take detailed notes in class, whereas the males tend to just sit and listen, occasionally jotting the odd note in their books. At the end of the semester, Felicity noted that the male students will often ask the female students for their notes. This practice annoys some of them, who are of the opinion that the male students should have just taken their own detailed notes, like the women did. Felicity is more lenient in loaning her notes to male classmates if they have attended classes all semester; she generally will not give her notes to students who she feels "don't deserve them". She once experienced a class where she had to adopt this 'masculine' practice of not

taking detailed notes due to the teaching style of the professor, so she is more understanding of this different learning style.

Felicity and the other women in the Mathematics degree program have bonded over being treated in a patronizing manner by male students during informal group work sessions, and the women now hold their own group sessions.

> FELICITY: I find there's kind of a little bit of a bias when we're with the guys. They tend to think that they have to teach us. So… it came to the point, especially this semester, where we said, 'You know what? Let's just work together.' Because we – it made us feel uncomfortable, and we were just like, 'Fine! We'll do it ourselves.'
>
> JENNIFER: [Laughter] 'We'll show you!'
>
> FELICITY: [Laughter] Basically. I think it's the fact that we're kind of a minority…

Personal Characteristics

Felicity believes that her success in mathematics and the sciences are related to her preferred manner of thinking and working.

> I think it's just the way my mind works. I have always had the logical thinking type of thing, I guess. I don't know if that's the word for it, but… I was always the type that had to – I never made a decision quickly. I always had to gather up my [Laughter] data I guess and then… I think ever since I was small. […] Just the way my mind works, and it fits well with Math, I find. Just because it came more naturally, I find… I think it was a good thing for me in the Math and Science side, but a horrible thing for me in the Social Science side. [Laughter]

Felicity also believes that her patience and determination have contributed to her success. She will work on a mathematics problem for long periods of time without giving up. Felicity's success with mathematics has also led to her setting expectations too high for herself. Coupled with her stubborn nature, this leads to her feeling frustrated; she won't seek help from others, so instead struggles alone.

> I always have to work on it by myself before I come up to people, so sometimes I tend to […] expect too much from myself, so I end up in rough situations

> sometimes because I'm just so stubborn and I think I can do it myself and I don't want anyone else to help me… to the point where people will see – let's say if I'm working in the Math Department. People will see that I'm struggling with a problem forever, and they're like, 'We can help' – 'No!' I can be very stubborn. [Laughter] […] I'm just used to getting things myself. […] Or getting things – it might be bad to say, but in Math, I'm used to getting things… one of the first people. […] when I don't, it frustrates me. […] I think I put myself at a standard a little too high for myself sometimes. […] give myself too high of expectations.

Education

Elementary School

When Felicity was in elementary school, she was involved in an enrichment program in which several grades were combined into one class. Felicity began the program in Grade 4, and she was placed in a split Grade 4/5/6 class. She recalled that she would do work mostly from Grade 5 and 6 when she was in Grade 4; she noted that her mother "would get so upset" since Felicity had such a heavy workload. When Felicity's family moved across town, she began Grade 7 in a school that did not have this enrichment program. She found that she was bored at school and became very focused on sports instead. Reflecting on her prior enrichment program, she noted, "it was hard, but it was good".

High School

Felicity's high school was a large French public co-educational arts school that had an academic focus; that is, all courses were offered at an academic level or above (e.g., enriched, gifted). She chose to take her classes in the middle of these three levels, as she "hated" the social atmosphere of the top level and didn't think the students in it were "very nice". However, Felicity feels that she could have handled the course material of the top-level classes: "I think that was maybe one of the reasons I just did a little faster than the people in my class, because I wasn't in the level that I should have been."

Felicity found that she was "always one of the students who understood a little quicker", which made her more confident in herself. She recalled one incident where one of her teachers directed the students in the class to ask Felicity for help because he had too many students asking him questions already. Felicity enjoyed helping her peers, and also tutored some younger students when she was in high school.

Felicity focused her high school coursework on classes in mathematics and sciences. She opted out of social science classes as soon as she was permitted, due to her dislike of writing.

> FELICITY: I avoided, as soon as I could, I avoided history and geography and stuff because I hated them. [Laughter]
>
> JENNIFER: So, what is it you don't like about them?
>
> FELICITY: I'm not good at them. [Laughter]
>
> JENNIFER: [Laughter] That's a good enough reason.
>
> FELICITY: Well, mostly because of the writing part. I'm very – it takes me double the time, let's say, to write something that I like than maybe someone else would.

Felicity participated in provincial mathematics competitions each year of high school. The coach of the mathematics team had taught Felicity's older siblings, but she did not have this teacher for any of her classes. She recalled her siblings telling her, "You'll love her! She's great!" Felicity and the other students who were preparing for the competitions would work with this teacher every other lunch hour, which Felicity really enjoyed: "[…] she kind of took our classes that we'd taken and pushed it a little further for us, which was great."

University

Felicity began university in a combined Mathematics and Science program. However, she found that the sciences "didn't come as naturally" to her, so she switched to strictly a Mathematics degree partway through her second year.

Felicity is in the Francophone sector, but she has found that her mathematics classes above the second year level have been primarily in English due to a lack of Francophone mathematics students. She has known how to speak English since she was five years old, but she still found that she had a bit of trouble adjusting to English-language mathematics classes as she did not know the terminology.

> When I first started, I felt like a moron. [Laughter] [...] to the point where I'd ask questions and my prof would be like, 'Clearly it's this. You should have known this two years ago.' And I just didn't know the term. But yeah. It was okay. The beginning was kind of odd, but once I found out what the terms were, it was fine.

She noted that her mathematics textbooks have "almost always" been in English, regardless of the language in which the course is taught. She pointed out that some of her classmates, who are unilingual Francophone students, have problems dealing with English-language textbooks; however, she feels that "it worked out" for her since she is bilingual.

Felicity's classes in first year ranged in size from 60 to 250 students, by her estimation. Her classes this year have been as small as seven students, which she has really enjoyed for a number of reasons.

> [...] it's great because you get to know the prof more and I feel it's more relaxed. And it forces you to pay attention. [Laughter] [...] You can't fall asleep, and it forces you not to be late because they make comments with you. [Laughter] [...] No, it's much smaller and I like it that way. [...] I feel like I've... appreciated the material more than I used to. [...] I guess because everyone was all on the same level when we discussed it amongst us.

Felicity noted that she has only had one female professor over the four years of her degree. However, in terms of the gender balance of the students, Felicity was surprised that

her classes had as many female students as they do; she perceives that the ratio of males to females is now "almost 50-50", although she believes that "some classes have a little more guys than girls". Felicity remembered there being an even greater proportion of male students in her first year classes, but she thought this may have been "because we had all the Engineers with us". She does recall at least four female classmates who, in second year, switched from their Mathematics degree programs to another major.

Felicity noted that, as of third year, she has generally worked with a group of male students from her mathematics classes. However, she likes to begin assignments and studying alone, and then meet up with the group. Since she now has this supportive group of friends, she tends to go to them with her questions from her mathematics classes. However, before she met them, she would often go see a professor on her own. Felicity noted that she is willing to ask questions in class, but only if she deems them 'smart questions', which she described as follows: "If it's something that – not that I think is stupid – but it's something that I think someone else would know, that I think I should know, I'll just bug the person next to me." Although she described herself as "not one to be shy", Felicity stated that she would ask questions "only in the classes where I understood enough to be confident enough to ask".

Felicity recalled one professor who she found exceptionally good, based on his teaching methods. She felt that the way he ran the class allowed her to take proper notes, as well as listen fully. She found that she understood clearly everything that was taught in class: "I'd never come out of a class with question marks. I knew what was going on. He answered the questions and he never made you feel stupid."

Felicity also enjoyed the mathematics course that she was taught by her only female professor. Felicity "loved" being taught by this professor, particularly because she was very organized.

> [...] everything was very well-structured. We knew from the beginning what was going to happen. Every class, we knew what was coming the next lecture. We knew – there was basically a schedule for the whole semester. [...] Everything was set. We had printed notes and you could take them ahead of time. They weren't full. You had to come in and complete them.

Felicity also found that this professor tended to make the classes more interactive, with more real-world applications of the mathematics content, such as linking graph theory with board games. Felicity recalled that this class was "one of the classes that had the most girls, which was nice." Felicity was impressed by the effort that the professor made to be personable with the students: "[...] she tried to communicate – have a better relationship with the class."

Another type of professor that Felicity particularly respects, although for very different reasons, is those who are very intelligent: "You admire their mind, basically. [...] They're a little socially inept." She described how these professors are able to fill chalkboards with equations and proofs without looking at their notes whatsoever "and it's usually all structured", which really impresses her. Felicity expressed how she hopes that one day, she will have that capability. However, she noted that sometimes, due to these professors' intellect, "they are harder to relate with in the classroom." She does, however, believe that she worked harder in their classes to try to "be on their level" in order to do well in their classes.

Conversely, Felicity had one professor she disliked so much that she has since avoided the classes that he teaches. She described him as follows:

> He's the type that wouldn't give back assignments. He's got tenure. He's set. [Laughter] Um… he's a very smart – he's just hard to follow […] Just all over the place and not structured at all. It's mostly when the prof is not structured that they lose me. So, I find myself having to formulate my own set of notes. […] And I find myself going to class less. [Laughter]

In fact, when she was in this professor's class, she found that she would skip class other than on test days and just tried to learn from the textbook; Felicity also noticed that several of her classmates did the same thing. She admitted that "if the textbook wasn't as amazing as it was, I would have failed the class".

Career Aspirations and Further Educational Plans

Felicity has applied for a master's degree in Mathematics, both at the University of Ottawa and an out-of-province university, and hopes to begin this September. Felicity noted that she was the only female student in her undergraduate program who applied to a master's program, and feels that "it should be special" when she undertakes her master's degree. She described her decision to continue her university education as follows:

> I was coming into this year thinking that after this – I thought I'd be done with math. So, I thought I would move more toward the business sector. But I really liked this past year – it was not about getting the grade but more about enjoying the material.

She has hopes to then complete a Ph.D. and become a mathematics professor, but she will make the decisions as she progresses: "I'm kind of taking it a step at a time. […] If I like it, then I will continue on to my Ph.D. If not […] I will go towards the business side of things." If the latter is the outcome, Felicity hopes to work her way up the business ladder, starting by working at small companies. However, she really enjoys teaching, so she thinks that being a university professor would be a good fit for her in that sense. Naturally, since she has yet to begin her master's degree, Felicity does not have a sense of

whether she will like research: "I'm not sure I could do that in the long, long run." She noted that she would be willing to teach at a college if she decides to end her university education after her master's degree.

View of Mathematics

Felicity's love of mathematics has been long-standing; she stated, "I loved math my whole life." She described how she knew "basically since Grade 3" that she would end up doing mathematics. Felicity attributes part of her love of mathematics to her father, who helped her with homework and liked to learn about her courses, even at the university level.

She feels that mathematics is simply a 'better fit' for her than other subject areas of study. Since mathematics came more easily to her, it increased her self-confidence.

> I think it was just because my mind tends to – I tend to understand… concepts a little faster than in other subjects, so it gives me kind of confidence in what I'm doing, so I feel more comfortable helping people and stuff like that.

Summary of Felicity's Mathematics Experiences

In Figure 9, a summary of the supports and challenges experienced by Felicity, with each dimension denoted by a different colour, is presented. The items in the left circle, such as 'Working on homework with father and brother' and 'Logical manner of thinking', were supports for Felicity. The items in the right circle, such as 'Parents' desire for her to become a doctor' and 'Taking university mathematics classes in English', were challenges for Felicity. The items in the intersection of the two circles, such as 'Female mathematics students at university' and 'Stubbornness', were both supports and challenges for Felicity.

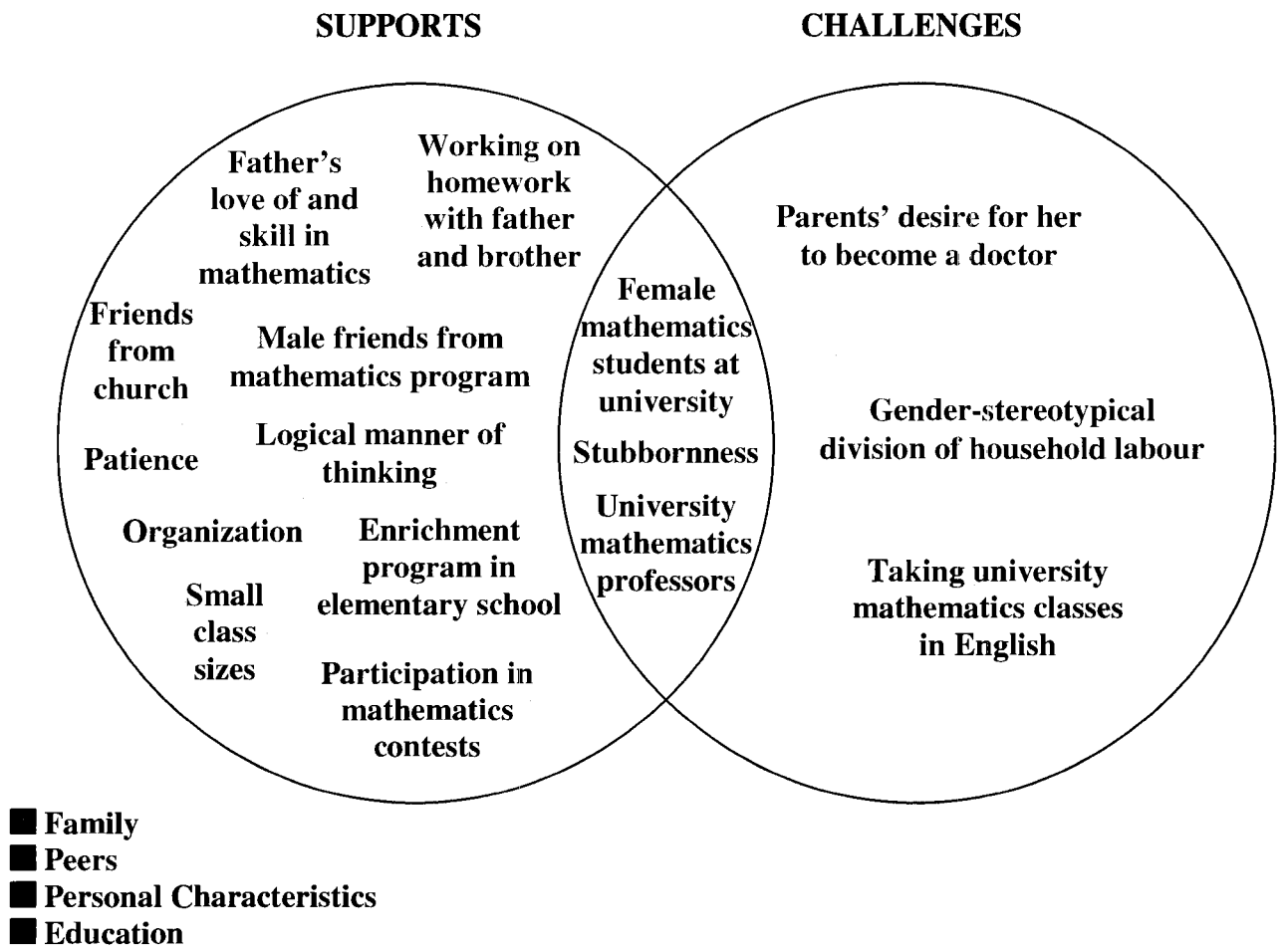

Figure 9. Summary of supports and challenges for Felicity.

Summary and Preview

This chapter contained a detailed account of each participant's mathematics experiences with respect to the four dimensions examined by the study: Family, Peers, Personal Characteristics, and the Formal Education System. These individual participant profiles provided the reader with a rich description of each individual's mathematics experiences, both in terms of the challenges they faced and the supports that were available to them. In the next chapter, I will describe the findings of my analysis of each of the four dimensions across the six participants. This cross-participant analysis will serve to

summarize the supports and challenges for the participants within each dimension, focusing on sub-themes within each dimension that were common to all participants.

CHAPTER 6: DIMENSIONAL ANALYSIS ACROSS PARTICIPANTS

In the previous chapter, I discussed each participant's mathematics experiences with respect to each of the dimensions of the study: Family, Peers, Personal Characteristics, and the Formal Education System. In this chapter, I provide an analysis that looks across all six participants' mathematics experiences with respect to each of the four dimensions of the study. Analysis was conducted by highlighting sub-topics within each dimension, and then analyzing the six participants' experiences with respect to those sub-topics. Key findings with regard to supports and challenges within the sub-topics of each of the four dimensions are presented in order to address my research question, which states 'In what ways do women who were educated in Canada and who are nearing completion of undergraduate mathematics degrees feel they have been supported and challenged in their high school and university mathematics experiences?'

Family

In this section, I discuss the impact of the participants' families on both their mathematics experiences and lives more generally. This section covers the following topics: parents' education and careers, parents' feelings about mathematics, parents' feelings about their daughters' degree choices, parents' feelings regarding education, household division of labour, impact of siblings, and family relationships.

The participants' parents have a wide range of educational backgrounds and occupations, most of which are unrelated to mathematics. In the majority of the families, the participants' fathers have more education than the participants' mothers, and this education is in a variety of fields. Due to their diverse educational backgrounds, the parents work in an assortment of blue- and white-collar jobs. Only one parent works in a

mathematics-related field, as a high school mathematics and science teacher. Notably, three of the participants have parents who received the majority of their education in another country (Morocco, Lebanon, and Haiti respectively), and who are first-generation immigrants to Canada. Due to issues surrounding immigration, some of these parents are under-employed, such as Felicity's dad, who is trained as a lawyer but is working in Canada as a taxi driver. No similarities among the education or type of career held by these participants' parents are apparent in the data.

With regard to their parents' feelings about mathematics, the participants generally felt that their fathers had more positive attitudes and were more competent in the subject area than their mothers were. Several participants fondly recalled working on mathematics homework with their fathers. In fact, Dana and Felicity believe that their fathers influenced their love of mathematics, due to their passion about the subject area. Brooke provided the only example of working with one's mother on mathematics; as a pre-school child, Brooke often played mathematics games and worked on mathematics activities with her mother. Non-immediate family members were also shown to help some participants with mathematics. For instance, Elise's mother was unable to help her when she struggled to understand fractions, so Elise's uncle, a construction worker, assisted her with this mathematical topic. Generally, the participants' parents were very supportive of their mathematics interest, but their fathers appeared to play more of a significant role in this aspect.

With regard to the participants' degree choices, reactions from their parents were somewhat mixed, although the majority of the participants reported that their parents were very supportive of any educational choices their daughters made, regardless of the field of study. No participants felt that their parents held gender-stereotypical views regarding

mathematics or any other fields of study. However, Dana and Felicity noted that their parents tried to influence them to go into other fields (medicine in both cases). Although both women began their university studies in fields more aligned with their parents' expectations, they eventually switched into mathematics. When Dana and Felicity explained their reasoning for their change of program, their parents were then accepting of the decision. None of the participants reported that their parents explicitly suggested they enter mathematics; the women appeared to have made these decisions on their own, based on their love of and aptitude for the subject area. Generally, parents were shown to be liberal in terms of gender-role attitudes regarding fields of study, and were supportive of their daughters' choices.

The participants all feel that their parents value education and want their children to have successful careers, regardless of the field. All participants' parents expected them to go to university; none of the participants mentioned any other possibility for a post-secondary route. Notably, Allison and Elise felt that they were pigeon-holed as the 'academic' in their family whereas the same expectations were not placed upon their siblings. In Allison's case, this was perceived to be due to different expectations for male and female children whereas Elise felt that this labeling had been due to her demeanor rather than a difference in the academic capacities of the children in the family.

Participants were questioned about household chores in order to learn about their parents' attitudes in this domain, which often is heavily gender-stereotyped. Interestingly, although all participants believed that their parents were very liberal in terms of gender-role attitudes regarding fields of study and careers, the same attitudes were not seen in day-to-day living in their households. Most participants felt that their parents' household tasks fell along traditional gender roles, and only a couple of exceptions to these traditional roles

were mentioned. In particular, Allison and Felicity felt that the women and girls in their households did far more work than the men and boys. Felicity attributed this to cultural beliefs from her family's home country of Lebanon whereas Allison felt there were stereotyped expectations in her family regarding gender roles in the household, and that the males in the family were lazy. Both Brooke and Felicity noted that they preferred to do stereotypically 'masculine' household chores, such as yard work. Felicity believes she functions as the 'second guy' (to her one brother) in her household. Brooke spent a lot of time doing 'masculine' activities with her father when she was growing up, as her brother was not interested in them. Parents' gender-role attitudes regarding housework were generally not shown to align with their gender-role attitudes regarding fields of study and careers.

The participants' siblings were all shown to have an impact on the participants' mathematics experiences. This impact appeared particularly strong when the participant had an older sibling. Of the four participants with older siblings, two participants have older siblings who hold careers in mathematics-related fields, having completed university studies in those fields prior. For instance, Chantal shared that she looks up to her older sisters, both of whom work in mathematics-related fields, and she followed in their footsteps. Nearly all of the participants mentioned that they worked with their siblings at homework time, often sitting around the kitchen table. This was not only a bonding time, but the participants often would turn to older siblings for assistance with any mathematics problems or assist younger siblings with their mathematics homework. Brooke attended her older brother's tutoring sessions, which allowed her to experience mathematics at a much higher level than her grade, and she noted that her brother did not mind her joining him for the sessions as he was not particularly interested in school. Overall, the participants'

siblings were shown to provide role models and support during the participants' mathematics experiences.

The participants all reported having close relationships with their parents and siblings. All the participants either currently live at home with their parents and siblings or lived at home for part of their university studies. Allison, Chantal, and Felicity expressed how their desire to remain living at home (which they do to this day) impacted their choice of universities to apply to for their undergraduate degree programs. Although Brooke now lives in a different province from her parents, she lives with her brother and considers him one of her best friends. Dana and Elise now both live away from home, but both report keeping in close contact with their family members. Clearly, family support is seen as an important factor in these women's lives.

Peers

In this section, I describe how the participants view their peers, and how their peers have impacted them. I first overview the participants' groups of friends in high school and university, and then provide examples of the participants' views of their peers in university: females in mathematics, females in other fields, and males in mathematics.

The participants reported having very mixed groups of friends in high school, with a wide variety of interests in terms of academics and extra-curriculars. Brooke was the only participant who shared a high school experience involving her group of friends and mathematics. The group of friends was together in the same calculus class, which they particularly enjoyed. None of the participants' friends from high school studied mathematics at university, and only a couple of participants reported having friends who went into related fields, such as science or engineering. Dana stated that most of her friends

hated mathematics, thought it was 'gross', and did not understand why she was interested in it. Several of the participants mentioned that they got along with basically everyone in their high school. However, Allison shared that the women in her high school tended to tease or ignore her, based on the fact that she was a strong student. Generally, participants' groups of friends in high school did not impact their feelings towards mathematics, and participants seem to have bonded with their friends on a level outside academic interests.

In university, the participants have continued to have diverse groups of friends, and only Elise and Felicity noted that they were close friends with a group of students from their mathematics classes. However, both Elise and Felicity also reported having other groups of friends to whom they were equally close, if not closer, than their friends from their mathematics classes, such as friends from church and friends from high school. A few participants mentioned that they frequently worked with their peers from their mathematics classes on assignments. The other participants tended to prefer working alone, or it was not logistically possible for them to get together with their peers to work on assignments. The participants' close friends tend to be students from other academic programs, their friends from high school, or friends from extra-curricular activities. The pattern of having a group of friends with varied academic interests continued for most participants at the university level.

When asked to describe their female peers in their mathematics classes, the participants tended to paint a similar picture; that is, they viewed the females in mathematics as very serious, intelligent, organized, shy, not very social, driven, and overly focused on mathematics. The majority of participants felt they were very different from their female peers in their mathematics classes. Brooke, Dana, and Felicity felt that their female peers had 'no life' outside mathematics whereas these participants explicitly

described how they placed value on socializing, and being involved in many activities outside school. It was more important to these participants to be well-rounded than to solely focus on school and get the top marks. Elise was the only participant who felt that she was similar to the other women in mathematics in terms of being very anxious, lacking in self-confidence, being shy and quiet, and always feeling the need to perform academically. None of the other participants described themselves in this manner. However, Elise distanced herself from the vast majority of other women in mathematics by describing how she was more feminine, in terms of being interested in dressing up, looking nice, and going shopping. Allison appeared to hold the most becoming view of the other women in mathematics, as she described them as less judgmental than women in other subject areas, and willing to 'stick together' as a group. Although the participants described the other females in mathematics with some complimentary adjectives like 'intelligent' and 'organized', the majority of participants distanced themselves from the other women in mathematics as they viewed them to be overly focused on mathematics, very serious, and not very social.

For those participants with a second major, they found great differences between the women in mathematics and the women in other subject areas. For instance, Allison described women who were studying English as being more catty and focused on appearance than the women in mathematics. Brooke described the women in Biology degree programs as being serious about their studies as they usually had a 'higher purpose', such as wanting to get into medical school or veterinarian school upon completion of their undergraduate degree. However, she found that the female Biology students were friendlier and more outgoing than the women in mathematics. On the other hand, Brooke called the women who were studying Psychology 'Valley Girls', a term that is generally used to

describe women who are ditzy and focused on their appearance, shopping, and boys. Dana described the women in Economics as being more relaxed than women in Mathematics, which Dana attributed to her perception that the program was easier. She also thought that the women in Economics tended to have a wide range of intellectual capabilities whereas she thought the women in mathematics were all very intelligent. Generally, women in other subject areas were seen as being more outgoing than women in mathematics, although were sometimes linked to other negative traits not ascribed to the women in mathematics.

Interestingly, participants who spoke about the males in mathematics did not find them to be similar to the females in mathematics whatsoever. Brooke described the males in mathematics as 'normal college guys, but a little geekier'. She felt that they were much friendlier than the women in mathematics and more willing to help others with any problems. However, Felicity felt that the males tended to patronize the females when they worked on mathematics assignments together, so the women would often work by themselves. Elise reported that she finds the men in mathematics much more relaxed and not as focused on being 'perfect' academically as she feels that she and the other women in mathematics are. For instance, Elise noted that male students would often go into presentations unprepared, willing to say 'I don't know' to questions, whereas she and the other women did not find this practice acceptable. Overall, the participants provided a very different perception of men and women in mathematics.

Personal Characteristics

In this section, I first outline personal characteristics that the participants believe helped them in their mathematics experiences. I then discuss personal characteristics that

participants viewed as hindrances, and then conclude by sharing an example involving self-doubt.

In terms of characteristics that supported the women in their mathematics experiences, several participants noted that they are very stubborn and determined. For instance, Brooke believes she is more motivated to do something if someone tells her she can't do it, as she likes to prove others wrong. However, Elise and Felicity noted that they sometimes will struggle on their own beyond a reasonable point, preferring to work alone rather than to risk looking 'stupid' by going to ask a professor for assistance. Brooke noted that this was also her attitude early in her university studies, but she has since overcome this hurdle and will ask for assistance. All of the participants expressed a long-standing love for mathematics, and highlighted their aptitude for the subject area. A few participants attributed part of their success in mathematics to being very well-organized with their work and materials. Dana noted that she was a very fast worker, which helped her during 'crunch' times like exams. Finally, several participants noted their love of the challenge of mathematics problems was supportive to their success; they would happily spend many hours engaged with a problem, patiently trying to solve it. Generally, participants felt that their determined nature and willingness to spend lengthy amounts of time on mathematics problems were instrumental to their success.

Participants also shared a variety of personal characteristics that they felt hindered their success in mathematics. Many participants noted that their tendency to procrastinate or spend too much time socializing had been detrimental. Other than procrastinating and socializing too much, the participants seemed to have very different challenges that arose from their personal characteristics. For instance, Chantal and Dana noted that the early morning scheduling of math classes does not mesh well with their natural sleep tendencies.

They would not be sufficiently wide awake during class to garner an understanding of the material, so they would have to decipher their notes later on their own. In terms of mathematical approaches, Elise feels that she often gets caught up in small details and loses sight of the bigger mathematical picture. Other personal characteristics that individual participants found problematic included being easily distracted and being dependent on professors for explanations of mathematical material, rather than being able to learn from a textbook. Although participants noted a variety of different personal characteristics that had caused them problems, procrastination appears to be the most common attribute that the women felt had hindered their success in mathematics.

Feelings regarding self-confidence in mathematics were also an issue for some participants. Chantal and Elise both felt that they doubted their abilities in mathematics at times. Chantal, however, felt that she was able to step back from the situation that had caused the negative thoughts (e.g., a poor mark on a test) and give herself a fresh start. Elise's issues surrounding a lack of self-confidence appeared more substantial, as she felt anxious, felt she needed to perform at all times, and was afraid to ask questions for fear that she may look dumb. Elise stated that she did not even realize she was such an excellent student, although she always received final grades of A+ in all her courses, until professors started to notice her and make comments.

Formal Education System

In this section, I highlight a variety of aspects related to the participants' experiences in the formal education system. I begin by describing notable experiences for the participants during elementary school, high school, and the transition to university. I then provide an overview of the women's university programs of study, male to female

ratios in their classes, and their notions of what constitutes good mathematics educators. Next, I outline issues experienced by the participants in the Francophone sector. Finally, I describe the type of mathematics the participants like, why they like mathematics in general, and their career plans.

Although they were not explicitly asked, a few participants shared stories from their elementary school days that they thought were important to their mathematics experiences. Allison reported being placed in split grades whenever the option was available, and doing the older grade's mathematics work, as she was bored with her own grade's work. She also recalled thriving on competition with boys in her classes. Dana was in an arts school for Grades 1 to 6, where half the day was spent on music, visual art, and drama and the other half of the day was spent on the other subject areas. When she changed to a regular elementary school for Grades 7 and 8, she was very bored with her work after being in such a compressed program. Felicity had a similar experience; after being in an enriched program for Grades 4 to 6, she moved to a regular elementary school where she was bored with the pace and content of the material being taught. Elise was the only participant who noted that she struggled with mathematics in elementary school and did not start to 'get it' until she was in high school. Overall, most of the participants who shared experiences related to elementary school reported being bored with their mathematics work.

The participants all attended public high schools, but they were involved in a variety of special mathematics programs. Both Chantal and Elise were enrolled in the International program at their Quebec high schools, which involved more enriched work, varied coursework, and a focus on community service. Allison, Dana, and Felicity recalled participating in national or provincial mathematics contests. Both Allison and Felicity reported that they participated every year and enjoyed the opportunity to work closely with

a teacher and learn more advanced mathematics. Elise noted that she was not invited to participate in the mathematics contests, even though she had the best marks for two years. Rather, two boys were always selected by the teachers to participate, and Elise recalled being bothered by this circumstance at the time. While the participants had a variety of high school experiences, most included some sort of enriched work in mathematics, be it in-class or in an extra-curricular activity.

Several participants noted that they had a very difficult time with the transition to university. They cited such issues as being intimidated by the large class sizes (and thus not asking questions), not adjusting well to early morning classes, not realizing how much work was required, and dealing with language issues (for a Francophone student who was forced to take an English-language mathematics class). These participants all found that they were able to adjust to university life by their second year of studies. Most participants recalled having first year classes that had hundreds of students. Their classes now range in size from fewer than 10 to approximately 50 students. The participants tend to enjoy smaller classes more as they feel more of a sense of connection with the professor and other students.

Several of the participants made changes to their university program of study; only Allison and Chantal are still enrolled in the same degree program in which they began (Mathematics and English; Mathematics). Elise and Felicity began in a more broad-based Science and Mathematics program and dropped sciences from their schedule, resulting in strictly a Mathematics degree program. Both Brooke and Dana began in other fields. Brooke added Mathematics as a second major to her initial Biology degree and Dana completely changed programs (from Biopharmaceutical studies to a double specialization in Mathematics and Economics). Notably, two of the three participants who are enrolled

solely in a Mathematics degree program (as opposed to a double major) are going back to school once they complete their current degree to obtain a second undergraduate degree in another field. Of the undergraduate participants in the study, only Felicity plans to do a master's degree in Mathematics. The changes to these women's academic programs have been substantial, and in some cases, have affected their career plans.

Although none of the participants noted that they had issues with the gender imbalance in mathematics, they all stated that it existed in their classes. All of the participants recalled generally having more males than females in their mathematics classes, and their estimations of the proportion of female students in mathematics ranged from 20% to 45%. Brooke noted that her statistics classes tended to have a more even balance of males and females than her other mathematics courses. Elise found the proportion of women decreased from approximately 40% in her undergraduate classes to 20% in her graduate-level classes. A few participants stated that they did not have any female mathematics professors whatsoever during the course of their degree, and the greatest number of female mathematics professors experienced by a participant was two. Clearly, a gender imbalance in mathematics, both in terms of students and professors, was evident in these women's experiences at this university.

The participants all recalled having excellent mathematics teachers and professors, but none of the participants mentioned that these educators acted particularly as mentors to them. Generally, participants described good mathematics educators as being very passionate about the subject area, able to communicate the material well, organized, and very personable toward and supportive of the students. Participants especially appreciated when teachers were helpful to them on an individual level and did not make them feel badly about asking questions. Conversely, poor mathematics educators were seen as those

who made students feel stupid by frequently making such comments as 'This is easy' and 'You should understand this'. Poor educators were also viewed as disorganized and unable to communicate the mathematical material to students. Some participants mentioned that they would skip classes and avoid enrolling in classes with these types of poor mathematics professors at university. Participants' views of a quality mathematics educator seem to involve mostly interpersonal aspects, such as communication skills and friendly personalities.

Five of the six participants are in the Francophone sector, and all of these participants reported having issues with language during the course of their degree. They noted that their first and second year mathematics classes were usually offered in French, but this was no longer an option in upper-year or graduate-level courses. Some participants reported that their mathematics textbooks were always in English, even if the course itself was taught in French. Although four of these five participants had been fluently bilingual since they were quite young, they still found doing mathematics in English challenging since they were not familiar with the terminology and differences in mathematical notation. Elise in particular reported being very frustrated by the lack of Francophone materials and classes offered at what is supposed to be an officially bilingual university, as she had to learn English at the age of 16 in order to take mathematics classes that were not offered in French. The lack of mathematics classes and resources in French was clearly an added challenge for the women in the Francophone sector.

In general, participants had similar reasons for loving mathematics. Nearly all of the participants mentioned that it was a subject that seemed to be a 'natural fit' for them; they did not need to work hard to understand mathematics. A few participants noted that they struggled with subjects that involved extensive amounts of writing, such as English or

the social sciences. Thus, they felt even more drawn to mathematics as it was an area in which they excelled. Participants also mentioned enjoying the challenge of working on problem solving. The idea that there was one answer 'out there' to be found and the satisfaction of 'finding' it was a pleasing notion to some participants.

With regard to the type of mathematics that the participants enjoyed most, all six women resoundingly voiced that they preferred applied mathematics to theoretical mathematics. Strong language such as 'hate' was used in regards to such topics as proofs, working in an infinite number of dimensions, and theory in general. Participants wanted to learn mathematics that made sense to them on a real-world level and was perceived as useful. Allison shared that she would not even consider further education in mathematics as she felt it would be too heavily based in theory.

Related to the participants' preference for applied mathematics, their career plans all have a common theme: the careers involve mathematics, but do not solely focus on it. Only Felicity is considering becoming a mathematics professor, but she is also interested in working in a business-related field. The careers planned by the other five participants are in the following fields: actuarial science, forensics, statistics (two participants), and high school teaching (mathematics and English). These careers use mathematics, but also require knowledge from other disciplines.

CHAPTER 7: ADDRESSING THE RESEARCH QUESTION

In this chapter, the research question 'In what ways do women who were educated in Canada and who are nearing completion of undergraduate mathematics degrees feel they have been supported and challenged in their high school and university mathematics experiences?' is addressed. First, the supports and challenges within each dimension in the study (Family, Peers, Personal Characteristics, and the Formal Education System) are summarized via Venn diagrams and linked with the existing research in the field. Then, three cross-dimensional themes are discussed and linked to existing research. The chapter concludes with a discussion of how the study's findings, both within and across dimensions, addressed the research question.

Findings by Dimension

In this section, I highlight the overall findings for each dimension, across participants. For each dimension (Family, Peers, Personal Characteristics, and the Formal Education System), I summarize the findings with a Venn diagram that shows factors that were supports and challenges, as well as those factors that were both supports and challenges, and those that were neither a support nor a challenge. Then, these findings are linked to related literature.

Family

In the Family dimension, the participants primarily experienced supports, as is evident in Figure 10. Some factors are placed in the overlapping section of the diagram, such as mothers' views of mathematics, as they were supportive in some participants' cases but challenging in other participants' cases. Also, two factors (parents' educational

backgrounds and careers) were neither an explicit support nor challenge, so they are located outside the 'Supports' and 'Challenges' circles.

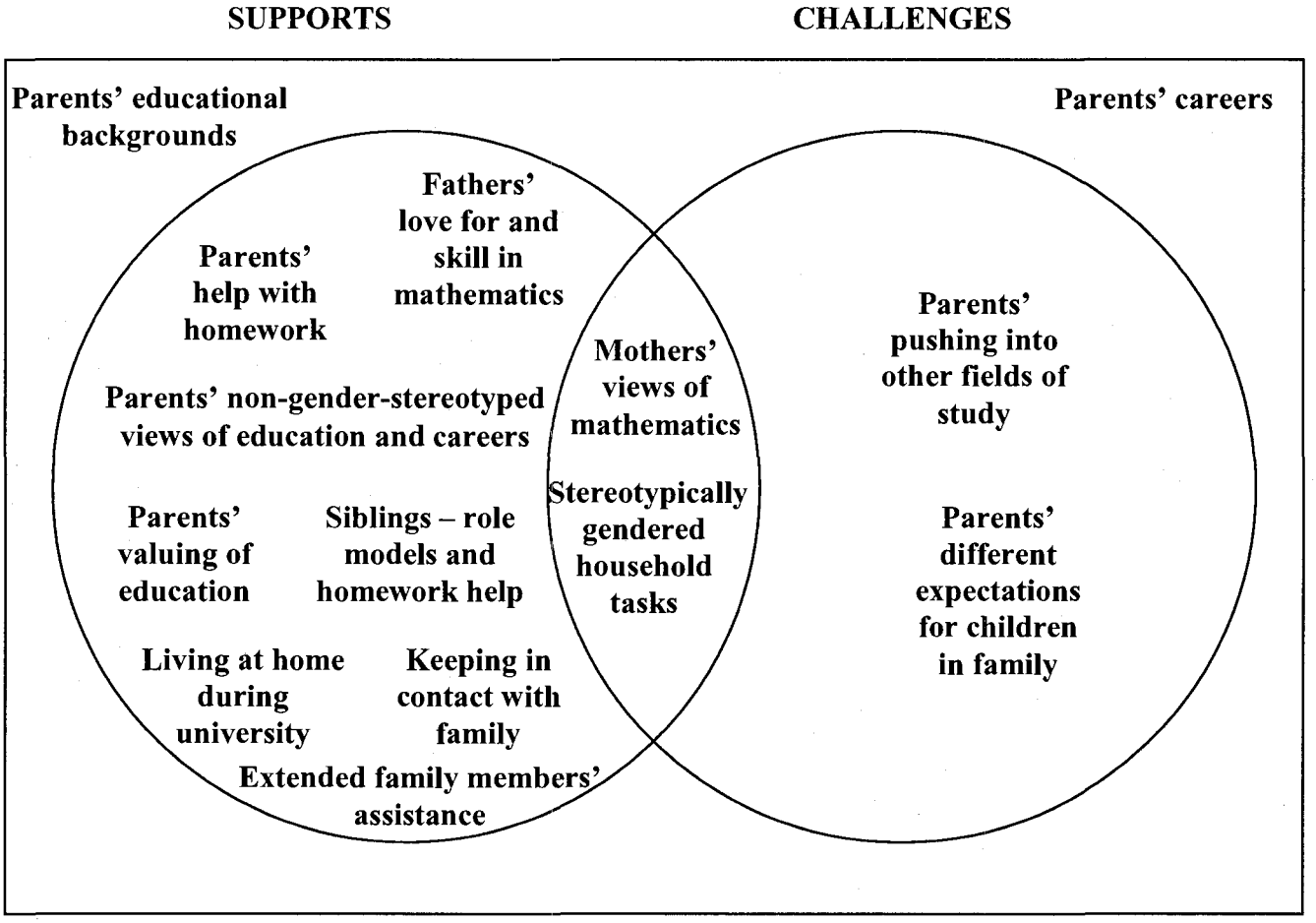

Figure 10. Supports and challenges in the Family dimension.

As shown in Figure 10, the participants' families (parents, siblings, and extended family members) were shown to positively impact the participants' mathematics experiences in many ways. The participants all described themselves as being close to their families, and felt they had been well-supported by their family members in both their mathematics experiences and lives more generally, although many participants noted that their fathers had a greater impact on their love of mathematics than did their mothers. Parental support has been shown in many studies (e.g., Blair, 1991; Gavin, 1996; Gill,

2000; Hanna, Kündiger, & Larouche, 1990) to be a key factor in women's mathematics experiences. For instance, in Gill's study (2000), women's choice of a mathematics-related field of study at the undergraduate level was linked to high levels of parental support.

In my study, parental education and careers were quite varied and did not seem to play a direct role in the participants' mathematics experiences; in fact, only one parent has a mathematics-related job. Five of the 12 parents finished their formal education at the high school level, and only two parents have education above the bachelor's degree level. This contrasts with the findings of previous studies (Gavin, 1996; Zeldin & Pajares, 2000) that found that having parents who worked in mathematics-related fields and who were highly educated was linked to women's choice of mathematics-related fields for university study. In my study, although the parents were generally not highly educated, they did place significant value on education and were very supportive of their children's educational endeavours. Perhaps outside circumstances, such as issues surrounding immigration, prohibited some of the parents from obtaining higher education.

Peers

In the Peers dimension, as shown in Figure 11, there was a greater mix of supports and challenges than in the Family dimension. Friends were the main supports for the participants, and classmates and coworkers were a combination of supports and challenges, or strictly challenges.

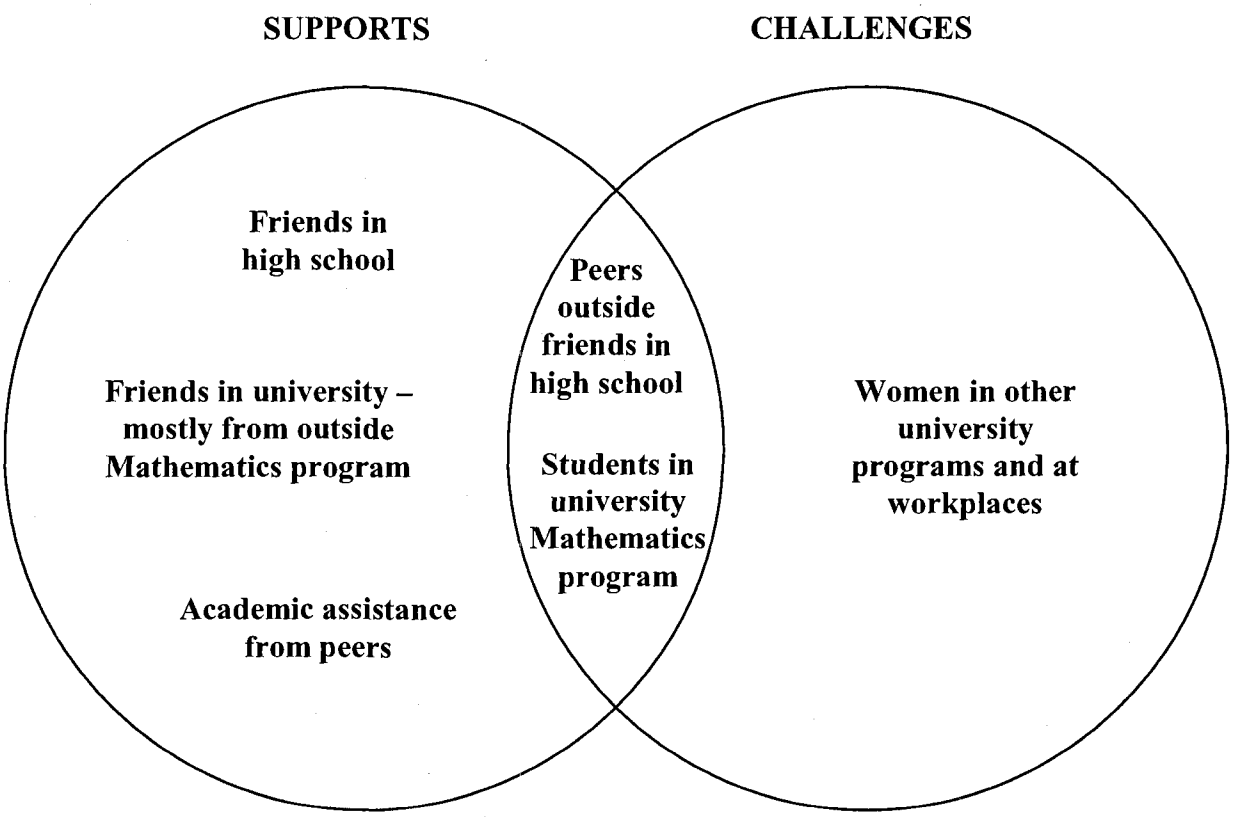

Figure 11. Supports and challenges in the Peers dimension.

The participants' friends at both the high school and university level were very diverse in their academic interests, although most were not interested in mathematics. Several studies (e.g., Gill, 2000; Hall, 2006; Zeldin & Pajares, 2000) have noted the importance of having peer support, both academically and socially, and having friends who are interested in similar subject areas. Although a few participants in my study had friends from their mathematics classes, most of participants' friends were from outside the department; thus, the participants tended to draw their support from non-mathematics-related peers. It appears that having a similarly-interested peer group did not seem to be an important factor related to choice of field of study for the participants in my study.

The participants in my study generally held similar views of the other women in their mathematics classes as being very serious, focused only on mathematics, and not very

social; most participants clearly distanced themselves in terms of their personalities from the other women in mathematics. Participants described women in other fields of study and men in mathematics very differently from the way they described the other women in mathematics.

Personal Characteristics

The personal characteristics that participants felt had supported and challenged them during their mathematics experiences were quite varied, as can be seen in Figure 12. Common attributes that the participants felt had supported them in their mathematics experiences included being determined and having a great aptitude for and love of mathematics. Common attributes that participants felt had hindered them were tendencies to procrastinate and socialize rather than work on schoolwork. Stubbornness was both a support and a challenge to the participants.

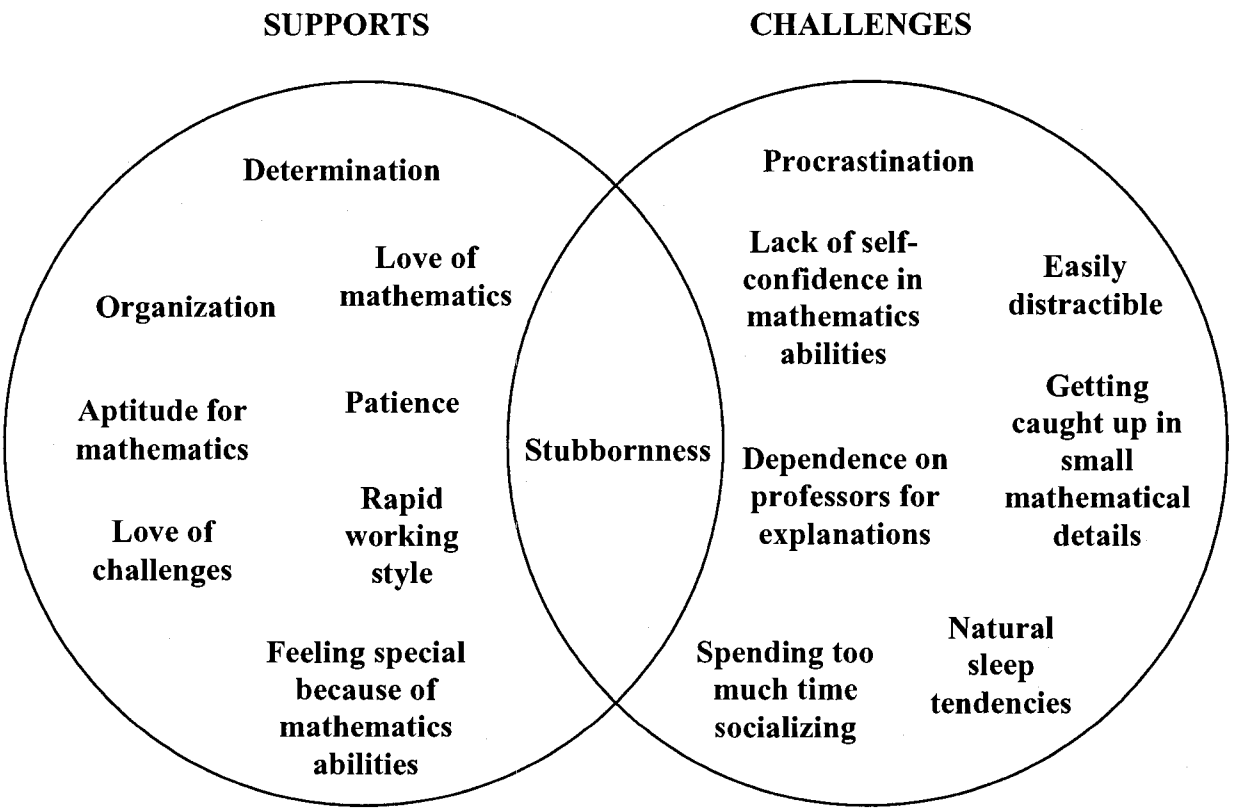

Figure 12. Supports and challenges in the Personal Characteristics dimension.

A lack of self-confidence in their mathematics abilities was challenging for two participants. Although lacking self-confidence in mathematics is frequently cited in the literature regarding females in mathematics more generally (e.g., Damarin, 1993; Fennema & Sherman, 1977; Richardson & Suinn, 1972), studies regarding females in mathematics degree programs tend to show these women as having strong beliefs in their abilities, high levels of self-confidence, and coping strategies (Seymour, 1995; Zeldin & Pajares, 2000). Some studies (Gill, 2000; Hall, 2006) have noted the importance of being passionate about and highly skilled in the subject area in order to pursue and persevere in it, and this was clearly evident for all the participants in my study. Several participants also described how they placed high academic demands on themselves, a finding similar to that of research

conducted with American undergraduate students at a women's college (Gavin, 1996). Other characteristics linked to perseverance are being competitive, determined, and having a serious academic attitude (Gavin, 1996; Rodd & Bartholomew, 2006; Zhao, Carini, & Kuh, 2005). The women in my study were all very determined individuals, and two participants described themselves as competitive, either now or in the past.

Formal Education System

With regard to the formal education system, the participants tended to have many similarities in their experiences. The women encountered many supportive situations, but they also faced several different challenges, as is shown in Figure 13.

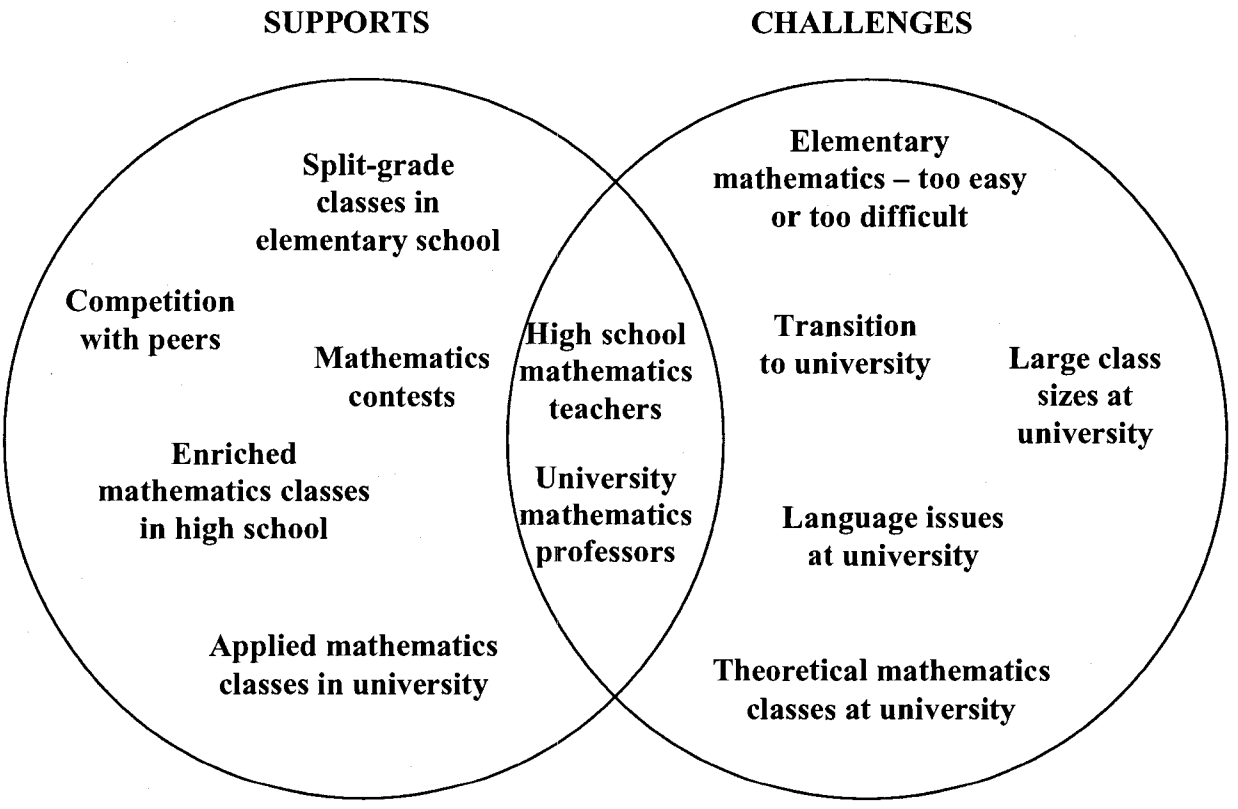

Figure 13. Supports and challenges in the Formal Education System dimension.

Several participants were involved with either in-class or extra-curricular enriched mathematics at the high school level. This corresponds to Gill's (2000) findings that participation in after-school programs at the high school level was linked to enrolment in mathematics-related fields of study at university. Gill also found that group work at the high school level was an important factor in her participants' choice of mathematics-related fields of study at the university level. However, no participants in my study explicitly mentioned group work when discussing their mathematics experiences at the high school level.

Although some participants reported problems with the transition to university, they all settled in by their second year of studies. In university, many participants changed their degree programs, are enrolled in double major degree programs, or are planning to take a second undergraduate degree outside the field of mathematics. All the participants stated a preference for applied types of mathematics, which is reflected in their career choices in mathematics-related, but not mathematics-focused, fields. The participants enrolled in the Francophone sector found they faced issues surrounding the language in which mathematics was taught at university.

The participants valued mathematics educators who were passionate, personable, organized, and communicated well. The participants felt that their best mathematics professors were those who treated them as individuals and were supportive and encouraging of students. Such findings have also been noted in a number of studies that examined perseverance in mathematics-related fields (Abri, 2006; Gavin, 1996; Herzig, 2004; Sax, 1994; Seymour, 1995; Zeldin & Pajares, 2000).

Themes Across Dimensions

When examining the findings from the four dimensions in combination, three recurring themes in the data that encompassed multiple dimensions became apparent. To briefly reiterate, data analysis was conducted by initially creating individual participant profiles for each dimension of the study (See Chapter 5). Then, the data were analyzed within each of the four dimensions across the six participants. These cross-participant findings within each dimension were discussed with respect to sub-topics within each dimension that were common to all participants (See Chapter 6). It was during this cross-participant level of analysis that I noticed three recurring themes that related to multiple dimensions.

These themes are as follows: First, the participants placed value on caring, supportive relationships. Second, the participants showed a strong preference for mathematics that was applied in nature. Third, the participants all experienced situations where they were felt they were 'othered', or felt they did not fit in with the dominant culture or with their peers.

Supportive Relationships

The participants were shown to value caring, supportive relationships, as was shown through their closeness to their families, descriptions of good mathematics educators, and separation from 'non-caring' characteristics they attributed to the 'other' women in mathematics.

The importance that the participants place on caring, supportive relationships is seen most clearly with respect to the participants' families. The participants all described themselves as very close to their families, whom they felt had been very supportive of their

educational endeavours. For example, Brooke described her family as "pretty nurturing... pretty accommodating for anything I want". Family support has been shown in several studies (e.g., Blair, 1991; Gavin, 1996; Gill, 2000) to positively affect women's enrolment and perseverance in mathematics-related fields of study. All the participants lived at home with their parents and siblings for at least part of their university education, and some participants shared that they only applied to universities in the city so they could remain living at home. Many participants fondly recalled working on mathematics homework and problems with their fathers, which acted as a bonding time and engaged the daughters in mathematics. Bonding over mathematics homework time also occurred with the participants' siblings.

Outside their families, the participants valued mathematics educators who were supportive of the students and who were friendly and personable. For instance, Dana described her favourite university mathematics professor as follows: "He'll make jokes once in a while. He'll talk about his daughter, his son. He just makes it more personal." Similar findings about the importance that women place on such caring characteristics of mathematics professors have also been found in previous research studies (Abri, 2006; Gavin, 1996; Herzig, 2004; Sax, 1994; Seymour, 1995; Zeldin & Pajares, 2000). For instance, Seymour (1995) found that the participants in her study liked professors who got to know them 'as people' and who really cared about them. The participants in my study felt that good mathematics educators needed to show passion about the subject area and communicate well, characteristics that both relate to an educator's ability to bond with students.

The participants' descriptions of the other women in mathematics were also telling of the value they placed on relationships. The participants tended to describe the other

women in mathematics as not very social or helpful to others in the class, and the participants distanced themselves from these women and characteristics, which implies that they value the converse characteristics. Several participants explicitly stated that they believed it was more important to be social and have a well-rounded life rather than strictly focus on mathematics, even if that hindered their academic achievement. This relates to findings of studies (Morgan, Isaac, & Sansone, 2001; Morrow & Morrow, 1995) that report that mathematics is viewed as a solitary field with little interpersonal involvement. Feminist and educational researcher Nel Noddings (1988) stated that "We must explore the unpleasant possibility that many girls do not *want* to be part of the math crowd because its members seem socially inept or aloof" (p. 18, emphasis in original). Even though the women in my study were enrolled in mathematics degree programs, they distanced themselves from the 'math crowd' – the 'other' women in mathematics. The participants in my study all valued personal relationships with their peers, but tended to obtain their friendships from outside the mathematics department, as they generally did not find they could relate to their peer group in the mathematics department on a social, personal level.

Applied Mathematics

All six participants clearly articulated a preference for mathematics that was viewed to be more applied and 'real-world' than theoretical in nature. This was further evidenced by their university degree choices and career choices.

Participants were very much aligned in their common preference for applied mathematics. In the existing literature regarding gender issues in mathematics education, women's preferences for certain types of mathematics are not frequently discussed; mathematics is often viewed as a single, homogeneous field. However, in my study, many participants expressed strong disdain for being forced to take theoretical mathematics

courses in their undergraduate degree programs. Allison shared that she would not want to study mathematics above the undergraduate level because "it would have to become theoretical". The participants in the study wanted to learn mathematics that they felt was practical and real-world applicable. My findings are related to those of a recent study of female engineers and engineering students (Abri, 2006) that found that women had a desire for relevancy in the curriculum and real-world applicability. Other earlier research (Belenky et al., 1986; Gilligan, 1982) highlighted women's preferences for connectedness in their learning. Related, the participants in my study showed their broad range of interests in their degree program choices: three of the participants are enrolled in double major degree programs (Mathematics with English, Biology, and Economics respectively) and two of the three participants who are in a strictly Mathematics degree program plan to obtain a second undergraduate degree in another field upon finishing their current degree.

With regard to the participants' career plans, only Felicity is interested in working in a mathematics-focused field; she would like to become a mathematics professor, but she is also considering working in the business world. The other participants' career choices include the fields of actuarial science, statistics, forensics, and education. Several participants voiced the value that they placed on using mathematics in their careers, but not focusing solely on it. Some studies (Lubinski & Benbow, 2006; Morrow & Morrow, 1995) have shown that females tend to prefer to work with people and organic matter. This relates to the findings of my research, as the participants' career choices all involve working with people.

Being Othered

'Othering' is defined by Weis (1995) as "that process which serves to mark and name those thought to be different from oneself" (p. 18). The participants in this study found themselves to be othered in several different ways, such as being mathematics majors, being female, and for some participants, being members of non-dominant cultural and language groups. Furthermore, even within the small cohort of women in mathematics, some of the participants felt othered.

The participants in this study were placed in a situation of being othered by the very nature of the subject they chose to study at university. In Canada, very few undergraduate students of either sex enrol in and graduate from mathematics degree programs. In the 2005/2006 academic year, only 3.51% of undergraduate enrolments and 4.35% of undergraduate graduations at Canadian universities were in mathematics and the related fields of computer science and information science (Statistics Canada, 2008a, 2008b). Of the undergraduate students in mathematics and related fields, women constituted only 25.3% of enrolments and 26.4% of graduations (Statistics Canada, 2008a, 2008b). Put another way, female undergraduate students in mathematics and related fields constitute approximately one percent of all undergraduate students (0.9% of enrolments and 1.1% of graduations). Thus, the participants are members of a very small proportion of the undergraduate students in general, the cohort of undergraduate mathematics students. Within this small cohort, women only account for approximately one-quarter of the students, making them members of an extremely small group. Although none of the participants explicitly stated that they were bothered by the gender imbalance in their classes, they all noted that it did exist. It is possible that the participants were so accustomed to classes with more males in them that they accepted the situation as 'the way

things are'. Only Elise shared that she had questioned why there were so few women in mathematics and deeply examined her own educational pathway through this lens.

Related to the gender imbalance in mathematics, issues surrounding societal notions of femininity were discussed by most of the participants. The participants tended to position themselves on the ends of the femininity-masculinity spectrum, with some participants identifying themselves as tomboys and some participants expressing preferences for 'feminine' activities. For instance, both Brooke and Felicity noted that they preferred 'masculine' housework tasks, and Brooke described herself as a tomboy. Her close friends consist of her brother and other men from the military base. Allison also positioned herself in contrast to the 'Barbie girls' at her high school who very much encapsulated stereotypical notions of femininity in terms of appearance, and she noted that these girls tended to either tease her or ignore her. Conversely, both Dana and Elise noted the importance of looking good and feeling feminine. Dana noted that people often did not believe she was in mathematics based on the way she looked. Elise contrasted herself and one girlfriend with all the other female graduate students in mathematics by noting that they liked to dress up 'for no reason' when they came to the office, whereas the other female graduate students were proud of being "in pyjamas doing math and being cool about it". Elise also noted that she and her girlfriend were unique as they also liked to engage in 'feminine' activities such as shopping. When discussing cultures that are heavily dominated by one sex, studies have found a variety of coping strategies and outcomes for the non-dominant group. Kanter (1977) found that members of non-dominant groups tend to make themselves less visible. This relates to the women in my study who separated themselves from stereotypical feminine culture; whether these were conscious or unconscious choices and actions, rejecting dominant notions of femininity may have made

it easier for these women to fit into the male-dominated culture of mathematics. Conversely, Walkerdine (1989) found that women in male-dominated fields may assert their femininity as "a defense against the frightening possibility of stepping over the gender divide" (p. 276). Similarly, Riviere (1985) found that female academics felt the need to act in stereotypically feminine ways in order to be reassured that they are, indeed, women. It is unknown whether either of these purposes was behind the actions and preferences of the women who acted in a stereotypically feminine manner, but they could be contributing factors, even at a subconscious level.

Several participants separated themselves from the other women in their mathematics degree program, describing many ways that they were not like 'them'. The participants tended to view the other women in mathematics as very introverted, serious, only focused on mathematics, and not very social. By positioning the other women in mathematics as an 'other', the participants thus positioned themselves as having the converse characteristics. These participants distanced themselves from some of the negative characteristics that are stereotypically attributed to mathematicians, such as lacking social skills and a singular focus on mathematics (Damarin, 2000; Picker & Berry, 2000, 2001). These participants prided themselves on being well-rounded individuals with diverse interests, social skills, and outgoing personalities. Dana described how she "would rather do a lot of things intensively… maybe do a little bit not as good at school, but live every day". These participants felt that they did not fit in with the other females in mathematics. Most participants considered the other students in mathematics to strictly be acquaintances and academic colleagues. The participants with a second academic major tended to feel that they did not fit in with those female students either, for a variety of reasons. For instance, Brooke referred to female classmates in her Psychology classes as

'Valley Girls' and stated "I'm not as Valley Girl as the girls in Psych". The participants' close friends tended to be from outside their academic majors, and often, from outside the university setting altogether.

Although this study did not attempt to explore the impact of cultural differences on women's mathematics experiences, cultural issues did arise in the interviews as three of the participants had parents who immigrated to Canada. Thus, the home country's culture had a large influence on the participants, particularly because the participants were all very close to their families. Cultural values have been shown to differ widely across countries, and these values can have significant impacts on both current citizens and citizens who have emigrated from their home country. For example, cross-national differences in the types of education and careers considered appropriate for women and the value placed on mathematics have been found in many studies (e.g., Baker & Jones, 1993; Hanson, Schaub, & Baker, 1996; Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; van Langen & Dekkers, 2005). Chantal's parents immigrated to Canada from Haiti, which she described as having a matriarchal culture where "anybody does anything". Chantal felt that her parents' views were influenced by Haitian culture, and this impacted how they raised their children. Dana and Felicity also made references to their parents' attitudes being strongly impacted by the views of the home country's culture. For example, Felicity felt that her parents' difficulties in finding employment after immigrating to Canada from Lebanon, coupled with what she termed the 'Arab mentality' regarding what subjects are considered 'worthy' of study (Law, Medicine, Engineering, and Pharmacy), influenced her educational plans. Her parents wanted her to be a doctor, as it would ensure high-paying employment, but Felicity eventually convinced them that mathematics was the career path she wanted to follow. They became more accepting of this choice once Felicity explained how she

wanted to work as a mathematics professor, which was also a high-paying career. Thus, even though these three participants were educated in Canada for all levels, they had a very different cultural experience at home from their peers whose families had lived in Canada for many generations. Although none of the participants mentioned having any issues regarding their ethnicity or home culture, this is a factor that could contribute to a feeling of difference.

Another way that some participants were othered was through issues surrounding non-dominant language. Five of the six participants were in the Francophone sector of the mathematics degree program at the University of Ottawa, and they all noted that their upper-level mathematics classes were only offered in English. Furthermore, French-language mathematics textbooks were often not available, even in French-language classes. Even for the participants who had been bilingual since a very young age, taking mathematics classes in English was a challenge due to the specialized terminology and differences in notation. The participants expressed frustration at the lack of Francophone materials and courses at an officially bilingual university. In the city of Ottawa, nearly 60% of residents are unilingual English speakers (Statistics Canada, 2008d), so the majority of the broader societal culture is non-Francophone. Even in Francophone degree programs at the University of Ottawa, an officially bilingual institution, Anglophone culture pervaded the participants' experiences, and provided another way in which the participants were othered. However, this issue may not apply to most other universities in Canada, as the majority of universities are strictly Anglophone or strictly Francophone institutions.

Response to the Research Question

This study was guided by the following research question: 'In what ways do women who were educated in Canada and who are nearing completion of undergraduate mathematics degrees feel they have been supported and challenged in their high school and university mathematics experiences?' Specifically, the supports and challenges were explored within a four-dimension framework that focused on the participants' families, peers, personal characteristics, and experiences with the formal education system. Furthermore, three cross-dimensional themes also relate to supports and challenges: the importance of supportive relationships, the preference for applied mathematics, and issues surrounding othering.

Supports

One of the key supports for the women during their mathematics experiences at high school and university was their families. The participants described themselves as being very close to their families, who they felt were extremely supportive. The participants found that their parents had very liberal gender-role attitudes regarding the participants' educational and career choices. The participants noted that their parents valued education, and that their fathers in particular helped them to develop a love of mathematics.

With regard to their peers, most participants found that their friends were supportive of their mathematics interest, even though they were not personally interested in mathematics. A few participants found that their peers admired them for doing mathematics, a subject they found very difficult. Some participants also found peer support

academically through working with the other students in their mathematics classes on assignments and studying.

Personal characteristics that supported the women in their mathematics experiences were quite varied. Characteristics that were common to all participants were determination, and having a great love of and aptitude for mathematics. More specifically, this love for mathematics related to applied mathematics rather than theoretical mathematics, as the participants valued mathematics that they saw as useful and real-world applicable. All participants were willing to persevere with mathematics problems for long periods of time. Some participants also felt that their organizational skills had helped them during their mathematics experiences.

The participants' mathematics skills and interests were further developed through their involvement in either in-class or extra-curricular enriched mathematics activities at the high school level. The participants felt that they had been supported in their mathematics classes by those teachers and professors who were caring, personable, organized, and communicated well. The participants particularly enjoyed university mathematics classes that were applied in nature.

Challenges

The participants generally did not face challenges from their families. Only two participants spoke of being pushed toward other fields of study at university by their parents, but even these participants found that their parents were supportive of their changes to their current degree programs.

The majority of participants felt othered as they did not feel that they fit in with the other women in their mathematics classes. Thus, they were challenged socially as they did

not have a peer group in their classes with whom to socialize and bond. The participants' friends were generally from outside their mathematics classes. More broadly, the participants were othered based on their membership in certain groups: mathematics majors, females, and non-dominant language and cultural groups.

As with the personal characteristics that supported the participants, the personal characteristics that challenged the participants also were quite varied. One common problem for the participants was a tendency to procrastinate or to spend too much time socializing rather than doing schoolwork. Undoubtedly, this finding is not specific to mathematics; many university students likely have these same tendencies. For two participants, a lack of self-confidence in their mathematics abilities was detrimental.

The participants were challenged in their mathematics experiences by poor mathematics professors – those who belittled the students, were disorganized, and communicated poorly. Two participants shared examples of extremely negative and disturbing comments made by their mathematics professors. Some participants reported that they would skip classes that were taught by these types of professors, or avoid enrolling in the classes altogether in order to avoid certain professors. The participants in the Francophone sector were challenged by a lack of mathematics classes offered in French, as well as a lack of French resources, even in French-language mathematics classes. Some participants found the transition to university to be quite difficult, particularly with regard to the large class sizes, but the participants settled in by second year. Finally, the participants felt bothered by their degree program requirements that forced them to take theoretical mathematics courses, when the participants clearly had a preference for applied mathematics.

A summary of the supports and challenges faced by the participants in their mathematics experiences is shown in Figure 14.

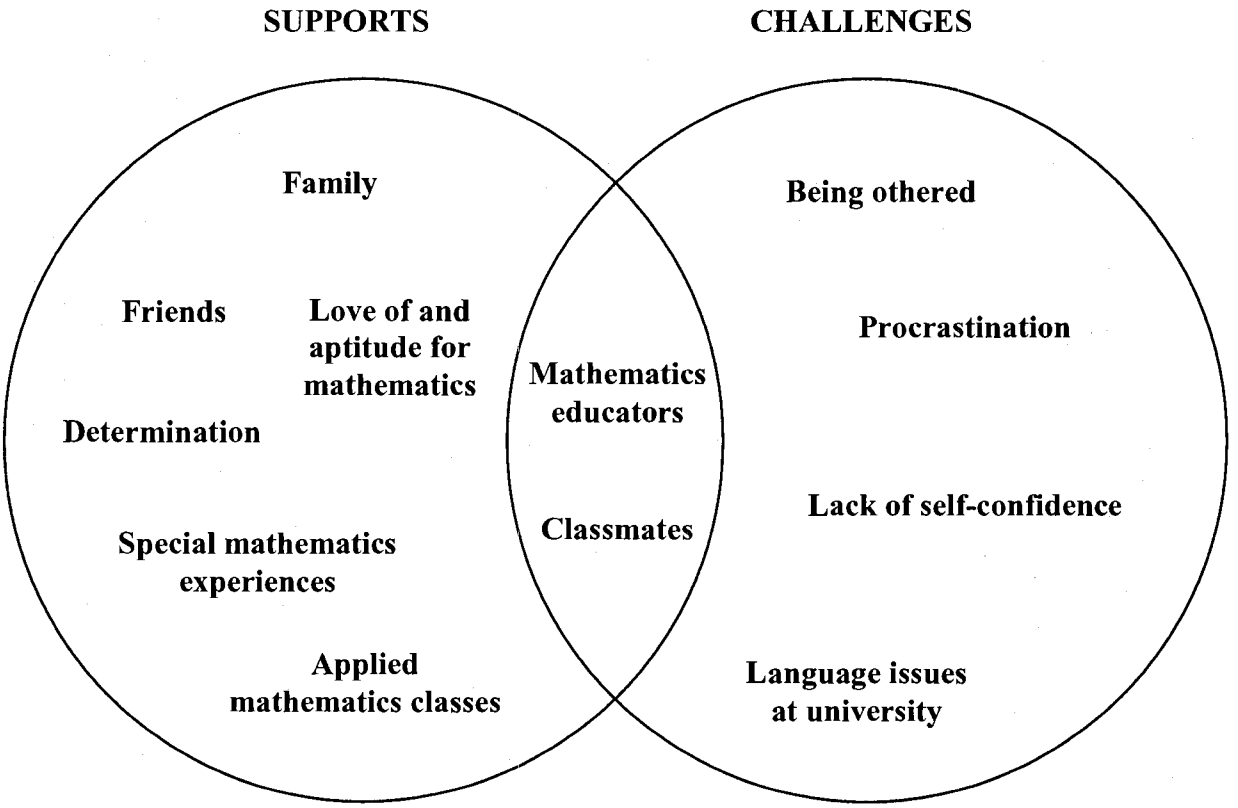

Figure 14. Summary of supports and challenges faced by the participants.

CHAPTER 8: CONCLUSIONS

This chapter begins with a discussion of implications of the study's findings for educational practice. Next, the contributions of this study to the field of gender research in mathematics education are outlined, and limitations of the study are noted. This is followed by a discussion of some questions and issues raised by this study, and suggestions for future research directions. The chapter is brought to a close with concluding comments about the study's findings.

Implications for Education

A topic frequently explored by mathematics education research is the setting in which mathematics teaching and learning occurs, and how that impacts students' experiences with and attitudes toward the subject area. The educational setting favoured by the participants in my study was shown by their preferences for certain styles of mathematics teaching and certain types of mathematics. Specifically, the participants placed great value on having supportive, caring relationships with mathematics educators. This aligns with studies (e.g., Gavin, 1996; Gill, 2000; Seymour, 1995) that have shown how supportive mathematics teachers and professors can strongly impact a woman's decision to enrol and persevere in mathematics at the post-secondary level. Further, the participants in my study all articulated a preference for applied mathematics, and several participants highlighted the importance of being able to see the real-world use of the mathematics they were learning. This aligns with recent studies (e.g., Boaler, 1997; Whitten & Burciaga, 2001) that found that instructional practices need to include a greater focus on conceptual understanding and connecting mathematics to women's lives. More generally, feminist researchers (e.g., Morrow & Morrow, 1995) advocate for cooperative

grouping, problem solving, variety in assessments, and the use of real-world contexts in order to make mathematics more meaningful to women. Of these pedagogical approaches, the women in my study expressed a great love for problem solving and a clear preference for mathematics that seemed relevant and real-world applicable. The findings of my study suggest that using the pedagogical approaches suggested by feminist scholars, particularly the use of real-world contexts, may help to interest and maintain women in mathematics as a field of study.

Contributions and Limitations of this Study

This study contributes to the field of research regarding gender issues in mathematics education in numerous ways. First, it provides insight into the mathematics experiences of the women who are 'success stories' in the field of mathematics in Canada: those who selected and persevered with undergraduate mathematics degree programs. By hearing their stories with respect to many areas of their lives, this study allows others to better understand some of the types of supports and challenges that exist for women in mathematics. This study also adds to the existing body of literature in this field by reinforcing some findings of previous studies, such as the importance of supportive family members and educators, as well as raising new issues such as the type of mathematics preferred by women, differences in family cultural backgrounds, and issues regarding language of instruction at bilingual institutions. This study also resulted in some findings that differed from previous studies in this field, such as the finding that parental education and careers did not seem to directly influence the participants' choice of field of study.

This study is limited by the fact that it was a small-scale study with six female participants from one Canadian university. The findings from this study are not

generalizable, but rather provide a glimpse into the lives of a group of women who are 'success stories' in mathematics in Canada. Since the study was volunteer-based, the women who participated are likely the more outgoing individuals in the group of women in mathematics, as they were willing to share their stories in one-on-one interviews with a researcher they did not know. Thus, the voices of women in mathematics who are less outgoing may not have been heard in this study.

Directions for Future Research

As I complete this research, several issues still remain, and some new questions have been raised. These issues and questions include the possibility of a unique nature of the population studied, issues regarding Canadian culture and multiculturalism, and questions regarding the related populations of men in upper years of undergraduate mathematics degree programs and women who left these programs.

First, due to the type of data collection in this study (volunteer one-on-one, face-to-face interviews), I wonder whether the participants were a unique subset of the women in undergraduate mathematics degree programs. Presumably, shy women would not be prone to volunteer for such a study as it involved speaking to a stranger about their experiences. Also, if the 'other' women in mathematics were as mathematics-focused as the participants described, they would likely not want to take time away from their mathematics studies to participate in educational research, particularly not near the end of the academic year. Thus, I wonder whether I interviewed women who were indeed a more outgoing, well-rounded type of student, so their view of the 'other' women in mathematics as being quiet, shy, and mathematics-focused was accurate, or whether their perception of the other women in mathematics was merely that: a perception. The participants in the study could

have very well been talking about each other, and there would be no way to know. It would be interesting to see if the same perceptions of the 'other' women in mathematics would be found in a study where all the women in an undergraduate mathematics degree program were interviewed, rather than only volunteers.

The second issue raised by the study relates to culture and ethnicity. Canada has become increasingly multicultural and has a very heterogeneous population in terms of language, culture, and ethnic background. The 2006 Census found that 19.8% of Canadians are foreign-born; the population of foreign-born Canadians increased by 13.6% since the 2001 Census, which is approximately four times higher than the growth rate for the Canadian-born population (Statistics Canada, 2007). Furthermore, 20.1% of Canadians are allophones (those with a mother tongue that is neither English nor French), according to 2006 Census data (Statistics Canada, 2007). Related, more than 200 ethnic origins were reported on the 2006 Census, and 16.2% of Canada's population is comprised of individuals who are visible minorities (Statistics Canada, 2008e). Given these statistics, the number of women in my study whose parents are first-generation Canadians is higher than would be expected. With three of the six women in the study in this situation, it raised further questions regarding which women are in mathematics in Canada. It is possible that more women from immigrant families (as opposed to women whose families have been in Canada for several generations) may elect to study mathematics due to cultural influences from their parents' home countries. As aforementioned, several studies have shown that there are large cultural differences cross-nationally with respect to the value placed on mathematics and the types of education and careers that are considered appropriate for women (e.g., Baker & Jones, 1993; Hanson, Schaub, & Baker, 1996; Huntsinger, Jose, Larson, Krieg, & Shaligram, 2000; van Langen & Dekkers, 2005). Since the participants'

parents played such a large role in their lives and were such a support for them, the culture of the parents' home country would have a significant impact. In the future, there may be changes in the number and cultural composition of students who enrol in mathematics at the university level, as Canada becomes an increasingly culturally and ethnically diverse country.

Related, another issue arose in this study related to the women in mathematics who did not qualify for the study due to its third requirement that the participants must have received all their education (elementary, secondary, and post-secondary) in Canada. When I stated this requirement during my in-class recruitment presentations (after stating the requirements of 'female' and 'third or fourth year of a mathematics degree program'), I noticed that nearly all the Asian women put their hands down, indicating that they were no longer eligible to participate. I also had other women contact me about participating in the study who were disqualified by this requirement. Thus, I wondered who all the non-Canadian-educated women in mathematics are –recent immigrants themselves, or perhaps international students who are attending Canadian universities, and whose families still live in their home countries. Studies that examined the educational experiences of immigrants found that these individuals faced issues specific to their immigrant status. In Zou's (2002) reflections on her experiences as a Chinese immigrant to the United States, she described dealing with her multiple identities and language issues, as well as feeling othered as a Chinese in United States and an American in China. Sfard and Prusak (2005) examined the experiences of Grade 11 students from the former Soviet Union who immigrated to Israel with those of native Israelis in the same mathematics class, and found that there were substantial differences in the learning styles and achievement in mathematics of the two groups of students. These differences were not fully accounted for based on exposure to

different educational systems, but also related to cultural factors of the immigrants' home country, particularly with respect to the authority and influential role of the immigrant students' parents, and issues surrounding othering, such as using mathematics success as a way to fit into the local culture. These two studies outline some unique issues that immigrant students may encounter during their educational experiences.

The cultural issues raised by this study bring forth further questions: If the majority of women who are studying mathematics at the university level in Canada are those with immigrant parents, or those who are immigrants themselves or international students, what is happening to the women from multi-generational Canadian families who were raised and educated in Canada? Are they selecting away from mathematics at the university level in a greater than statistically expected proportion? Essentially, who are the women who are studying mathematics at the university level in Canada? To begin to understand the complexities regarding the multicultural mosaic that is Canada, and how that affects university mathematics enrolment and perseverance of women, future studies may want to explore larger populations, such as all women in mathematics programs in one or several Canadian universities, to better understand precisely the nature of the composition of the female students in mathematics degree programs at the university level, and how cultural issues play a role in these women's choices of mathematics as an academic major.

Also, to fully understand issues surrounding perseverance in mathematics degree programs at the undergraduate degree level, future research might want to examine two other related groups: men, to see if they face similar issues to women in mathematics degree programs, and the counterpoint to these women – women who began in mathematics degree programs but dropped out or changed fields. By strictly examining the unique group of women involved in the study, it is difficult to establish that the findings

would not also be similar for the two aforementioned groups; however, I elected to study my unique group of participants as I feel they are understudied in the research literature, particularly in terms of hearing their individual stories. By providing many perspectives on the story, a comprehensive summary of factors that contribute to success and perseverance in mathematics can emerge.

Concluding Comments

While this study raised many questions and new issues regarding women's experiences in mathematics, it also had many significant findings. The participants' resounding preference for applied mathematics was a new finding in this field of research, as previous studies tended to treat mathematics as a homogeneous field. This raises the question of exactly what types of mathematics, if any, are preferred by most females. If this question was further investigated using a wide range of female populations, the findings could lead to suggestions for new directions in mathematics teaching and learning. This study also found that supportive relationships were key to these women's success, both in terms of family members and educators, which relates to prior feminist research that highlighted of the importance of caring relationships and connectedness. The cultural issues that were raised by the study were rarely mentioned in previous literature that is specific to gender issues in mathematics education; in fact, an examination of several of the closely related studies to this thesis showed that virtually none of these studies even mentioned ethnicity or culture, let alone their impact on the participants' mathematics experiences. Due to the increasingly multicultural composition of Canada, these issues are certain to become even more apparent in the future. Related, the participants were othered in a number of ways, some of which related to culture and language.

Overall, when examining the study's findings with a broader scope, the theoretical perspective that guided this study was shown to align with the women's preferences. My position that gender issues in mathematics are linked to socio-cultural factors, and that pedagogy aligned with feminist ideologies will help to improve the mathematics experiences of females was shown in this study to be highly relevant. If the stories of the women in this study are viewed with this lens, suggestions for future directions in mathematics education become apparent.

Footnotes

[1]For the purposes of this thesis, the biological term 'sex' will refer to two sexes, male and female, as these are the sexes used in all known research studies about mathematics. However, the author acknowledges that there are more than two biological sexes, and refers the reader to *Sexing the Body: Gender Politics and the Construction of Sexuality* by Anne Fausto-Sterling (2000) for further reading on this topic.

[2]All quotations from Allison were taken from the transcript of the single-session interview conducted March 7, 2008 on the University of Ottawa campus.

[3]Participants were not explicitly asked about their elementary school experiences in the interviews. However, if a participant spontaneously shared stories about her experiences at elementary school, these stories were included in the 'Formal Education System' section of the participant's individual section of this chapter.

[4]All quotations from Brooke were taken from the transcript of the single-session interview conducted March 12, 2008 on the University of Ottawa campus.

[5]All quotations from Chantal were taken from the transcript of the single-session interview conducted March 31, 2008 on the University of Ottawa campus.

[6]All quotations from Dana were taken from the transcript of the single-session interview conducted April 7, 2008 on the University of Ottawa campus.

[7]Dana was stylishly dressed, in shape, and attractive.

[8]All quotations from Elise were taken from the transcript of the single-session interview conducted April 25, 2008 on the University of Ottawa campus.

[9]All quotations from Felicity were taken from the transcript of the single-session interview conducted May 1, 2008 on the University of Ottawa campus.

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Appendixes

Appendix A: Interview Protocol

Semi-Structured Interview Protocol

Project: M.A.(Ed.) Thesis – Women's High School and University Experiences that Influence the Pursuit of Undergraduate Mathematics Degrees

Date:	**Participant:**
Time:	**Position:**
Location:	**Email Address:**
Interviewer: Jennifer Hall	**Phone Number:**
Found out about study:	**Age:**

[Greet the participant and thank her for participating. Give a brief description of the study and interview process, including recording. Assure her of confidentiality and anonymity of responses. Review, sign, and date the consent form.]

Questions:

Note: *Potential follow-up questions are listed in bullet points under the main questions.*

1) Please describe your current university program of study.

2) Why did you select this program at this university?
   - *Why do you like mathematics?*

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4) How did your experiences in high school impact your interest in mathematics?
   - *Did you have any teachers who acted as mentors?*
   - *Did you have any classes that had a particular impact?*
   - *Were you involved in math contests or a math league/club?*
   - *Were you involved in an enrichment program?*
   - *Did you attend an all-girls' school, private school, or other special school?*

5) How has your university experience impacted your interest in mathematics?
   - *Did you have any professors who acted as mentors?*
   - *Did you have any classes that particularly inspired you?*
   - *How did the change in class size affect you?*
   - *How did the more impersonal nature affect you?*
   - *Did you become involved in any math-related clubs or activities?*
   - *What is the approximate ratio of males to females in your mathematics classes? Has this changed over the course of your degree?*
   - *What is the approximate ratio of male to female mathematics professors that have taught you?*

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6) How has your family affected your interest in mathematics?

- *What kind of impact did your parents and siblings have on your decision to apply for math programs at university?*
- *Do they work in mathematics-related fields?*
- *Do they have higher education in mathematics?*
- *Are they personally interested in mathematics?*
- *What kind of gender role attitudes do they have?*
- *Did your family members' roles (supportive/not) change once you were in university and (possibly) living away from home?*

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7) In high school, did you have similarly interested peers or peers who were supportive of your interest in mathematics?
   - *Did your friends also show an interest in the subject?*
   - *Were you open about your interest in mathematics?*
   - *Were you ever treated differently because of your mathematics interest? *Only asked if they didn't hide their interest**
   - *Were you involved in mathematics clubs or activities where you made friends with similar interests?*

8) How have peers in your university degree program impacted your mathematics experience?
   - *Did you form social, academic, or other types of support networks?*
   - *Did you join similar mathematics clubs?*
   - *How else did you support (or not) each other?*

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9) Which of your personal characteristics do you feel have particularly impacted your mathematics experiences in both high school and university?
   - *Which characteristics do you feel helped you?*
   - *Which characteristics do you feel hindered you?*
   - *What characteristics do you feel that separate you from your other mathematically-talented female peers (e.g., other girls who performed equally well in high school but did not select mathematics for university study; other women who began in mathematics at university, but dropped out or changed fields)?*

[Ask the participant if she has any further questions or comments. Thank her for participating in interview.]

Appendix B: Consent Form

Informed Consent for Participants

University of Ottawa

Primary Researcher
Jennifer Hall
M.A.(Ed.) Candidate
Faculty of Education

Supervisor
Dr. Christine Suurtamm
Assistant Professor
Faculty of Education
suurtamm@uottawa.ca
613-562-5800 x4144

Description of Project

As a Master's student in the Faculty of Education at the University of Ottawa, I am conducting a study entitled 'Women's High School and University Experiences that Influence the Pursuit of Undergraduate Mathematics Degrees'. As a third or fourth year undergraduate mathematics degree student, I am inviting you to participate in my research study. The purpose of my study is to learn about the factors during your high school and university experiences that influenced your enrolment and perseverance in your undergraduate mathematics degree program. If you agree to participate, you will participate in a semi-structured interview that deals with a variety of factors related to your high school and university mathematics experiences. This single interview should take approximately one hour to complete and will be conducted in January or February of 2008 at a mutually acceptable time and location. The interview will be audio-taped to allow for transcription. You will also be provided via email with a summary of your transcript to check for accuracy prior to any data analysis.

Your participation in this study is entirely voluntary and you may refuse to answer any question(s) or may withdraw at any time without penalty. If you choose to withdraw, all data gathered until the time of withdrawal will be destroyed. Any information you share will remain strictly confidential. If quoted, you will be assigned a pseudonym, and any identifying details will be removed.

The results of this study will be used in Jennifer Hall's M.A.(Ed.) thesis and potential further publications. The data will be stored in a locked filing cabinet in the Pi Lab at the University of Ottawa and will only be accessible to Jennifer Hall and Dr. Christine Suurtamm. The data will be destroyed five years after the completion of Jennifer Hall's M.A.(Ed.) thesis.

If you have any inquiries about this study, please contact Jennifer Hall or Dr. Christine Suurtamm at the contact information provided above. If you have any inquiries regarding the ethical conduct of this study, please contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5, (613) 562-5841, or ethics@uottawa.ca.

Informed Consent for Participants

I have read the above information. I understand the purpose of this study and what is required of me, and I agree to participate. I have been assured that my participation is voluntary and that my identity will remain confidential. I am aware that I am free to withdraw from the study at any time without any negative consequences.

I am aware that any inquiries about the research study should be addressed to the Primary Researcher, Jennifer Hall (, or her Supervisor, Dr. Christine Suurtamm (613-951-5800 x4144 or suurtamm@uottawa.ca).

I am aware that if I have any concerns regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 159, Ottawa, ON K1N 6N5, (613) 562-5841, or ethics@uottawa.ca.

I am aware that there are two copies of the consent form, one of which is mine to keep.

Participant's signature: _____ Date: _____

Researcher's signature: _____ Date: _____

Supervisor's signature: _____ Date: _____