

Female Gender Disparities in High School Mathematics, Science, and Career Choices

by

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#### ABSTRACT

The purpose of this study was to investigate the perceptions of principals and counsellors, on female gender disparity in high school physical science, mathematics, and career choices. The research question was what are the perceptions of principals and counsellors on female gender disparity in mathematics and physical sciences? The investigation was completed through a case study approach. The concept of equality with reference to the legal guarantees of equality in the Canadian Charter of Rights and Freedoms (1982) were used as the conceptual framework for this study. Data collected from one-on-one interviews with five principals and five counsellors, from two school districts in a province in Western Canada, were analyzed and triangulated with the professional literature. Findings indicated that school philosophy, role models, gender views, and the perceptions of mathematics and physical science were implicated in why female gender disparity persists in mathematics and physical sciences.

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## CHAPTER I

### Introduction and Statement of the Problem

Although we know that education and careers in mathematics (Alkhateeb, 2001; Fennema, 2000; Wilson, 1991; Cowley & Easton, 1999), science (Simpson, 1996; Women in Science and Engineering, WISE 1991,1992), technology (Simpson, 1996), and trades and engineering (WISE, 1991,1992) are open to females and males and, more specifically, that females are as capable as males in these education and career areas (Wilson, 1991; Simpson 1996; WISE, 1991,1992; Cowley & Easton, 1999), low female participation persists (Gaskell, Eyre, Oberg, & McLaren, 1993; Gattiker, 1994; Fullan 1990; Cowley & Easton, 1999; Wilson, 1991; Greenfield, Peters, Lane, Rees, & Samuels, 2002; Fullan 1991; BC Ministry of Education, 1999; Statistics Canada, 2000; WISE, 1991, 1992; Boutros-Ghali, 1995; UNS, 1994; Greenfield, Peters, Lane, Rees, & Samuels, 2002; Scheibinger, 1991; Probert & Wilson, 1993; Acker, 1994; Gill & Grint, 1995; Ng, 1995; Penny & Kelly, 1990; Shakeshaft, 1987). What remains unclear is why low female participation in these areas continues. Female gender disparity in mathematics and science is an issue for educational leaders, as more new careers require mathematics, physics, chemistry, and biology. Furthermore, the persistence of female gender disparity in Canadian society is a contradiction of the guarantees of equality in the *Canadian Charter of Rights and Freedoms* (1982).

Whereas some studies indicate a gender bias against females (Gaskell et al., 1993), other studies suggest a bias against males (Cowley & Easton, 1999). Some assessments, such as one performed by the Fraser Institute in the article *Boys, Girls and*

*Grades: How do Girls and Boys Compare across the Province*, have shown girls are outperforming boys in mathematics and other subjects, and that this trend has been occurring for many years (The Fraser Institute, 1999). Whether studies argue which gender is actually being biased against, evidence is mounting that overall gender bias is playing a large role when differences between males and females, albeit historically quite small, have been measured. The small measured differences have been getting smaller over time (Fennema, 2000).

Lawton (1997) stated that in regard to standardized testing, “results from tests given to nationally representative samples of eleventh graders reveal a bell-shaped distribution of scores for both genders, but with fewer females than males appearing at both the very lowest end and at the very highest end” (p. 1). Although these same tests have been adequate in predicting male performance in post-secondary education, they have failed to produce the same accurate prediction of female performance. Females actually perform as well in college as their male cohorts who outperformed the females on the same standardized aptitude tests (Lawton, 1997).

Gaskell et al. (1993) conducted a study of gender issues in student choices in mathematics and science in British Columbia. Although their study was designed to compare female participation rates in the sciences and mathematics, to see what attracted girls to these subjects, this did not happen. First, participation rates varied from year to year, making comparison impossible. Second, stable participation rates were attributed to many factors, not just school factors. For example, “parents (sic) aspirations and material support” were not considered school factors (pp. 153–154). Third, schools with a high female participation rate also had a high male participation rate. And fourth, few schools

had developed strategies “to attract girls to mathematics and science subjects” (p. 154). Although they did not find out how to strategically reduce female gender disparity, there was enough evidence in the data to suggest that female gender disparity could be reduced by applying the principle of “gender-sensitivity” at all levels and grades (p. v).

Baroness Greenfield CBS of the United Kingdom has most recently stated that low participation of females in these areas of female gender disparity is an issue for “society, for organizations (as strategy and policy setting agents), for employers and for the individual” and especially in regard to global competitiveness (Greenfield et al., 2002, p. 9). The same could very well hold true for Canada. The greatest loss to Canadian society proposed herein may occur in the area of human resources and individual self-actualization. Individual and societal losses, in this regard, are equally as important.

According to the organization, *Women in Science and Education*, WISE (1991, 1992), the *doors* to education, and therefore career choices, are open to everyone, yet strongly significant divisions by gender on the completion of science and mathematics in post-secondary education are still observed. Males and females, in Canada, are not equally participating in mathematics and science education (WISE, 1991, 1992).

Although studies have investigated males’ and females’ participation rates in science and mathematics education (Gaskell et al., 1993; Greenfield et al., 2002), achievement (Cowley & Easton, 1999; Lawton, 1997), and psychological sex differences (Kolaric, 1989), none have set out from the perspective of educational leadership to answer why gender disparity persists. Early socialization, skill shaping, interest shaping, and choice shaping are some of the known approaches that have been used to steer females away from career paths and education leading to engineering, mathematics, and

physical sciences (Wilson, 1991). Based on this, what may well prove to be the stimulus may be motivational encouragement or discouragement, early experience, and perhaps a differentiation in the accessing of courses (Lawton, 1997), which affect the participation rate.

### *The Purpose*

The purpose of this study was to investigate the perceptions of principals and counsellors on female gender disparity in high school physical science, mathematics, and career choices. Knowledge from this research will benefit educators, by bringing the issue of female gender disparity in mathematics and physical science, and a means to resolving the issue, to their attention. Furthermore, knowledge from this research will benefit girls' education in mathematics and physical sciences.

### *Research Question*

What are the perceptions of principals and counsellors on female gender disparity in mathematics and physical sciences?

### *Conceptual Framework*

The researcher used similar aspects of analytic feminist ideas of gender as defined by Cudd (2002). The reason for stating that the similar aspects of analytic feminism were used is that analytic feminists have a similar perspective to the researcher's own paradigm. Analytic feminists have chosen to incorporate gender equality along with traditional analytic methods. The problem with using strictly an analytic feminist

framework has been considered. The decision was made to use more than one feminist framework because of the wealth of knowledge from many different feminist sources.

The problem of selecting a conceptual framework or theoretical framework for this study has been due chiefly to the fact that many disciplines have studied the issue of female gender disparity, and made useful contributions to what is currently known about female gender disparity. The difficulty in finding a theoretical framework was that none appeared to be sufficient to obtain the necessary knowledge.

Although it may appear that this issue should have been addressed through women's studies, and that therefore a theoretical framework from women's studies would be sufficient, the researcher felt this tactic was also insufficient to address the magnitude of the problem. The discipline of women's studies is still new, and there remains debate as to whether this discipline is a discipline in and of itself, or whether it is an inter-disciplinary discipline (Baker, 2003). Also, the scope of the audience in women's studies tends to be limited, although not entirely, but primarily to women. This statement is not intended to denigrate women's studies whatsoever.

The researcher also had concerns that, by using a theoretical framework from any one discipline, the potential for contributing to multiple scholarly disciplines and practical applications might be lost. This is because the nature of the problem crosses traditional boundaries of disciplines, the same as education crosses the traditional boundaries of disciplines. The researcher decided to use concepts that were strategically unifying and inter-disciplinary. The framework, therefore, is one that has evolved through the process of identifying the problem with the incorporation of definitions and principles of equality.

Certain assumptions had to be made by the researcher, in principle, to form a framework for this research as follows:

1. That all children have equal right to equal benefit (Canadian Charter of Rights and Freedoms, 1982) of education regardless of their registered sex at birth, or conceptual definition of gender, so that they may have equal opportunity to participate in society.

2. That all educators who teach children have the fiduciary duty to educate child students regardless of how the educator perceives their student's birth sex and regardless of the gender the student may appear or not appear to possess.

3. That a fiduciary (Collins English Dictionary, 2000, definition fiduciary) relationship is ipso facto (bound by the very fact) legally binding between educator and student(s), where the educator is bound to educate student(s), without prejudice or discrimination, and in the student's best interests, in respect to equality rights legislated in the *Charter of Rights and Freedoms* (1982).

4. That dividing males and females into two conceptual groups was necessary for gaining knowledge on female gender disparity. This was also necessary for stating the problem and providing full disclosure to the participants, with a simple gender conceptual framework and the same questions so the educators could communicate why they perceived female gender disparity persists.

5. Furthermore, in terms of the researcher's bias, because women's status in Canada changed from non citizen to equal citizen, female gender disparity should have been well on the way to being an issue of the past.

6. Children's best interests in education are everyone's best interests, regardless of whether any child is perceived as male or female.

The assumptions and ideas in this section have been used to guide the researcher, along with principles as described in Part III, Article 10 of the *Charter of the United Nations, Convention on the Elimination of All Forms of Discrimination Against Women* 1979, as presented in the next sub-section. These ideas have formed the conceptual framework for this study. The ideas framing this study have specifically included the principles and guarantees of equality, as stated in the *Canadian Charter of Rights and Freedoms* (1982).

### *The Significance of the Study*

This study focused on the awareness and perceptions of principals and counsellors on female gender disparity in high school mathematics, science, and career choices. The significance of this study is both practical and scholarly.

Educators' recommendations on how to best reduce female gender disparity are useful to other educational leaders and beneficial to students and society. Through this investigation, readers may come to know more about gender disparity as it is perceived to

affect males and females alike and therefore promote gender equality in mathematics and science for the benefit of all students.

The scholarly significance of this study rests on the fact that these data provides information to members of the scholastic community regarding a gap in knowledge on why female gender disparity persists. Knowing why female gender disparity persists, from the perspective of counsellors and principals, increases the knowledge base of educational leaders and scholars. This is important for helping to ensure that decision making in education means better practices and not practices that might violate children's rights and best interests.

Overall, this knowledge of what is perceived to contribute to the persistence of female gender disparity and what is perceived to reduce female gender disparity provides practical and scholarly educational leaders with a better knowledge base to improve their schools in combination with their own local educational strategies.

### *Study Background*

Since the early part of the last century women have gained citizenship, and equal rights to education and legal equality in many countries throughout the world. The legal changes have been fundamental for women to access professional careers and vocations, where, once, entrance to education leading to those careers and vocations, and thus compulsory membership associations, was limited to males. Canada recognizes women as fully participating members of society by law and as such each female is entitled to all the rights, responsibilities, and privileges that accompany personhood. The fundamental

right to equal citizenry is guaranteed in the *Canadian Charter of Rights and Freedoms* (1982) on *Equality Rights*, Part II section 15, as stated in the following:

1. Every individual is equal before and under the law and has the right to the equal protection and equal benefit of the law without discrimination and, in particular, without discrimination based on race, national or ethnic origin, colour, religion, sex, age, or mental or physical disability.
  
2. Subsection (1) does not preclude any law, program or activity that has as its object the amelioration of conditions of disadvantaged individuals or groups including those that are disadvantaged because of race, national or ethnic origin, colour, religion, sex, age or mental or physical disability.

In spite of the removal of legal barriers to equal participation of men and women, and the guarantee of equality in the *Canadian Charter of Rights and Freedoms* (1982), there is a perception that women have failed to participate equally with men (Wilson, 1991; Clegg, 2001).

Furthermore, the principles of Section 15, with respect to gender equality, have been expressed more specifically in the *Universal Declaration of Human Rights* (1998) and the *Charter of the United Nations' subsection Convention on the Elimination of all forms of Discrimination against Women* (1979) thus: “the full and complete development of a country, the welfare of the world and the cause of peace require the maximum participation of women on equal terms with men in all fields” (Part I, Article 3). Equality, therefore, is not about males versus females, but it is quite literally about males and

females. The key principle identified is the *maximum participation* of everyone. The statements on the criteria for gender equity in education is specifically ascribed to in Part III, Article 10.

Although this is not Canadian legislation, per se, it is a document to which Canada has contributed as an original member state of the United Nations. Canada has been involved in the United Nations since its inception in 1945. Paul Heinbecker (2003), Ambassador and Permanent Representative of Canada to the United Nations, has stated that:

In 1945 Canada was among the countries that gathered in San Francisco to create a new organization committed to promoting peace and security, to fostering international cooperation in solving economic, social and humanitarian problems and to promoting culture and respect for human rights. Canada has been an active member of the United Nations ever since and remains committed to the ideals that inspired the San Francisco Conference. (Welcome section, para 1)

According to Ambassador Heinbecker, United Nations' conventions are Canadian conventions. The following is the United Nations criteria for the elimination of discrimination of women in education worldwide:

States Parties shall take all appropriate measures to eliminate discrimination against women in order to ensure to them equal rights with men in the field of education and in particular to ensure, on a basis of equality of men and women:

a) The *same conditions* for career and vocational guidance, for access to studies and for the achievement of diplomas in educational establishments of all

categories in rural as well as in urban areas; this equality shall be ensured in preschool, general, technical, professional and higher technical education, as well as in all types of vocational training;

b) *Access to the same curricula, the same examinations, teaching staff with qualifications of the same standard and school premises and equipment of the same quality;*

c) *The elimination of any stereotyped concept of the roles of men and women at all levels and in all forms of education by encouraging coeducation and other types of education which will help to achieve this aim and, in particular, by the revision of textbooks and school programmes and the adaptation of teaching methods;*

d) *The same opportunities to benefit from scholarships and other study grants;*

e) *The same opportunities for access to programmes of continuing education, including adult and functional literacy programmes, particularly those aimed at reducing, at the earliest possible time, any gap in education existing between men and women;*

f) *The reduction of female student drop-out rates and the organization of programmes for girls and women who have left school prematurely;*

g) *The same opportunities to participate actively in sports and physical education;*

h) *Access to specific educational information to help to ensure the health and well-being of families, including information and advice on family planning (section 15).*

Charter of the United Nations, Convention on the Elimination of All Forms of  
Discrimination against Women, 1979 (Part III, Article 10)

The above quote from the United Nations' *Convention on the Elimination of All Forms of Discrimination against Women* (1979) is the convention written to set the standards of equality education worldwide. It was written so that females do not just have access to the same education as males, but actually have the same education as males, for the same opportunities to develop and participate equally in societies around the world. The difference between having access to the same education and having the same education is crucial because a person may have access to a program, but through social, psychological, or other forces, not be able to exercise their rights. They may not even be aware of their rights. They may also not know the implications of not exercising their rights. Educational choices may have been loosely made, or omitted, without the complete implications of their choices or inactions being fully understood.

The importance of females accessing the same education as males is more important as each day passes, due to the ever increasing rapid rate of change in technology, the advancement of knowledge, and the fast pace of information dissemination, that is occurring around the world and at light speed (McMillan & Schumacher, 1997). Personal computer usage has had a major impact on the way we educate, are educated, can educate, and need education (Boutros-Ghali, 1995). Advancement in science, mathematics, and technology has made possible all what was theoretical only a few years ago.

The fundamental shift into a knowledge-based economy has, for the most part, transpired. This is demonstrated at Development Gateway, a World Wide Web portal specially designed to ease access to information on sustainability for poverty groups (no date, Knowledge economy section). As a direct result of this knowledge-based economy, the absolute numbers and types of rewarding careers in science and technology have expanded beyond most people's expectations. And since education typically precedes careers, decisions today by students to omit science and mathematics from a basic education program will impede them from accessing these careers. In spite of this, many students, including both males and females, avoid these subjects. Those individuals who do participate in the fields of science and/or mathematics can be provided, through their education, the means to make significant contributions in science and mathematics as well as having an appreciation for science.

#### *Gender Inequalities in the Post-Secondary and Secondary Education System*

Male students in post-secondary education greatly outnumber female students in mathematics and physical sciences (WISE, 1991, 1992). Whereas male students have been choosing to study mathematics and science at the secondary level, the majority of female students appear to have been taking mathematics for graduation purposes, and thereafter opting out of such courses and further post-secondary education programs which lead to careers requiring mathematics (Gaskell et al., 1993). These prerequisite courses are not specifically limited to careers in the physical sciences, social sciences, and mathematics. Many female students are making choices which may effect their access to fulfilling and lucrative careers, such as engineering, medicine, and the military

officer profession, which all require a strong foundation in mathematics and physical sciences WISE, 1991, 1992).

Because the job market increasingly requires science and mathematics as the basis for many of the remunerative careers, a higher percentage of female students may encounter an increased rate of joblessness and longer periods of unemployment, and even poverty, as a result of their educational choices. This may occur in spite of their abilities and aptitudes. Empirical studies have demonstrated that the mental abilities of the female population are as capable in science and mathematics as the mental abilities of the male population (Lawton, 1997; Scheibinger, 1991; Sonnert, 1995).

Although we can measure the participation rates of males and females, researchers have claimed that finding solutions and strategies has been very difficult, largely due to the variety of factors. The gender disparity is multifaceted (Fullan, 1990; Gaskell et al., 1993). Fullan (1990) states that societal, political, and economic forces influence whether or not a proposed change in education will succeed. This has been shown in Figure 1.1, depicting the probable constituent members of a school and influences that are most likely at play within any given school at any point in time. Figure 1.1 was developed from the work of Fullan as understood by the researcher. Changes in education depend on the basic assumptions held by those in positions of leadership. Fullan further informs us that:

Initiation of change never occurs without an advocate, and one of the most powerful is the chief district administrator, with his or her staff, especially in combination with school board support or mandate. In some circumstance, the district administration may not be interested in innovation, and little may

happen.....By the same token, administrators can be equally powerful at blocking changes they do not like. (pp. 54–55).

The chief district administrator, or the superintendent as is referred to in British Columbia, has the audience of other educational leaders who are perhaps as important, if not more, than the Superintendent herself. Fullan (1990) tells us that personal biases interfere with the practical application of the principle of equality in administration of education. Specific negative attitudes regarding gender may have well been tolerated and accepted only a few years ago, but today those attitudes are no longer tolerated. Furthermore, due to societal changes such as with today's technology, what was deemed appropriate technical educational advice in yesteryears is not necessarily appropriate advice for all students either this year, or for the next few years.

In spite of the efforts to change, education cannot be viewed as an insular entity. There exists multiple influences on girls, besides teachers, staff and educational administrators, such as social influences, political influences, the influence of government policy at all levels of education, parents and siblings, community influences, school culture, peers and peer culture as portrayed in Figure 1.1.

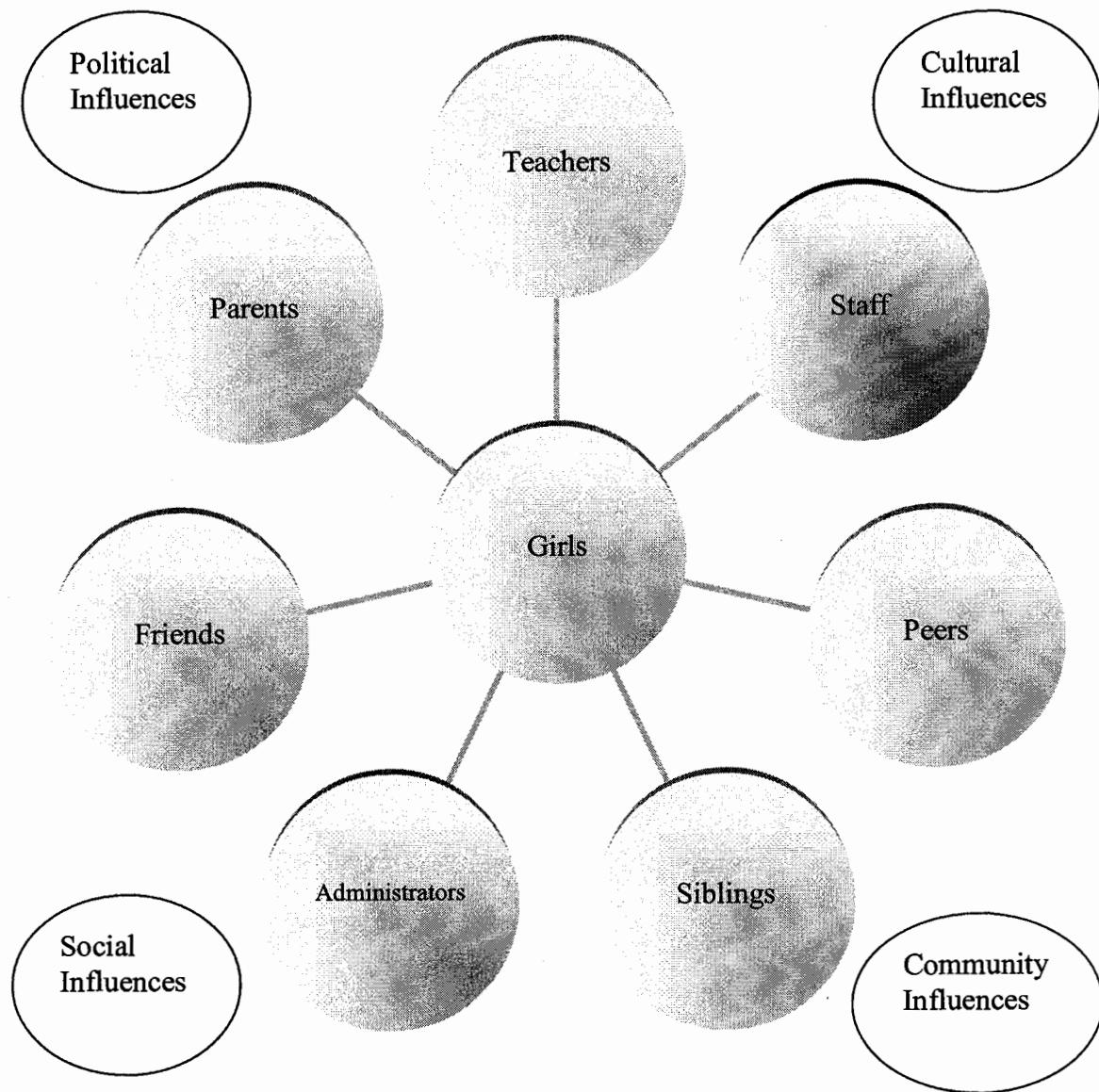


Figure 1.1. The dynamic influences in school on female students.

Source: Fullan (1990).

Many of these influences, such as those encountered outside schools, are outside the direct control of educators; however, there are many areas within the school where educators have firm influence (Fullan, 1990).

Although community influences, such as politics, social, and cultural influences, are considered to be and are perceived as outside of schools, every school has a culture, a political environment, and is a small community. Leaders need to be better informed about what happens within schools, to act rather than react to crisis (Murphy, 1985).

### *Definitions*

This section has been included to provide the reader with some simple definitions including, first, female gender disparity; second, the physical sciences and lastly; gender stereotype.

Female gender disparity: A term used to describe situations where females are participating in a minority. For example, Bhargava (2002) has used the term “female gender disparity” in reference to low female literacy rates as compared to males in India.

Physical science: The systematic study of material, nature, and the physical universe. The methods of study in physical science are performed through organized observation, experiment, and measurement. As physical science is organized into various branches, it may be referred to as singular when discussing physical science as a whole, or plural, such as physical sciences. Mathematics, physics, chemistry, and biology are three branches of physical science. Mathematics includes, but is not limited to, algebra, calculus, and geometry. Chemistry, physics, and biology are three of the main branches of the physical sciences. Chemistry is the study of the “composition, properties, and

reaction” of particular substances. Physics is the study of the “properties of matter and energy, and the relationship between them.” Biology differs from chemistry and physics as it is the study of “living organisms,” and is generally considered a life science, whereas the other two are considered physical sciences. Although mathematics is used in all three main branches of the physical sciences, physics is “based on mathematics.” Each of the three branches of the physical sciences also contains their own internal branches (The Collins English Dictionary, 2000). In Canada, the branches of biology, chemistry, and physics are introduced as separate courses in secondary education. While mathematics is taught commencing in elementary education, algebra and calculus are primarily introduced in secondary education.

Gender stereotype: A gender stereotype is an over-simplified viewpoint or biased attitude regarding whether those of the same sex group or an individual’s gender have sex-linked abilities, capabilities, and behaviours that are pre-determined, considered innate, and based on their birth sex. Examples of gender stereotypes are as follows: men have careers while women have babies; soldiers are men whereas women are housewives; men are strong and women are the weaker sex (Wilson, 1991).

### *The Research Assumptions*

The following are the research assumptions in this study:

1. The researcher assumed awareness and perceptions of female gender disparity to vary between counsellors and principals and also to vary between schools.

2. The researcher assumed that none of the schools would be reducing female gender disparity in Physics 12 due to the observation of the persistence of female gender disparity in physics from secondary education, post-secondary education, and onward into careers.
3. The researcher assumed participants would be honest.
4. It was assumed that some of the educators would have ideas on how to make improvements.

### *Delimitations*

A qualitative case study was conducted with ten participants from five different schools. The study was delimited to the five principals and five counsellors who volunteered from two schools districts in a western province of Canada. The number of participants was limited to ten because it was considered to be a sufficient number for the purpose of the study (Creswell, 1998). Quotes of the participants from the interviews, and paraphrased statements, have been included as evidence in the results to allow the reader to determine the “confirmability” of the research (Creswell, 1998, p. 200). The data was delimited by the knowledge of the ten participants in this study, eight of whom were male, and two were female. No data was collected from other schools, and no consideration was given to the entire population of principals and counsellors or any other educational leaders. Furthermore, the gender of the researcher was a limitation in the study; as a limitation, the effect of her gender on the participants could not be controlled. Furthermore, although critically considered, interviewer bias could also not be completely controlled for in the interviews.

### *Summary*

In summary, this chapter introduced what is known about the problem of female gender disparity, regarding opportunities that are open to females in mathematics and physical sciences, along with male and female equality in their ability to perform in these areas. Overall gender bias, whether against males or against females, was identified as playing a role in historically small measured differences between males and females. Where small differences have been identified, there remains no definitive answer as to whether these differences are factual or the product of gender bias within the tests.

In British Columbia, female gender disparity in mathematics and physical science has also been attributed to factors both within and outside of schools, such as parental influences, material support and “gender sensitivity” (Gaskell et al., 1993, p. v). In Europe, losses to society, employers, and the individual, in regards to global competitiveness, were identified as three areas where the losses, due to female gender disparity, were greatest. According to WISE (1991), the problem has been identified: females are still participating in low numbers in spite of open doors to female participation.

The reason for the persistence of female gender disparity has not been examined by researchers. Although many studies have investigated sex differences, low participation rates by females in mathematics and sciences, and psychological factors, none have answered the question as to why female gender disparity persists. The purpose of this study was to investigate the perceptions of principals and counsellors on female gender disparity in high school physical science, mathematics, and career choices.

Knowledge from this study would benefit both educators and girls in mathematics and physical science.

The conceptual framework used in this study was based, first, on assumptions of equality, and children's equal right to equal benefit according to the Canadian Charter of Rights and Freedoms (1982), and second, the fiduciary duty of educators to teach all children equally, and third, that this duty is ipso facto, and binding between educators and students. Fourth, that acknowledging gender as male and female was important for answering the question as to why female gender disparity persists. And fifth, the framework included an assumption that, since women's status had changed from non citizen to equal citizen, female gender disparity should be a past issue. Finally, that the best interests of children, regardless of their gender, are everyone's best interests.

These assumptions, with the assumptions of equality in Part III, Article 10 of the *Charter of the United Nations, Convention on the Elimination of All Forms of Discrimination Against Women* 1979, formed the framework for this study.

The significance of the study was practical and scholarly. By knowing the reasons why female gender disparity persists, educators may know how to improve the situation, and promote gender equality and better decision making, so that students and society may benefit. A better knowledge base, in combination with local educational strategies, would provide educators with a way to reduce female gender disparity.

Legal changes in Canada have been at the core of female professional career development in careers that traditionally excluded female participation. Although legal barriers have been removed, and there are guarantees in the *Canadian Charter of Rights and Freedoms* (1982), there has been a failure of equal participation of men and women.

Maximum participation of both men and women is required for world peace. In education, this means the same conditions, curricula, examinations, and teaching staff with the same qualifications. The elimination of stereotypes has been considered fundamental along with same opportunities for scholarships, grants, access to programs, and physical activities such as sports (Part III, Article 10 of the *Charter of the UN, Convention on the Elimination of All Forms of Discrimination against Women*, 1979).

Rapid changes in technology, information, and knowledge means that equality in access to education is more important than in years before. Changes in these areas means more careers are opening in these areas. Omitting mathematics and physical science in education precludes one from accessing these careers, such as engineering, medicine, and the military officer profession. Furthermore, the job market requires more mathematics and physical science, meaning more females will experience joblessness and poverty due to educational choices, and in spite of equal ability (Lawton, 1997; Scheibinger, 1991; Sonnert, 1995).

Female gender disparity is multifaceted (Fullan, 1990; Gaskell et al., 1993) and requires an advocate. Biases interfere with the practice of equality (Fullan, 1990). Multiple influences on girls are through the constituents, including administrators, government, parents, siblings, peers, and through social, cultural, and political contexts both from within and outside the school (Fullan, 1990).

There are three useful definitions in this study. First, female gender disparity, where females participate as a minority; second, physical science, the systematic study of the material world, from nature to the universe; and lastly, gender stereotype, the over-simplified biased viewpoint regarding those of a particular gender,

Four research assumptions were made at the onset of the study. First, there was an assumption of variability between participants and between schools. Second, it was assumed that none of the schools would be reducing female gender disparity, and third, that participants would be honest. Lastly, it was assumed that participants would have ideas on improving female gender disparity.

The study was delimited purposely to five principals and five counsellors, from two districts in a province in western Canada. Quotes and paraphrased statements from the interviews form the confirmable evidence in the findings (Creswell, 1998). The data collected was bound to the ten participants, eight males and two females. Consideration was limited to the five schools. Neither the effect of the researcher's gender, nor the researcher's bias, though considered critically, could be completely controlled in the interview process.

The following chapters contain the literature review, the methodology, the findings, and the discussion.

In Chapter II, the literature review proceeds from the general, including the global and historical context of female gender disparity, to the specifics of the last three decades, from an educational perspective. The experiences of girls and young women in mathematics and physical sciences are then detailed. The responses of educational counsellors to female gender disparity, and the views of educational administrators on female gender disparity are presented at the end of the chapter.

Chapter III contains the methodology used in this qualitative study so that readers may know how the study was conducted, and the data was analyzed.

Chapter IV contains the findings, which include the principals' and counsellors' perceptions on female gender disparity in mathematics and physical science. The findings have been presented according to the four major themes: first, gender view, gender equality, and gender bias; second, role modelling; third, school philosophy; and finally, the perception of mathematics and physical science.

Chapter V presents the discussion on gender views, role modelling, school philosophy, and the perception of mathematics and physical science, followed by the conclusion of the study. This chapter then covers the participants' recommendations on how to make improvements, a statement on the importance of advocacy in resolving female gender disparity, the limitations on the study, and the researcher's recommendations for future research.

## CHAPTER II

### Literature Review

#### *Introduction to Literature Review*

This chapter contains the review of literature and provides readers with a brief review of the history and general issues of women's participation in Western society, including: the global and historical context of female gender disparity, a summary of the last three decades and an educational perspective, female gender disparity in mathematics and physical sciences as experienced by girls and young women, literature on educational counsellors and their responses to female gender disparity, literature on educational administrators and their view of female gender disparity, and conclusion to the review of literature. The purpose of this study was to investigate the perceptions of principals and counsellors on female gender disparity in high school mathematics, physical science, and career choices.

#### *The Global and Historical Context of Female Gender Disparity*

An understanding of the historical context of female gender disparity in the West is important in relation to understanding the historical context of female gender disparity in education in Canada (Sen, 2001). Sen has stated the importance of seeing the issue of gender disparity within a cultural and historical context. He has described female gender disparity in India with emphasis on the importance of the context of history, culture, politics, and socio-economy, in respect to understanding female gender disparity in

science and mathematics. From a Canadian context, and from a Western geographical perspective, these contexts are also important (Sen, 2001).

The historical literature has not always characteristically included the phrase, female gender disparity. The reason for this is that female gender disparity was identified within the last Century. The history of the unequal participation of females with males is the historical origin of the term female gender disparity. It is unclear, in an historical context, when the actual use of the term female gender disparity began or who introduced this terminology. In terms of the global context of education, female gender disparity has been identified as a major issue around the world (Boutros-Ghali, 1995). Women are still considered the world's largest excluded group of people. According to Sen (2001):

Gender inequality exists in most parts of the world, from Japan to Morocco, from Uzbekistan to the United States of America. However, inequality between women and men can take very many different forms. Indeed, gender inequality is not one homogeneous phenomenon, but a collection of disparate and interlinked problems. (Seven types of inequality section, para 2)

Although Sen (2001) has identified that gender disparity appears, in some respects, to be utterly distinct from one part of the world to another, there are aspects of the problem of female gender disparity that are the same (Sen, 2001). What this knowledge gives us is a basis to explore the phenomenon of female gender disparity in regard to regional particulars. The regional distinctness of female gender disparity, as a social problem, must furthermore be solved within particular regions.

Historically, social and political triggers of change have been connected to events. These political events have been observed concurrently with changes in law. Changes in the perceptions of women's abilities have also been simultaneous. These historically significant events have had a dramatic influence on what education women and girls have been permitted to access. The representation of the cascade of events in this section has been delimited to the last four Centuries, to provide an historical synopsis to the reader, with more attention to political and social events in the last Century. The decision by the researcher to delimit the history to specific events of the last four hundred years is intended for the sake of brevity. This is also in respect to the fact that women's participation in science has been traced back to the earliest known scientific endeavours, about four thousand years ago. There has been speculation, according to the website *Four thousand years of women in science*, that the participation of males and females together as thinkers goes well beyond this time (1997–2003). Where possible, discussion of the historical context has been limited to studies and careers that pertain in some way to science and mathematics.

Although there are many vocations where female gender disparity can be historically illuminated, the fields of technology, trades, and science are particularly relevant in relation to current trends in female gender disparity in science and mathematics. (Sandhu & Sandler, 1986, Scheibinger, 1991; Stephenson & Fisher, 1982). An historical analysis of women and technologies has shown that, although women have always used technologies (Sandhu, 1986), during the last four hundred years most of the technologies have been dominated by males (Scheibinger, 1991).

Not every historian supports the historical record that women have not been involved in non-traditional occupations, including science and technologies. According to Stephenson (1982), there have been few jobs “historically non-traditional for women” (p. 3). Stephenson and Fisher (1982) do not state what jobs were historically non-traditional but include: welding, carpentry, electronics, mathematics, and industry as vocations that have historically included the participation of women. Scanzoni and Scanzoni (1981) state that, prior to the colonial era (1620 to 1776), records showed women could legally perform over two hundred occupations.

According to Beckham, Carbonell, and Gustafson (1988), attitudes towards women’s minds were extreme, from being considered fully capable to being considered completely incapable.

Throughout the last Century, the professional literature changed from debating gross differences between the genders in intellectual abilities, to demonstrating no significant differences in intellectual abilities (Beckham et al., 1988). The duality of this debate has persisted historically, and is very apparent within debates concerning traditional roles, non-traditional occupations, legislation, and technologies.

Whether vocations have included women or been considered traditionally excluding of women, and therefore girls, much of the discussion of women and trades and technologies has focused on legislation and traditional roles. Although Stephenson and Fisher (1982) claimed that women did non-traditional jobs, there is no argument of what the social position for women and girls has been in the last four centuries and up until the last Century.

Historically, the social choices for females were limited. They could work; earn low wages or no wages in limited areas. They could also get married. Once married, women were their husbands' property (Scanzoni & Scanzoni, 1981). The woman worked in the house for the husband and the husband was owner of the household, and dutiful provider. The woman, as wife, was the husband's property and her duty was to serve her husband. "Wife beating" was legally sanctioned (p. 314). Similarities were drawn between the social status of women as husband's chattel and slavery.

The most notable events that changed the status of women from property to person did not happen until one hundred years ago. At the beginning of the last Century, various social and political movements changed society. New legislation was written and improved, more equitable laws were passed. This was a first in the historical events that permitted women their own rightful paid employment (Scanzoni & Scanzoni, 1981), and to vote (About Parliament—Historical Information, 1999). However significant this historical event was, it was insufficient and further historical events have transpired. The second significant event occurred during WW II.

The participation of women in non-traditional occupations in WW II was the next significant event in the history of women's participation in society because it pushed women's capabilities to perform in non-traditional fields, politically and socially on centre stage. Women proved they were fully capable of performing the work that was traditionally the exclusive male domain. The traditional role of women changed in WW II when many women entered into these non-traditional occupations. In the United States of America, opportunities arose for women to enter these occupations, from the position of the need of that country at war, the perceived social acceptability of women to perform

non-traditional jobs, as well as what was considered the duty of women to contribute during WW II.

*Rosie the Riveter*, the promotional poster used to attract women into non-traditional jobs and technologies in the United States of America during WW II, pictured a strong yet feminine woman with big muscles and a beautiful face, depicted on the University of Arizona Website). The opportunities that were created for women also meant more women had currency to spend. Metzger (2003) stated that the effect of more women working in trades and technologies was that:

Women had their own money and could do with it what they pleased. They became more independent....Though relatively short-lived, WW II provided a way for women to do what they wanted. Far fewer obstacles stood in the way of women proving that they were extremely capable. Women are capable of anything, it's too bad that it took a war to make everyone see it. (Rosie the riveter and other women World War II heroes section, para 1)

Once the war ended, women's freedom regressed and many women were forced to leave their newly acquired non-traditional occupations so that men returning from war could be employed. Since then, this type of action has been recognized as discrimination (Heitlinger, 1993). Also during WW II, women started working in the newly created field of computers as computer programmers, and by the end of the war, the majority of computer programmers were female (Reskin & Roos, 1990).

Although there was regression in the role and freedom of women in vocations after WW II, social changes continued and further legislation was created on the

international political stage. This document became known as the *Universal Declaration of Human Rights* (1948) (*Fiftieth Anniversary of the Universal Declaration of Human Rights 1948–1998* [1998]). This was the third significant event.

It took three more decades with the *Universal Declaration of Human Rights* (1948) for Canadians to legislate human rights. The *Canadian Charter of Rights and Freedoms* (1982) was written in 1979, and became the fourth significant event in terms of changes for women in Canada's history. The legislation of the *Charter of Rights and Freedoms* (1982), online at Ministry of Canadian Heritage, demonstrated not only that women's role had changed, but also that politics and the social organization of society had changed in tandem. Politicians had decided that the legislation of the time was insufficient to protect citizens and thus Canadian law was changed (*Charter of Rights and Freedoms*, 1982).

Hence, the legislation of the *Canadian Charter of Rights and Freedoms* (1982) became the fourth significant event in terms of women's participation in Western society in North America, and this time, in Canada. The equivalent document in the United States of America is entitled Title IX. According to the President of the United States, this document has been in existence in the United States of America since June 23, 1972 (Presidential Press Release, 1999). Furthermore, according to Brady (2002), there remains controversy over its implementation. Title IX was to change female participation in sports, education, and careers. Although this was the goal, Americans still recognize the need for further change (Marklein, Williams, Rodin & Jackson, 2002). The new Canadian Charter of Rights and Freedoms (1982) became the legal framework by which standards of Canadian society, in terms of the benefits of society, including education and

careers, and the application of law, could be considered. Prior to the *Charter of Rights and Freedoms (1982)*, there was no legal basis to challenge female gender disparity.

With the legislation of the *Charter of Rights and Freedoms (1982)*, there finally existed a legal source document within Canada, according to the Ministry of Canadian Heritage, for the establishment of balance and fairness between men's and women's participation in society (The 20th Anniversary of the Canadian Charter of Rights and Freedoms).

In spite of this significant event in Canadian history, further changes have been slow to come about. Since the inception of the legislation of the *Canadian Charter of Rights and Freedoms (1982)*, women have created various organizations to facilitate change, such as *Women in Trades and Technology National Network (WITT NN, no date)*, online. Also, the National Advisory Board on Science and Technology (Canada), Human Resource Committee (1993), has focused change effort around helping women and girls to overcome barriers to non-traditional trades and technology vocations, and accessing education in these vocations. Other organizations have been incorporated, such as *The Association for Women in Mathematics (AWM, 2003)* online, and universities have set up organizations to encourage the participation of women in science. A couple of examples are: *Women in Physics*, online at the University of Toronto (2002), and *Women in Science and Engineering* at the University of Victoria (Scott, 1998). The focus has not just been on women in these areas, but on girls' education leading to these areas.

There has been a movement for women to be involved in all areas of Canadian society where there has been a female gender disparity. Women have been accepted into combat arms in the military, the organization considered by Hacker (1989) to be one of

the ultimate male-dominated organizations. In spite of these changes, female gender disparity has persisted in education, post-secondary education, and careers.

Although legislation and social change have been demonstrated in the events leading up to our present day, equality has yet to be completely established. Various perspectives have been argued as a basis for the continuation of gender disparities.

In North America, the persistence of female gender disparity has been described as being connected to historical roots in regard to beliefs and gender stereotypes and bias. These beliefs have been used as justification for different education and career paths for males and females (Phillips, 1990). The historical record in Canada shows females were counselled away from non-traditional educational programs (Orientation to Trades and Technology, OTT, 1987), concentrated in educational fields leading to low-paid jobs (Heitlinger, 1993, Probert & Wilson, 1993), and given different curricula than males (Acker, 1994). Women have also had unequal opportunities to participate in science (Hanson, 1996). Most of these practices were documented in the late eighties and early nineties. Over a decade has passed since many of these more recent issues were documented, and yet female gender disparity persists. Since there are no legal barriers to participation, and there has been confirmation that there are no intellectual barriers to participation, the issue of female gender disparity in science and mathematics has been revisited. According to Scott (1998), similar questions need to be asked, such as:

Why are young women staying away from these fields when high-tech and knowledge-based industries have a huge demand for people educated in these disciplines? And, some people ask, should we even care that women are not preparing for such careers? (p. 1)

And according to Coddling (1998) in Scott (1998):

We should definitely care,' says Dr. Penny Coddling, UVic Vice-President Academic and Provost, and a Professor of Chemistry. 'There are lots of reasons. Without women in these fields, we lose 50 (sic) per cent of the available brain power when we need all the brains we can get. It's unfair for young women not to access these personally rewarding and lucrative jobs. And with technology such a dominant part of our lives, those lacking knowledge get isolated, live closed lives.' (p. 1)

Academics are not alone in the quest to answer such questions. Females were once blocked entry into even the management of technology (United Nations Publication, 1995, p. 84). Recent research has been performed and articles written on female gender disparity across multiple disciplines in areas such as: sociology (Benjamin, 1991; Hanson, 1996; Fraser, 1990, Kolb, 1992; Rose, 1994, Kearlsey & Lynch, 1994; Ng, 1995), literature (Holbrook, 1992), journalism (Faludi, 1991), business (Kanter & Nichols, 1994), history, anthropology, and women in science respectively (Stephenson, 1982; Ogilvie & Meek, 1996), education (Gaskell et al., 1993; Lawton; 1997), mathematics and science (Gaskell et al., 1993, Franklin, 1985), and women's studies (Barad, 2003). Although we know that female gender disparity persists, there is a gap in the literature as to why persistence continues when we have had the guarantee in the Canadian Charter of Rights and Freedoms (1982) for over twenty years.

Female gender disparity has also been investigated in relation to various issues and topics including technology (Sandhu & Sandler, 1986), and employment

(Stephenson, 1982; Reskin & Roos, 1990). Analysis has been directed towards changes in the role of women (Heitlinger, 1993) in relation to the traditional role of women (Heitlinger, 1993), and changes in socially constructed norms of behaviour of women (Scanzoni & Scanzoni, 1981) and law.

Organizations have formed to support women in non-traditional occupations. Many of these organizations have evolved chapters across the country (WISE, 1992). Established organizations have integrated women into non-traditional occupations such as the military (Hacker, 1989).

The aforementioned scholarly inquiries are highly relevant in regard to the education of females because the role of women in society, and the social struggle for equality, changed many adults' perception of what girls' education should consist of. Although the women's movement, the changes in legislation, and the changes in women's role in society have been gradual, one thing that pervades the historical literature is that it is difficult to delineate where issues of female gender disparity in regard to women and girls begin and end. This problem may not be a problem for general discussion but it is problematic in regard to reviewing literature on girls in science and mathematics education, because the literature has been composed by adults whose bias, regarding females, is not always openly disclosed.

The next sub-section deals with issues associated with female gender disparity in a more particular sense. The text begins with some more recent references, within the last thirty years, regarding what is known about female gender disparity, followed by references to juxtaposing beliefs in regard to gender, politics, and relationships of individuals within schools, from the perspective of educational administration, and then

moves into particular references on what has been studied in education in regard to girls and female gender disparity in mathematics and physical sciences. The transition between the different levels has been carefully articulated, to provide a rich reading linking the general knowledge to the particular knowledge on female gender disparity.

*Summary of the Last Three Decades and an Educational Perspective*

Two overriding perspectives have been observed in the historical literature. Specifically, these two perspectives are whether females are believed to be equal to males or whether females are deemed to be unequal to males. In terms of politics and social policy, changes have been made for the inclusion of women and girls in every aspect of society, including all programs and subjects in education. This is the perspective that men and women are equals. But, from the perspective of what some consider the traditional beliefs about women, women have been viewed as unequal to men. Juxtapose these two perspectives about the equality of women and men, or inequality of women to men, and it is clear there is the potential for either perspective to have remained in political conflict within society. The two juxtaposing political positions are important to consider in relation to where these contrasting perspectives are found. Although the views are abstractions, the people and their concrete equal abilities in mathematics are not (Fennema, 2000).

Negative political positions against the equality of men and women have been documented. We do know that female gender disparity has been considered a product of archaic biased beliefs that were once commonly held (Holbrook, 1992) and that many people did not believe in educating females (Faludi, 1991). Educational counsellors

discouraged girls from studying certain subjects (National Conference for Women in Science and Technology, SCWIST, 1983, Status of Women Canada, SWC, 1989). Due to discouragement, many girls dropped out of programs (Hicks, 1991). Women were given poor career guidance, concentrated in lower ranks, subjected to archaic gender roles, and excluded from formal networks (United Nations Publication, 1995, Collier, 1995). They were even prejudiced against by being subject to demeaning gender stereotypes (Gattiker, 1994). Women were also discriminated against by those, males and females included, who failed to perceive their own actions towards females as discrimination (Van Nostrand, 1993). Classroom interaction studies have shown that there is preferential treatment of males (Gaskel et al., 1993).

There is also evidence of gender bias in standardized tests (Lawton, 1997).

Collusion between males against females has, furthermore, been a serious issue for some female professional academics, who are the ultimate scholarly female role models (Ng, 1995).

The issues faced by girls in education, young women, and professional academic women in advanced educational institutions and careers appear to have persisted at the same time in history, and in different social groups, and amongst different age cohorts. What this infers is that it does not appear possible to separate the social effects of gender disparity on women in society and treat this aspect of female gender disparity as utterly distinct from the social effects of gender disparity of girls in the same society, because it is the same case in the same society at points in time. The separation of women and girls in regard to the case of female gender disparity is an artificial boundary that adds very little meaning beyond separating adult life from child life, and yet this boundary is

important in order to address female gender disparity as it is in relation to the education of girls, and the experiences of girls in secondary education science and mathematics.

This thin veneer separating female gender disparity in relation to girls, and female gender disparity in relation to women, is moot in terms of gender but not so in terms of hierarchy of responsibility. One grows up to become the other whereas the other, by virtue of age and experience, is expected to provide leadership to the one that is a child.

The difficulty to separate the issue becomes more obvious when one queries why an assumption would seem so logical and also so skewed, because, by virtue of age and experience, and the expectation of equality, adults, including males and females, are equal in regard to the expectation of responsibility to children as well as to other adults. In regard to why any adult males would collude against an adult female, as depicted by Ng (1995), raises the issue that some males deem gender a grouping sufficiently defined so that they may draw lines in the sand and discriminate against women in positions of authority, for their own self interest. Although a woman may defend herself, children need adults to defend them. Ultimately, children rely on adults for their education; therefore adults are bound to resolve the issue of female gender disparity in science and mathematics.

The findings of discrimination against females are serious. Academic research has already been focused on removing barriers to women's equal participation (Morrison, 1992). Academics have analyzed economic and social barriers (Benston, 1988). Between the Charter of Rights and Freedoms (1982) and the provincial mandate for students to be taught equally, and the removal of barriers to education and careers, it remains unclear why female gender disparity persists in schools and post-secondary education, in the

physical science and mathematics subjects which lead to careers in these fields. Whereas education precedes most careers and vocations (Heitlinger, 1993), and female gender disparity persists in physical science and mathematics, and female gender disparity has been observed concurrently in education and careers, a gap in the literature in relation to why female gender disparity persists in science and mathematics education has been identified.

The researcher has considered this area to be a location to begin the inquiry because it is reasonable to consider that the future prospects regarding the careers of females begin, as they do for all students, during their education years. Although one may state that education is for all students equally, given the persistence of female gender disparity in mathematics and science, it has not been clear how female gender disparity is being manifested, and whether it is political, social, or a combination of both. Although this was not clear, it is clear that female gender disparity is an educational leadership issue that should be a priority for resolve.

Hodgkinson, in Storey (1997), from *In The Real World: School Leaders and the Political Fact*, stated that the Romans used an expression to capture politics as “Cui bono? Who gets what from whom and how?” (p. vii). Since education has already been established as intended for all students in the public school system, that question has been answered. Yet female gender disparity in science and mathematics persists. Why?

Even international studies have also failed to ascertain why female gender disparity persists. In the *Third International Mathematics and Science Study*, a highly credible study with data from thousands of participants, Schreiber (2002) found an anomaly in disparity between schools on socio-economic status and gender; in particular,

a disparity between schools at the same economic level. Some schools of the same socio-economic level had gender disparities while other schools did not. Furthermore, some schools showed disparities in achievement by gender and some schools did not. Reasons why gender disparity differed between schools of the same socio-economic status and reasons why gender disparity existed within some schools, while not in others, were not identified in the study (Schreiber, 2002).

*Female Gender Disparity in Mathematics and Physical Sciences as Experienced by Girls and Young Women*

First of all, historical findings, according to Hearne and Lasley (1985), have indicated that females have different aptitudes, but their findings have shown no difference in aptitudes for conceptual ability, math application, languages ability, computer ability, and reading comprehension. Furthermore, an individual preconception of pre-existing innate mathematics ability has been implicated in whether or not a female practices or does not practice mathematics (Buerk, 1985).

Second, the debate over abilities in mathematics as innate or not innate has been central to the issue of educating females in mathematics and science. Assessment has been at the centre of the debate, with certain assessments being argued as biased against males and others biased against females. In 1990, Joseph Horn published a paper on the Scholastic Aptitude Test (SAT), a test that is seen to be biased against females. He claimed that the ever so slightly lower assessments of young women compared to young men, through an analysis of SAT results, were accurate reflections of innate gender differences. Horn further argued that girls received higher grades in school because they

were considered to be better organized, and that they actually were being incorrectly assessed at the school level, and that their slightly lower scores on the SAT were evidence of this fact. He used this argument to support his view of innate abilities by gender.

Although girls may be better organized in some schools, there does not appear to be any evidence that organization and work ethic are innate. Rather, it has been proposed by Ramos and Lambating (1996) that organization and work ethic are strategies that may be used in some schools by more females than males. Other strategies do exist. Test strategies to improve test scores have been suggested as reasons why males outperform females on SAT. A strategy is learned and therefore not innate. The test strategy employed by more males may be a strategy used to offset poor organizational skills. According to Ramos and Lambating (1996), the difference between the performance of males and females on SAT may be due to better guessing strategies, and not better ability. How males may have learned to take and make better risks, in comparison to females, is not clear. Better risk-taking strategies may make the difference between whether a person gets into a particular university and, furthermore, whether they receive scholarships.

Thirdly, perceptions of how an individual sees themselves, as within a group and self gender stereotyping, may have something to do with different successful test and grade score strategies observed. The claim that ability differs between the genders has not been substantiated; however, there have been studies that indicate differences in self perception of abilities between males and females. According to Englehard (1990), girl

students perceived themselves as performing poorer than their male counterparts in mathematics, even though they had the same grades.

Fourth, other studies have claimed that environmental factors have given males an advantage over females, in spite of females' valid better grades (Callas, 1993).

Disparities have been noted both within and between other countries, such as France and England (Lees, 1994).

Fifth, teaching strategies have been used to demonstrate that certain methods produce good results for both boys and girls. Arguably, if boys and girls were actually innately different by ability, teaching strategies and methodologies would have different effects on boys' and girls' achievements. In Mexico, for example, strategies and methods that have been claimed to be gender neutral have been developed, which showed results that levelled learning and achievement for boys and girls. This method, where classes are broken into smaller groups, has been called "co-operative learning" (Nattiv, 1994, p. 285).

Co-operative learning has been investigated through a study in female gender disparity in the physical sciences. According to Ostling and Urquart (1992), this method has produced results because, as claimed, it did not permit girls to be victims. Although protecting girls from boys appears to be what educators are attempting to do, by utilizing such a methodology, a message is also being delivered: that, by virtue of the method used in classes, under certain circumstances, where the method is not used, girls will be victims. This sends a poor and complex message to girls that, in order for them to perform in academic courses, they need a special approach in order to learn. Concern has

also been stated that the central problem may be an actual bias against academic achievement (Ostling & Urquart, 1992).

And sixth, gender disparity has been considered a cultural phenomenon and not a product of innate abilities. The issue becomes clearer when science and mathematics education in countries such as Saudi Arabia are investigated. The results of their education system provide an opportunity for unique insight. According to Nagat (1994), Saudi Arabia has a dual education system. Mathematics and science streams are considered open to girls. While their social lives are segregated, their ability to perform mathematics, teach and learn mathematics, as well as science, is not limited in any way, nor is their gender perceived as giving them a disadvantage in learning mathematics.

What is unique about the situation is that Saudi Arabian females do not experience allegations of inferior intellectual abilities in mathematics, or battle against perceptions of whether they can perform equally in professions such as teaching and medicine. They do have equality challenges, but not in relation to their faculties. The analysis of the situation illuminates disparities by gender in other countries as products of cultural beliefs.

A seventh area that has shed light on the issue of female gender disparity has been the observation of a change in the behaviour of girls once they reach a certain age.

According to the Women's College Coalition (WCC) in Guzzetti and Williams (1996):

Girls in elementary school are ambitious, outspoken, and usually receive better grades than boys. But beginning around age 12, girls tend to lower their goals and muffle their voices. Girls' attitudes, according to WCC, are largely determined by the expectations of others, especially parents and teachers. They often don't

receive the same encouragement that boys do to take charge, voice their opinions, or pursue subjects such as math and science in school. (Encouraging girls to take charge section, para 1-2)

The aforementioned quote reflects a state of girls in education in the West. It is not clear how girls go from being ambitious and outspoken to sullen and discouraged. It is clear that encouragement is required. This quote has been pondered, and the burning question remains, why are girls not encouraged to take charge, voice their opinions, pursue math and science in school when teachers observe their behaviour changing? Why is this phenomenon not receiving more attention? What are the mechanisms that produce the discouragement of young women? Why is this tolerated? It appears to the researcher that if a society were truly offering equality to all members, and doing so in practice, there would be true support for girls to practice equality, to be proud of who they are, learn mathematics and science, and their voices, especially their voices, would not be muffled. The age where girls' behaviour appears to change is also the age where girls begin secondary education. The experiences of girls in secondary school may provide further contextual evidence.

There has been considerable confusion in regard to what is and what is not occurring in secondary education. According to Bacharach, Baumeister, and Furr (2003), although gender issues have not been implicated as originating in secondary school per se, neither have secondary schools yet been found to reduce either gender disparities or, for that matter, other types of disparities. This directly contradicts the statement that, during secondary school years, girls tend to become sullen and quiet. Blame also appears

to be shifted from one area, and then away from that area, or level of education. What appears to be missing is a complete understanding of the context in which female gender disparities are observed. Still, some researchers have made attempts at understanding qualitatively the context of girls in their educational years, and the practices through which female gender disparities exist, in terms of what girls are experiencing, and how the disparities appear to be recapitulated.

And eighth, according to Boaler (2002), the actual analytic “home” of the cause of female gender disparity has changed from being seen as internal female qualities (the innate debate) to that of being a product of different environments and relationships in school, home, and work. The change from focusing on girls as the source of their problem, to the environment, is a fundamental shift in the investigation of female gender disparity, because females are no longer perceived, in this framework, to be the cause or primary source of their own female gender disparity. Oddly enough, in spite of the re-focus of attention away from female innate abilities as the cause of female gender disparity, the relationships as they were observed were still perceived as being a result of essential differences between the genders.

A problem remains in different learning styles. Learning styles have been considered a product of a biased approach of teaching styles that condition was of learning. By stating styles in the first place, there is an appearance of innateness where actually the style is not innate at all but a social conditioning. Nevertheless, according to Boaler (2002), the most persistent explanation for differences between boys and girls in her study, in regard to both participation and achievement, has been in regard to learning styles. Girls have been assessed as better at arithmetic and boys better at problem solving.

Her analysis proposed that girls were inclined to mathematical methods, because they are conditioned to being compliant and to rote memorize, whereas, on the contrary, boys have been conditioned to challenge and to be non-compliant. This non-compliant behaviour has meant boys could therefore “change mathematical methods” (p. 134).

In spite of the determination of seeking a concrete basis for female gender disparity, there remained a perception of a stereotyped view of gender in regard to gender disparity. What was not fully stated was that the problem of female gender disparity may be resolved by teaching girls and boys the same way, using the same conditioning, and therefore the different learning styles, as well as female gender disparity, may be eliminated.

Boaler (2002) also discovered that “procedure-oriented” traditional mathematics learning, that is, performing mathematics through a mere application of algorithms, results in later disaffection of mathematics (p. 133). This was interpreted as meaning that the methods of learning that girls were encouraged to employ removed the stimulation and challenge of learning from the subject being studied, and replaced it with another boring and therefore less meaningful, easy-to-abandon process. Furthermore, assessing achievement through tests, at a particular point in time, gives a researcher or teacher a measure of a student’s achievement level at a particular point in time, but does not disclose to the assessor why the student performed at that level. What this means is that, by teaching process without depth of understanding, the subject would not be liked, nor would any desire to learn the subject be instilled into the student. In her observation, that meant females were disaffected.

Focusing on the environment has disclosed the co-productive pedagogical practice that contributes to measurable differential learning patterns (Boaler, 2002). The implication of this finding is dramatic in that it appears to explain why girls might be performing well on examinations in school, but then perform poorer later on SAT. Although this appears to be definitive, the finding that females performed in mathematics by learning process and rote memorization without valuing depth of understanding, as perceived in boys, has not been completely substantiated in another similar study in a different location. Although the argument presented by Boaler (2002) does indicate that the boys in her study were more likely to seek a deeper understanding and therefore develop better problem solving capabilities, a study performed by Mason (2003) found that girls did in fact value knowing why a particular process or algorithm worked. Girls stated they did not rely on memorization for solving problems.

In consideration of the two studies above, it is clear that the different contexts aforementioned produced different results observable within the female population. The approaches to teaching, when scrutinized, appear to be the same for boys and girls. Teach the girls to understand and they will appreciate understanding. The teacher's bias, in regard to how to teach girls equally, is therefore crucial.

The next scenario and ninth point, from a Canadian study, illuminates a conundrum that females, when considered as the innate source of their problem, face. This study does highlight a serious issue faced by young women in advanced science. Although research illuminates the environment as the source of female gender disparity, this study still focused on the females as the source of the problem, as though females operate in a vacuum. Blaming the female as the source of her own problem is a

continuing problem. In order for the problem in particular situations to be resolved, the female has to find a way to resolve. If those around her do not see themselves as being biased against females when in fact they are, and they do not see themselves as part of the problem, by virtue of the nature of the blindness to their own gender biases, and the fact that the female cannot change the bias that is against her, others may claim that she has failed to resolve a situation where she has a problem, and therefore, no one else but herself is to blame. The individuals with the gender bias blame the female for her problem while reinforcing the basis for the bias through the observed female's failure to change the situation.

Enman and Lupart (2000) have shifted blame to secondary science education, prior to post-secondary education, and even towards talented young women themselves, for not continuing on in advanced fields of science. The argument by certain scholars is not that the females who had chosen to go into advanced fields of science were not capable, but that the innate world views which they tend to lean towards (not explained in the study) does not permit them to participate in non-traditional fields of science. (It is important to note here that it is completely unclear to the researcher how a world view could be innate.) Nevertheless, females who had declared science majors were blamed for leaving studies in science. Scholars also claimed that the females in their study chose to leave studies in science due to changes in epistemologies and "negative dissonance" (Enman & Lupart, 2000, p. 175).

This raises a point of an obvious contradiction. If world views were actually innate, then how could they change? Although pedagogical practice was emphasized in their study as a source of the problem, Enman and Lupart did not study secondary

education. Also, there appeared to be no consideration to inquire whether the members of the organizations to which the young women studied and belonged to, and where they began to experience a change in world view and negative dissonance, were actually responsible for discouraging them. In addition, they omitted the more radical question, that is, why females were changing their world views and why females in their programs had been experiencing negative dissonance (Enman & Lupart, 2000). This study was also one of the few Canadian studies that looked at the issue of young women leaving science programs. What is known from this study is that the females in their study were discouraged, their world views changed, and they dropped out of studies in advanced fields of science.

The tenth point is the pervasiveness of female gender disparity. According to Joyce (2000), current research shows that female gender disparity “is seen across ability levels,” begins in primary school, and continues through post graduate education (pp. 261–263). The evidence that females leave higher levels of study in non-traditional areas of science may be an indicator of the problem of female gender disparity and concomitant gender biases that have not been resolved.

*The 1990 British Columbia Mathematics Assessment: Gender Issues in Student Choices in Mathematics and Science* (Gaskell et al., 1993) illuminated the eleventh point, that of a proposed female gender disadvantage. Researchers articulated concerns that females were not being prepared to succeed in a world where females were at a disadvantage. It remains unclear what the disadvantage was defined to be, when girls have been recognized as being fully capable, and yet participate in low numbers. By attaching the word disadvantage to female gender disparity in mathematics, it almost

appears as though there was a lack of articulation of the conundrum that they perceived. They acknowledge that females were considered to be as capable as males, and yet it appears they hesitated to state that what girls experienced after education was female gender bias, and not a female gender disadvantage at all.

The study by Gaskell et al. (1993) endeavoured to bring together many different perspectives of girls, so that the views of girls would be understood. The research team consisted of researchers from several of the universities in British Columbia, and included input from governing committees on “research design and the development of interview protocol (p. 2). Although the name of the study indicates “gender issues in student choices in mathematics and science,” therefore including boys and girls, there was a purpose of illuminating “factors which contribute to patterns of high and low participation by students, particularly girls, in mathematics and physical science courses in the province (p. 1). This was a part of the secondary purpose of the study; the primary purpose of the study was to “describe the patterns of participation by gender in the university-oriented senior level mathematics and physical science courses across the province” (p. 7).

Although a deeper understanding was sought, questioning why female gender disparities persisted was not within the purview of their study. Furthermore, their study specifically recruited the participation of girls and female teachers (Gaskell et al., 1993). Without the Gaskell et al. study, the foundation for asking why female gender disparity persists may not be as relevant as it is now, given the years that have passed since the study was conducted. Asking why female gender disparity persists is very different from describing and illuminating gender issues and factors within a system, at a point in time.

Interestingly enough, the results from the primary purpose of the study highlighted the lack of homogeneity between provinces, with varying degrees of gender disparity in British Columbia, Alberta, Saskatchewan, Ontario, and New Brunswick. New Brunswick demonstrated the least measurable gender disparity amongst all the provinces. The province with the greatest gender disparity was described as British Columbia.

According to Gaskell et al. (1993), girls interviewed expressed desires to study and have careers in some of the traditional fields, such as nursing, but girls also expressed desires to study and have careers in “engineering, architecture, law, medicine, aviation, commerce, and business.” Girls communicated the desire to have careers, independence, and perhaps a family (p. 133). Outcomes stated that “students should have equal access to knowledge” (p. 141) but that physical science teachers should practice “gender sensitive teaching strategies” (p. 160). Gender sensitive strategies to attract girls were recommended for implementation, as were gender audits, but there was no mention of gender bias as a problem that required resolve.

And there is the very important issue regarding what is truly happening to girls today, socially, within the education system, in regard to the physical sciences and mathematics. There has been a problem with knowing what is happening in Canada, within science and mathematics courses, as there is an absence of current empirical studies on the experiences of girls in education; therefore, the literature reviewed on the experiences of girls has been primarily from literature on the phenomenon from outside of Canada. The recent literature on what girls are experiencing within their education, within science and mathematics courses, suggests that, for many girls, their educational needs in science and mathematics are not being met. Even the most argumentative studies

that argue boys are being short changed in schools acknowledge that girls are being “short changed” in science and mathematics (Kleinfeld, 1998, Abstract section, para 1). This is the twelfth point enlightening what girls are perceived to experience in regard to female gender disparity in science and mathematics.

What being short changed means is that girls are not being allocated the resources in mathematics and science that boys are receiving. Resources are not just material, but are also human resources. Examples of such short change have been recently documented in the areas of science and mathematics (Kleinfeld, 1998) in regard to psychological support, where boys receive three times the psychological attention from school psychologists than do girls (Vardill & Calvert, 2000). It has been documented that girls are subject to harassment by boys (and not necessarily sexual harassment), and it has been documented that teachers, even with full knowledge of the harassment of girls, will often side and favour boys while passing over girls (Ohrn, 2001). Interaction studies still indicate that in-class attention is still primarily going to boys in elementary school, with boys receiving more attention for “childish” behaviour (Einarsson & Granstrom, 2002, p. 126). Does this mean that if girls want to get more attention from teachers they should be encouraged to behave badly?

Girls appear to not be getting the attention they require to succeed in science and mathematics. This has been substantiated in many schools around the world, including the United States (Streitmatter, 1998), Africa (Lloyd & Mensch, 2000), and Europe (Ohrn, 2001), where even programs intended to reduce female gender disparity have been found to reinforce gender stereotypes (Equal Opportunities Commission, EOC, 1999).

Solid empirical studies have shown conclusive evidence that girls are simply not allocated the same educational resources as boys to succeed.

The thirteenth point is the issue of whether sex segregated classes will resolve the problem. The single sexed classroom experience has been recommended as a solution to the problem of the unequal allocation of educational resources. Single sexed classrooms, as explored in the United States (Streitmatter, 1998) and Denmark (Kruse, 1992), have been adopted for the purpose of permitting the complete development of girls, without being subject to the ill effects that result from less attention within mixed sex classes. The following quote best describes some of the proposed benefits, as well as some of the cautions regarding single sexed classrooms, for improving the education of girls in segregated physics or science classrooms:

Sex-segregated education can be used for emancipation or oppression. As a method it does not guarantee one outcome. The intentions, the understanding of people and their gender, the pedagogical attitudes and practices, are crucial, as in all pedagogical work. The aim here is equal rights and equal worth for girls and boys, so that they can meet and experience equal and mutual appreciation and respect. (Kruze, 1992, Reflections section, para 2)

How people understand their own gender was stated as important. What was not clearly stated was that non-biased gender views were crucial in implementing equality in education. But is sex segregation the answer to a problem created within a male dominated field of study? Girls entering male dominated fields of study, leading to careers that are male dominated, will not be segregated. Although this may be the

solution in some situations, this does not resolve the issue in a country that requires people to work together as equals and that has legislated equality. Even so, sex segregated classes have been claimed to be of benefit to both boys and girls. The benefit to girls has been claimed to be in the area of self esteem and higher participation (Reinhard, 1997).

It remains unclear why sex segregated classrooms would improve girls' self esteem and increase participation. Perhaps improvements in self esteem may be a product of the girls finally receiving the educational attention and resources they need to succeed. Perhaps the act of creating such a class, for its success, challenged the educators at the same time? Perhaps creating the situation gave the educators the impetus to ensure successfully taught students? Since most schools are mixed and girls achieve, perhaps the real knowledge may be that the teachers could no longer blame the girls for their gender disparity, and got on with teaching the girls what the girls needed to learn and know, in order to achieve in mathematics and physical sciences.

And a fourteenth area reviewed includes the differences between the types of mathematics used within specific physics courses. Although there has been considerable research into mathematics and female gender disparity, there have not been as many studies that looked specifically at physics. A study conducted by Tai and Sadler (2001) compared the performance of males and females in both algebra-based college physics and calculus-based university physics. In their study, females outperformed males in the algebra-based college courses, and males outperformed females in calculus-based university physics. Although these differences in regard to algebra-based or calculus-based physics were noted, a sufficient explanation for these gender differences was not

found. In the same study, however, a significant finding was discovered with regard to secondary school pedagogical approaches. Both males and females, whose past mathematical experiences focused on “deep and narrow” approaches, performed better than male and female students whose past mathematical experiences were “broad and shallow” (p. 1035). This gave further credibility to the idea that a deeper understanding of mathematics is as important for females as it is for males.

Although there have been a few studies that have looked at mathematics and physics in relation to female gender disparity, only one recent study was found in regard to chemistry. This study was interesting because the students were all known to be high achievers. Zeigler and Heller (2000) looked at student esteem amongst high achieving chemistry students. They analyzed the knowledge and confidence of boys and girls. The level of knowledge amongst all the participants was high, and as expected, there was no female gender disparity by performance. However, girls who thought that chemistry was a boys’ subject had “low levels of self-confidence, higher levels of anxiety, and more feelings of helplessness” (Discussion section, para 6). This study was particularly interesting because there was no doubt about the equal performance ability variable of females and males in the sample studied. By comparing both males and females of equally high ability, the researchers were able to draw attention to the biases of the students as a whole, and in particular, the biases that the females had developed, in spite of their high achievement. What this study brought forward is the importance of teaching students that there is no intellectual inferiority by gender, that both males and females are equally capable, and debunking the myth that there is inequality by capability between males and females. If girls are taught to believe in gender bias, the internalization of the

gender bias against girls affects their self esteem. Given the falsity of the myth, it behooves educators to eradicate gender bias.

*Educational Counsellors and Their Responses to Female Gender Disparity*

The literature on educational counselors in this sub-section has focused on “gender bias,” theoretically in regard to gender norms, and developmentally in regard to actual child development. Recommendations have been made regarding the necessity of the counsellor to openly recognize that individually held beliefs of gender are “belief systems” and not reality (Gold & Hawley, 2001, p. 200). The development of the gender perspective of counsellors has been considered no different in relation to what has been observed and considered in the development and socialization of any other person. Human socialization has been linked directly to stereotyping. How socialization produces these beliefs has been well analyzed. Whether overtly or covertly, individuals make observations of others, and later form assumptions regarding their own life “choices” from what they internalize as “like” themselves or “un-like” themselves (p. 200).

What has been seen as crucial in regard to a counsellor’s personal gender identity is whether they can acknowledge their own personal gender biases. Failure to acknowledge personal biases regarding gender leads to three main concerns in regard to gender disparity. First, the failure to acknowledge and understand personal gender bias may limit the counsellor’s ability to counsel students, without imposing “life option” limitations (p. 201). Second, if the gender bias is not acknowledged as a belief system, the counsellor may impose their own “gender value system” on the student. Finally, the counsellor may, by applying their gender bias in counselling, direct the student to particular services on the basis of their bias, or make improper assessments (p. 201).

In addition, there have also been other observations of psychological distress in both males and females who value traditional notions of male and female roles. Although there has been an assumption that counsellor students would be less inclined to gender stereotype, the study conducted by Gold and Hawley (2001) did not find counsellor students to be more egalitarian or have an androgynous perception of gender. This has been found to be problematic. According to Gold and Hawley “such personal biases have been shown to affect counselling progress” and furthermore, that biased qualities “could call into question a student’s suitability for endorsement as a professional counsellor” (p 201). Counsellor bias has also been linked to insensitivity in regard to other “cultural” and “identity” issues (p 201).

And, differences between the perceptions of male and female counsellors, regarding female occupations, are known. Actual gender biases have been documented. Male counsellors, through their gender bias, perceive females as being inclined to “traditionally feminine and semi-skilled occupations” whereas female counsellors see female students “as interested in college-level occupations.” The differences between the perceptions of male and female counsellors disappear when asked about women entering male fields. Although the differences disappear, it is only because the gender bias is the same. In this particular instance, both male and female counsellors have been found equally biased against females in regard to non-traditional fields (McCormick, 1990)

The necessity of counsellors to examine their own individual assumptions regarding gender has also been substantiated by Hoffman (1996) but with one additional comment. Hoffman stated that counsellor educators should also address the issue of gender at the socio-political level.

Two main reasons, from a psychological perspective, account for the perception differences between male and female counsellors' in regard to females and occupations. The first reason for the difference has been attributed to the work of Sigmund Freud and his explanation of female personality and development. Freud's work blamed the source of the problem on females themselves and not the environment or socialization. The second reason presented on the differences between male and female counsellors' perceptions of females and their occupations has been attributed to "sex bias extant in the macro-culture" (McCormick, 1990, Programs and Practices section, para 6). Regardless of the source of gender bias, consensus within the counselling educational community is that gender bias is a problem that requires individual counsellors to resolve so that they do not impinge their gender bias onto students.

#### *Educational Administrators and Their Views of Female Gender Disparity*

Literature from the perspective of administrators on female gender disparity in science and mathematics is almost non-existent. Typically, what little has been written regarding female gender disparity tends to reflect either that administrators do not believe that female gender disparity in science and mathematics is an issue, or that all they can do is reschedule classes, to avoid conflicts between choir practice and a science class (Mewborn, 1999). The administrators have a duty to ensure all members in the school community know and understand the top priority of equity. What is not clear is whether principals themselves value strategically resolving female gender disparity in science and mathematics. Furthermore, there is a gap in the literature as to what administrators' views of females in science and mathematics are, and whether they are required to have the

are, and whether they are required to have the same level of understanding of the negative effects of gender bias, as has been suggested is required of educational counsellors (Gold & Hawley, 2001).

### *Summary*

This Chapter reviewed the literature on female gender disparity, from a global context of female gender disparity, including a historical context of female gender disparity, and an in-depth review of the context of female gender disparity as it affects girls and women. The review proceeded from the general global and historical context of female gender disparity, from a Western perspective while including perspectives from outside the Western World. Changes in the role of women and girls and changes in politics, society, and law have occurred in tandem. Western bias regarding females has continued to be a problem, in spite of changes in the role of women, the creation of the Charter of Rights and Freedoms (1982), and organizations to facilitate the inclusion of women in non-traditional occupations.

Academics have focused on female gender disparity from across many faculties. Employment opportunities have been opened to females, in all non-traditional areas, yet female gender disparity persists. Two main perspectives have been observed, including a gender biased perspective that females and males are unequal, and an unbiased perspective that males and females are equal. The biased perspective has been problematic because of the discrimination which females have experienced in the pursuit of equality, in education, career guidance, and careers. The bias against the knowledge that males and females are equal affects girls, because girls are socialized to become

women. The persistence of female gender disparity is therefore an issue for educational leadership, to resolve in the areas where it persists in physical science and mathematics.

In particular, scholars have argued both perspectives, including a biased gender perspective that small measured differences prove innate differences, and scholars who have not found significant differences in males' and females' abilities to perform in mathematics and physical science. The debate has shifted back and forth from depicting the root of the problem as one internal to females because of a belief in innate differences, and then as a product of the environment. Both quantitative and qualitative studies have illuminated gender bias as contributing to the persistence of female gender disparity. When gender bias is controlled through methodologies, and gender equality practiced, it appears that female gender disparity resolves. Although methodologies have been useful in illuminating ways of resolving the problem, very little attention has focused on the gender views of those actually dealing with female gender disparity.

Historically, counsellors have promoted the perspective that gender equality is necessary in order to ensure that gender bias does not limit life options for students. Although there has been considerable emphasis on gender equality, gender bias has been observed within the counselling community in regard to females in non-traditional areas of study. With regard to administrators, there has been very little documentation, with the exception of the important role principals play in ensuring equality in education for all students.

What this aforementioned knowledge meant in regards to this study was that the researcher had to proceed with the knowledge that there would most likely be differences in viewpoints by participants on the problem of female gender disparity in physical

science and mathematics. Since gender bias was already observed in the counselling community as being an aspect in limiting the counselling of student life options, and since this issue in relation to administrators has not been studied, finding the awareness and perception of female gender disparity in mathematics and physical sciences became an important point to begin the study. Due to the relationship of administrators scheduling classes and counsellors counselling students in the selection of subjects, courses, and programs, knowing the perspectives of both counsellors and principals on the same questions, in the same schools, and at the same point in time, was decided to be practical in resolving female gender disparity in mathematics and physical science.

Chapter III contains the methodology of this study, including; the research question, the qualitative approach, and the research design, sampling and triangulation. From here, the reader may know the procedures used to gather the data, how the data was analyzed, and what means were undertaken to ensure all the participants' perspectives were heard.

## CHAPTER III

### Methodology

#### *Introduction to Methodology*

This case study was an investigation into the perceptions of counsellors and principals on why female gender disparity persists in mathematics and the physical sciences in secondary education, and the perceived implications to female students' career choices. The researcher analyzed principals' and counsellors' perceptions of female gender disparity in mathematics and physical sciences, through face to face interviews with five senior counsellors and five principals from five secondary schools. This Chapter presents the research question, followed by the research design. Then, a section follows on sampling, how the interviews were conducted, as well as procedures, and the method of analysis. This is so the reader may know how the data was collected, whom the data was collected from, and how the researcher analyzed the data. A section on the pilot study has been included. This Chapter not only explains the procedures and methodology used, but also describes the situation and context to facilitate reader transferability. The purpose of this study was to investigate the perceptions of principals and counsellors on female gender disparity in high school physical science, mathematics, and career choices.

#### *The Research Question*

The research question was: What are the perceptions of principals and counsellors on female gender disparity in mathematics and physical sciences? The question was

formulated in response to the continuation of female gender disparity in mathematics and the physical sciences.

### *Qualitative Approach*

A qualitative approach was selected for this study for several reasons. First, it is the best approach for answering the questions concerning why. In the case of female gender disparity, why female gender disparity persists was of central interest. Second, due to the known gap in literature, there was perceived to be an academic need for deep and meaningful exploration of female gender disparity from the perspective of secondary school leaders. Third, there was perceived to be a requirement for writing long passages, explaining the evidence and presenting quotes. Furthermore, the researcher was both able and impassioned to commit and spend time in the field, and later spend long hours analyzing the data, in order to contribute to resolving the issue of female gender disparity in mathematics and physical science (Creswell, 1998).

According to Creswell (1998) the design of a qualitative study begins with a single focus, a problem, an issue to research, which needs an answer along with the selection of one of the traditional methods of inquiry . The question is then taken to the field to collect data from “multiple sources of information” (p. 19). Ethical issues are considered and included in the design, such as “seeking consent, avoiding the conundrum of deception, maintaining confidentiality, and protecting the anonymity of individuals with whom we speak” (p. 20). Data is then organized and analyzed by working through “particulars to more general perspectives” (p. 20) and “abstraction” (p. 21). This step in the process is generally considered to be an intermingling of forms in the analysis, such

as “metaphors, developing matrices and tables, and using visuals” (p. 20). The study is then presented according to the “traditional approach to scientific research” including, “problem, question, method and findings” (p. 20). The participants’ and the researcher’s perspectives form the narrative (p. 20).

There are many advantages to using a qualitative research design such as this method, as it permits the researcher to delve into many variables within the same study. This is very different from quantitative research, where the researcher is limited to very few variables and many cases (Creswell, 1998). A qualitative research design has specific characteristics that, when combined, are powerful. According to Creswell, these characteristics include: the collection of data in the field, the researcher as central to the collection of data, an outcome through a process of inquiry, inductive analysis, focus on the perspectives of participants, the use of rich, thick expressive language, and persuasive reason.

Furthermore, Creswell (1998) reminds us that the differences between qualitative and quantitative research designs means that questions of causality and correlation, which one may determine through quantitative methodology, are not within the purview of qualitative research design. Having stated this, qualitative research design and quantitative research design are important aspects of science, in which one provides the substance through which the other may be used to explore and determine significance respectively. Whereas, according to McMillan and Schumacher (1997), quantitative research design permits the use of a single measure to determine an objective outcome, qualitative research is used to determine multiple realities regarding a social situation. In quantitative research, the purpose is to establish relationships between variables. The

purpose in quantitative research is to understand a social situation from the perspective of participants in the research. The fundamental assumption of the use of an experimental design, or a correlational research design, is intended to reduce error and bias, and to use a detached instrument to measure the variables in cases. These assumptions differ greatly from the qualitative research design, where subjectivity is “disciplined” and the “prepared person becomes immersed in” social situations (p. 17). Whereas the final goal of quantitative research may be to determine “universal context-free generalizations” (p. 17), the goal of qualitative research is to illuminate “context-bound generalizations” (p. 17). The original matter on which the quantitative study is formulated originates in qualitative study from quantitative research design. Both qualitative and quantitative research designs are essential to good science. According to Oppenheimer in Hewitt (1985):

By trying to understand the natural world around us, we gain confidence in our ability to determine whom to trust and what to believe about other matters as well. Without this confidence, our decisions about social, political, economic matters are inevitably based entirely on the most appealing lie that someone else dishes out to us. Our appreciation of the noticings and discoveries of both scientists and artists therefore serves, not only to delight us, but also to help us make more satisfactory and valid decisions and to find better solutions for our individual and societal problems. (p. xxi)

Both science and art are therefore inextricably related to each other, in the quest for sound knowledge. Qualitative research design embraces a specific location within scientific method.

The scientific method includes five specifically conceptualized stages. The first stage, usually a qualitative stage, is the recognition of a problem. The second stage is qualitative, where the researcher explores possible answers. The third stage is also generally considered qualitative, as the researcher predicts consequences of the exploration and possibilities announced in the second stage. The fourth stage, which is often confused with the ultimate stage of science, is the stage where most quantitative research design is employed. This is the stage that tests the predictions determined in the first three stages. The fifth and final stage, which is not truly final at all, is a stage which synthesizes the second, third, and fourth stages into a simple theory (p. 2). The theory is then tested and when new problems are identified, the cycle commences once again. Thus, the scientific method provides us with a mental construct through which qualitative and quantitative research may be understood to fit with equal importance and robustness in science.

### *Research Design*

A case study approach was chosen to investigate female gender disparity in high school mathematics, science, and career choices in this current study.

According to Creswell (1998) a case study must be bounded by location and time. This case study was not only bounded by location and time, but also by the issue of female gender disparity (Creswell, 1998, p. 62). Female gender disparity was the case

studied through the perceptions of principals and counsellors. This case study approach provided the researcher with the opportunity to compare and contrast differences and commonalities among the perceptions of educators on female gender disparity (Creswell, 1998; McMillan & Schumacher, 1997) with government statistics and the professional literature. A rich, thick, informative, narrative presentation of emerging patterns, in the qualitative results, or themes, was arranged in text, including original quotes from the interviews, so that the meaning portrayed by the participants is clear to the reader (McMillan & Schumacher, 1997).

Yin, (1994) states that the research design logically links the “data collected” (p. 18) from the research question (p. 19) to the conclusions (p. 18). The research design is the plan used to collect the data, analyze the data, and make interpretations (p. 19). Since a qualitative study is not one where all the variables can be controlled, such as in an experiment, quality has to be assessed through different efforts (McMillan & Schumacher, 1997, p. 608). Quality control was maintained throughout this study by maximizing both validity and reliability (p. 18). Validity was maintained by ensuring the researcher respected, and reflected as best possible, the voice of the participants in the interpretation (McMillan & Schumacher, 1997, p. 619) so that the mutual meanings of the participants and researcher are visible in the interpretation as presented in the results and discussion.

Reliability was ensured through consistent measures and methods throughout the study (McMillan, 1997, p. 616). This was performed by using the same researcher, the same interview process including the same information in the complete disclosure to the participants, the same opportunity to participate in member checking, and the same

consistent process of inter-raters. Reliability of data was ensured to the extent that reliability may be ensured in a qualitative study through controlling the methodology, research design, procedures, materials, method of analysis, and also ensuring that the participants are from a population of experienced professional educators. The data that was collected from the professional educators can be said to be reliable due to the credibility of the participants and their active role in the investigation of this study.

The researcher's involvement in the interview was to facilitate the discussion of the participant on female gender disparity. The interview questions formed a preliminary guide to the dialogue and included both the researcher and the participant. When ambiguity was apparent to the researcher, further "probing" questions were prompted by the researcher. The role of the researcher was perceived as participant, yet care was taken not to present biased leading questions, so that the participants communicated their perceptions and knowledge instead of speaking to the researcher's bias (McMillan & Schumacher, 1997, p. 264–267).

The case studied was female gender disparity in mathematics and science. The perception of each participant on female gender disparity was the focal point for collecting the data, and their perspectives were analyzed. The goal of the study was to clarify why female gender disparity persists, and to make recommendations for improvements.

The overall research design began with the identification of a problem and a gap in the literature to solve the problem. Although McMillan and Schumacher (1997) discuss the research process as sequential, as this was a qualitative study, different steps, such as the review of literature and ethical concerns, were revisited throughout the study.

The problem identified was the persistence of female gender disparity in mathematics and science, and career choices in lieu of no perceived legal barriers to participation, and legislation intended to guarantee equal participation (Charter of Rights and Freedoms, 1982). The literature was reviewed and the review of literature was revisited and updated throughout the study. The question, why female gender disparity persists in science, mathematics and career choices, was selected as the main research question.

The source of data was identified as professional educators in leadership positions within schools. Ethical approval to proceed was obtained from the University of Victoria. Further approval to proceed was obtained from the districts, the participant principals, and finally, the counsellors. The steps taken, from study design to the implementation of the study, were based on accepted research protocol. The data was collected and analyzed, as described in this Chapter. The reporting format is the format required for partial fulfillment of the requirements of the degree of Master of Arts, Master's thesis. The audience is intended to be both scholastic and general population.

The design of the study included interviews, member checks, peer review, inter-rater, triangulation with multiple sources of professional literature, and a declaration of researcher bias. In this study, the five principals' and five counsellors' perceptions were the multiple sources of data and the interview questions formed the single measure. The other sources of information for triangulation were government statistics and the professional literature.

Tables 1 to 5 were shown to the participants in the complete disclosure to the participants in the interviews and part of the triangulation (Appendix A). The principals

and counsellors paired from five schools provided two sources of data per school, further strengthening the construct validity.

The test of internal validity was performed as a case study tactic, which proceeded from the interviews, through the analysis of topics, to finding patterns and building categories and themes. External validity was tested through using multi-sites, using the same interview format with the same questions, the same method of collecting the data, the same informed consent, and the same researcher for both collecting and analyzing the data. By using multi-sites, the researcher intended to gather information across sites, so that generalizations could be drawn across these sites (McMillan & Schumacher, 1997).

Validity between the researcher and the participants in this qualitative study was ensured by providing the participant with as much background information as time could permit before the interviews started. This was important so that the participant knew the basis of the inquiry, the background statistics, and the general questions they were to answer in the dialogue. The concept of female gender disparity was fully explained as a situation where females were not participating in the numbers that would be expected given that there are no legal barriers to their equal participation. The briefing of the full disclosure of the informed consent provided a point of reference, from where the participant and the researcher could form a meaningful dialogue. The school statistics also provided a point of reference whereby the participant could speak to the issue of female gender disparity, and their knowledge according to their experiences and perceptions. This established a common ground of information between the researcher and the participants, including all the material in the briefing, provided enough information so that the participant knew where the researcher was coming from in regard

to the questions. When it appeared the participant was answering the questions with ambiguity, the researcher asked questions so that any possible multiple interpretations of answers could be clarified before moving on to the next question.

The data collecting procedures were repeated exactly the same way, with each interview. The interviews were transcribed and returned to the participant for their member check. Furthermore, data reliability was incorporated in the research design, through not only member checking, but also inter-rater reliability, and through the stages of the analysis, and by triangulation of the data with multiple sources of professional literature.

### *Sampling*

This study took place in five schools, in two districts in a western province of Canada at the end of spring and the beginning of summer, prior to summer recess 2002. Participants communicated that stress levels amongst educators were high as many of the participants' colleagues had received notices that they had been laid off due to decreased funding. Some of the principals expressed how upset they were about having to give their most recently employed teachers, some who had been with the school for many years, these notices of lay-off. Most of the principals expressed that they were doing everything they could to ensure that many of their educators remained on staff. In spite of the stressful situation, the participants appeared to be both interested in the study and concerned educators. Many of the educators also informed the researcher that they were also parents themselves.

Five principals and five counsellors, from five secondary public schools, were invited to participate in the study (Appendix B). A principal and a counselor were invited to volunteer from each school. Principals, as a part of the sample, were chosen to be involved in this study due to their top leadership positions and administrative duties within each school. Counsellors were chosen to be a part of the sample because they have contact with all the students in relation to counselling students, both in groups as well as one-on-one, about not only what courses and programs to consider, but also what courses and programs lead to different careers. The counsellors were the senior-most counsellors available at each of the five schools at the time of the study. The aim was to interview the senior-most counsellor from each school, to gather data from those with the most experience. Their duties were considered leadership oriented in that they provided direct leadership to students.

All the participants were senior educators with more than five years' experience as educators, in various schools including urban, inner city, and rural schools within the public school system, and within a western province of Canada. The populations of students in each of these schools were between approximately 850 and 1,250 students, with two schools between 1,000 and 1,199 students, and two schools over 1,200 students.

Eighty percent of the participants interviewed were male. Due to the small numbers of participants, and the limited ethnic diversity of the participants who did participate, specific participant racial or cultural affiliation has not been disclosed, to maintain confidentiality, and the assurance of anonymity guaranteed to the participants in the informed consent forms.

Anonymity and confidentiality were protected in this study. Neither actual participant names nor pseudonyms have been used to identify the participants. Due to the sensitive nature of the study, and the guarantee made by the researcher, this investigation has been reported in keeping with the promises made as depicted in the following quotation from the letter of informed consent:

I understand that my participation in this research is completely voluntary and that the research will have no effect on my employment status. I may withdraw my participation at any time with no repercussions and that any of the data collected up to the time of withdrawal will not be included in the research thereafter. I understand and have read the research questions. I also understand that my anonymity and confidentiality will be maintained throughout the research (Appendix B).

And furthermore, since each participant knew what they stated, and that they could therefore know from what they read what the other participant stated from the same school, and since the researcher felt it necessary to protect each individual from this within-school dynamic, and because this was considered an ethical dilemma in regard to grouping statements by individuals by number or pseudonym, a decision in regard to numerical identifiers or pseudonyms was made. No individual numerical or pseudonym identifier was used in the presentation of results. This was to specifically protect the anonymity of each individual within each school, and from the knowledge of what the other participant stated. Where statements were mutually validating, these statements have been presented together to show within school agreement. The researcher

considered it ethically necessary to draw a line in regard to numerical or pseudonym identifiers, so that the voice of the participant was presented without the need of censoring the material. Although it may be argued that qualitative studies use some form of participant identifier, and that using identifiers makes the reading easier, both the spirit of the intent of numerical and pseudonym identifiers and the responsibility of the researcher to the participants was considered. McMillan and Schumacher (1997) state that, in regard to confidentiality and anonymity:

Researchers have a dual responsibility: protection of the participants' confidences from other persons in the setting whose private information might identify them, and protection of the informants from the general reading public. However, the law does not protect researchers if the government compels them to disclose matters of confidence. (p. 420)

Since the simultaneous presentation of confidences would provide a window of opportunity for either participant to know what was confided by the other participant in the same school, the decision to not present numerical or pseudonym names was made. The decision was made in all consideration of care, fairness, and above all, to do no harm to the participants or violate the participants' trust (McMillan & Schumacher, 1997). Participant voices have been presented in the results section in Chapter IV unless a participant had no response. Not all of the responses to the questions were made in sequence of the question. Where an answer to a question was made further along the dialogue, the data was then presented in the appropriate section.

The participants were from two school districts in a western province of Canada. Invitations were mailed to all the principals of secondary high schools within two school districts. Five principals volunteered and gave permission for the researcher to invite the senior counsellor. Although a random sample of the volunteers was planned, since the research design included ten participants, and five principals and five of their senior counsellors volunteered, 100 percent of the volunteer participants were interviewed.

### *Triangulation*

Triangulation is “qualitative cross-validation among multiple data sources, data collection strategies, time periods, and theoretical schemes” (McMillan & Schumacher, 1997, p. 619). According to Yin (1994) and Creswell (1998), the research is credible due to the different sources of corroborating evidence, from multiple sources of data. The sources of data used in this study included the interview data that was collected with the single measure, and multiple sources of the professional literature. The government published statistics included statistics available from the Federal and the provincial government. Interpretations made by the researcher were made on the basis of the perceptions from the interview data, the statistics published by the government, and the professional literature.

The scope of the literature included multiple perspectives from many different disciplines, and is considered a variety of credible sources of information and knowledge. The empirical statistics published by the government and the professional literature are credible sources used to complete the perspectives of the participants. Where possible,

the professional literature and the government statistics have been used to verify the findings in tandem.

The participants added credibility to the study due to their experience as educators with professional status, all of whom had been granted post-graduate degrees and were in leadership positions within the public school system. The perspectives of the participants were considered to be highly trustworthy. Authenticity, “the faithful reconstruction of participant’s multiple perspectives” (McMillan & Schumacher, 1997, p. 606), credibility, and trustworthiness are three principles that have been employed to ensure this study meets with standards of quality data (Creswell, 1998).

### *The Interview*

According to Creswell (1998), there are three different methods of conducting an interview, including telephone interviews, focus groups, and private one-on-one interviews. These three forms of interviews are all used for gathering data that is either difficult to observe or not available anywhere in print. Telephone interviews are useful when face to face interviews are not possible, due to distance or time restraints, but “informal communication” through gestures are missed. Furthermore, there is the cost of the long distance phone bill (p. 124). Focus groups are used to invoke responses from the interaction of participants, but have some drawbacks, such as individuals dominating the conversation while other individuals may hesitate to share their thoughts in front of other people.

One-on-one interviews provide the participant anonymity but, according to Creswell (1998), require participants who are not shy. This interview method was used in

this inquiry so that participants would share their perceptions without being concerned about the perceptions of other participants. It was also anticipated that counsellors might be more comfortable sharing their perceptions without the principal of the school present, given the principal is above the counsellor in the hierarchy of the organization.

Furthermore, it was anticipated that principals might be more willing to share their perceptions one-on-one for similar reasons. Conducting separate interviews between counsellors and principals was also used as corroboration, internal verification, and to see whether principals and counsellors differed in their perception of female gender disparity.

The following were the interview questions:

1. According to provincial data, there exists a discrepancy in mathematics, physics, chemistry, biology, and computer science by gender. Can you comment on this?
  
2. Are you aware of any local discrepancies at your school? Can you comment on this?
  
3. In more depth, why do you think these discrepancies exist?
  
4. What impact does this have on female student's future education and career choices?

5. Have you any suggestions on how to improve the situation? If there is no difference by gender in mathematics, biology, physics, chemistry and computer science in your school, what do you attribute the success to?

6. Have you got any further comments or thoughts on how to make improvements?

The interview questions were designed to focus the dialogue on female gender disparity so that the central research question, why female gender disparity persists in the physical science, mathematics, and career choices, could be illuminated. The logical process included assessing awareness of female gender disparity, perception of female gender disparity, at large and in the school, knowledge of implications of female gender disparity, and recommendations for improvement.

There was a foreshadowed problem, that, since there was an observed female gender disparity and a gap in the literature, there was a potential that awareness of female gender disparity would vary from participant to participant, from well known and knowledgeable to unknown. For this reason, it was decided that it was important to establish awareness at the beginning of the interview. Foreshadowing was stated by McMillan and Schumacher (1997) to be an important aspect of research question (p. 112), and this principle was incorporated in the interview questions.

The aim of the first question was to assess whether the participant perceived and was aware of female gender disparity in the province. The aim of the second question was to determine if the participant was familiar with their school's gender demographics

in mathematics, biology, chemistry, and physics, and if they knew whether or not they had a female gender disparity at their school. This data was important because the rates were verified with the school performance report. The participants were all informed in advance that they would be asked about the participation of males and females in the sciences and mathematics at their school. This was considered important to do because the researcher anticipated that if they were not informed in advance that they would be asked about school participation rates, they might get frustrated with the question.

The aim of the third question was to draw out the participants' perceived reasons why female gender disparity existed and persisted. The fourth question changed the focus from reasons why female gender disparity persisted to what they perceived were the implications on female students' future career choices. The fifth question, which was designed with two parts, was aimed at drawing out recommendations for improvement. The question was worded carefully because the researcher did not access information about the school performance prior to attending the interview. This was important in order to maintain as much researcher objectivity as possible. Also, because the rates were not known, the researcher left the question open ended, so that schools with strategies and which were reducing female gender disparity would have an opportunity to share their knowledge on recommendations for improvement. Participants in schools with female gender disparity may also share ideas on how to make improvements, as well as describe the difficulties and leadership issues they were facing. The last question was both a concluding question as well as an opportunity for the participant to share any further thoughts.

### *Procedures*

Invitations were sent to all the principals of two districts in a western province of Canada (Appendix C). Once the principals volunteered and consented to include their senior counsellors, the counsellors were invited to participate in the study. As soon as a counsellor agreed to participate in each school, independent interviews with the principal and the counsellor were arranged.

All interviews commenced after a full disclosure of the purpose of the study, and the signing of the letters of informed consent (Appendix D). A copy of the informed consent (Appendix E), copies of Tables 1 to 5, shown as part of the full disclosure were left with each participant, and a signed copy of the informed consent was kept by the researcher. One of the interviews was recorded by hand at the request of the participant. The interviews were transcribed and copies returned to the participants for them to member check, to ensure the written transcripts were valid, and to make any changes they wished to make so that what was transcribed was in keeping with their perceptions. Once the transcripts were returned, the data was analyzed.

A field log was kept to keep track of interviews, codes, time spent at each location, date, and some of the ethical considerations. Letters mailed to participants were also recorded in the field log, as were the telephone calls.

### *The Pilot Study*

The participants in the pilot study came from a senior secondary school and therefore a different population of educators. The pilot study was limited to one school because no other senior secondary schools volunteered to participate. There were no

differences in the procedures used in the pilot study, except for the method of recording the interviews. The method used to record the interviews in the pilot study was by hand. The following tests were an important part of piloting the study including: testing the interview questions, testing the method of recording, testing the method of analysis, testing the process of member checking, testing the briefing of the peer review, and testing the researcher throughout the pilot study. Feedback from the participants and the peer reviewers on the process was essential. Participants in the pilot study stated that they would have preferred the interviews to be tape recorded instead of recorded by hand, therefore this method was used in the investigation. Peer reviewers provided feedback to the researcher on the way the researcher reconstructed the participant's perceptions in regard to protecting the voice of the participant from researcher bias.

### *Method of Analysis*

Analysis of the interview data proceeded through seven steps including, first, reading each interview as a whole; second, condensing the statements into phrases or original text; third, placing these into easy to use tables separated by counsellor and principal; fourth, identifying and listing descriptive topics; fifth, comparing and contrasting topics into similar and dissimilar categories; sixth, classifying the topics into categories; and seventh, listing all topics into refined themes.

Steps one, two, and three were fairly straight forward. First, once the transcript had been returned from the participant, the transcript was read and issues or topics were identified. Then in the second step, space was made in the left hand margin to insert text boxes, with the topics or issues and verbatim quotes inserted. In the third step, the data in

the text boxes were transferred onto a matrix. Separate matrixes were used for principals and counselors, and in the order of the interview questions.

The next three steps were more complicated because the topics had to be paraphrased into smaller phrases. Once this was completed each of the topics was moved about into different groups. The researcher used questions to see whether they fitted one category more than the other. This was done for both the counsellors and the principals.

Refining the data sets required questioning whether “some topics [were] closer in content to certain topics than others? [Were] some of them subtopics of others? [Were] there other topics in the data that ... [were] not recognized?” (McMillan & Schumacher, 1997, p. 512). The data sets were shifted around until the simplest form of different categories was recognized. The analysis was considered complete when the themes could account for all the topics. Patterns emerged using challenging possible combinations with the disconfirming evidence, that which did not fit the criteria, and alternative explanations (McMillan & Schumacher, 1997). Due to the similarities in the data between the principals and counsellors, the data was merged.

The analysis appeared complete, but there were lingering questions. The researcher applied the principle of parsimony and reduced the number of themes from five to three because some themes overlapped with other themes. Creswell (1998) called this portion of analysis, categorical aggregation, “where the researcher seeks a collection of instances from the data, hoping that issue-relevant meanings will emerge” (p. 249). Discrepant data was evaluated based on whether it was disconfirming in relation to the emergent patterns or themes (Creswell, 1998; McMillan & Schumacher, 1997) or confirming. Findings that were quantitative and could be verified were verified with

government statistics or professional literature. Member checking was conducted prior to the analysis, and peer review was conducted once the interviews were analyzed for themes.

### *Inter-rater*

Inter-raters were included in the research to ensure that the perspectives of the participants were not ignored by the researcher due to her bias. It was also a test of reliability and validity. Creswell (1998) states the peer reviewer plays the role of the “devil’s advocate” who “keeps the researcher honest” (p. 202). Because of the quantity of data and length of the analysis in pages, each peer reviewer was provided with two randomly selected interviews. Forty percent of the interviews were peer reviewed. Feedback from the peer reviewers, on whether the voice of the participant was preserved in the analysis, was incorporated into the final report.

Each inter-rater received, in person from the researcher, two randomly selected copies of an interview with a principal and an interview with a counsellor. Inter-raters were each individually briefed regarding the purpose of the study, how the data was collected, how the data was analyzed, and their role in the study. From there, each inter-rater reviewed the analysis, at their leisure, to ensure the perspectives and voices of the participants were included in the analysis. At the end of their review the inter-rater briefed the researcher on areas that they believed were covered adequately, and which required more attention.

### *Member Checks*

Member checks were employed in this study. According to Creswell (1998) member checks are one of the important procedures used to “solicit informants’ views of the credibility” (p. 202). Employing member checks ensured the participants played an active role in the case study research. Each of the participants received a copy of their transcript as soon as it was transcribed. The transcripts were transcribed word for word. Punctuation was included by the researcher. The participants were informed that they could change anything in the transcript that they thought better reflected their perception. As soon as they had completed checking the transcript, a revised copy was returned to the researcher. One of the participants chose not to participate in member checking.

### *Rich Thick Description*

Creswell (1998) considers a detailed description necessary in the reporting of a case study, because it allows “the reader to make decisions regarding transferability” (p. 203). The researcher has included rich descriptions to allow for as much “transferability” as possible by the reader to his or her own situation (p. 203). Also, the researcher has presented as many quotes as possible, to ensure that the voices of the participants are reflected in the results.

### *Summary*

The case study methodology described in this Chapter was used to discover why female gender disparity persists, from the perspectives of principals and counsellors. The research question was designed to systematically elicit perspectives from professional

educators as to why female gender disparity persists, to explore awareness, reasons why female gender disparity persists, the implications of female gender disparity, and recommendations. The design of the study was created with a purpose to understand female gender disparity, from the participant's perspective (McMillan & Schumacher, 1997). The intention of the design was to allow for an emergence of themes from the data collected, through the analysis. The researcher's bias was that female gender disparity has a negative effect on females, as it limits their subjects studied as well as their career possibilities.

Reliability was achieved in the study through the careful use of the same materials, procedures, and individuals. This was important so that the perspectives of the participants could be analyzed with as little error as possible originating from the procedure or the researcher. Feedback on the interview questions, the single measure, was obtained from the researcher's supervisor, and the committee. The instrument was tested in the pilot study, along with the process of peer review and the method of analysis and the process of peer review. The consistency of the measure, to elicit the level of participant awareness, perceptions of why female gender disparity persisted, perceptions of the implications of female gender disparity, and recommendations was key to reducing error within the interview. The nature of the qualitative study required tight controls over the procedure, and tight controls over the design. The methodology was adhered to so that the participants would have freedom to share their perceptions, and played an active role in the case studied. The participants played a crucial role in discovering why female gender disparity persists, and contributing to making improvements.

The interpretation is valid as it rests on the voices of the participants and triangulation with the professional literature (Creswell, 1998). Internal validity was tested through a case study tactic, through every aspect of the research procedure. External validity was tested through the constancy of materials including the same questions, the same letters of invitation, the same fully informed consent, and the same researcher. Validity and reliability overlapped in the methodology in regard to the same measures, the same procedures, the same method of collecting the data, and the same method of analyzing the data. The fully informed consent was crucial to creating an interview meeting of researcher and participant, whereby the researcher and the participant were on the same page. Furthermore, the data was collected during the same period of time, and therefore school pressures for the preparation of the end of the year were the same for all the participants. The interviews were performed in the participants' offices at their own schools and at a time convenient to them.

Creswell (1998) has stated that a good qualitative study must use verification procedures to ensure the study is trustworthy. This study has used triangulation, peer review, also known as "inter-raters" (p 202), "clarifying researcher bias" (p. 202) by stating the researcher's bias from the onset of the study, "member checks" (pp. 202–203) and "rich thick description" (p 203).

The next chapter, The Findings, contains the principals' and counsellors' perceptions on female gender disparity in mathematics and physical science. These perceptions have been presented in four major themes: first, gender views, gender equality, and gender bias; second, role modelling; third, school philosophy; and lastly, the

perception of mathematics and physical sciences. Evidence substantiating these themes has been presented through direct quotes from the participants.

## CHAPTER IV

### Findings

#### Principals' and Counsellors' Perceptions on Female Gender Disparity in Mathematics and Physical Science

##### *Introduction*

This Chapter has been organized into four subheadings according to the main themes derived from the analysis; namely gender views, gender equality, and gender bias, followed by role modelling, school philosophy, and the perception of mathematics and physical sciences. To respect the voices of the participants, quotes will be used to narrate, as often as possible, the perceptions to the reader, so that the reader may decide how to transfer the data to his or her own situation.

##### *Gender Views, Gender Equality, and Gender Bias*

Generally, most of the participants expressed a belief system reflecting gender bias and the stereotyping of gender, that boys and girls were different. This sub-section presents the gender views of the participants, commencing first with a discussion of gender bias directed at co-operative learning; second, gender bias and life options, third; a view of gender as equal. A fourth gender view presented was also one of equality, and that of not "playing the weaker sex game." And fifth, gender equality and the appearance of gender traits were an important gender view communicated. The sixth and last point was that of swaying between articulating equality, gender bias, and lack of awareness.

As stated in the review of literature by Gold and Hawley (2001), it has been recognized that individually-held beliefs of gender are “belief systems” and “not reality” (p. 200). Participants spoke about girls and boys as though they were not the same and that each required completely different teaching methods. For example, one participant stated that “the primary program is a cooperative program ... designed for the education of females, not designed for the education of boys.” The view that males and females were so very different and required different teaching methods was not substantiated in the professional literature. Research has shown that the co-operative method has been used to successfully teach mathematics to both boys and girls. This same participant believed emphatically that even the language of males was different from the language of females, as shown in the following quote:

... whole language, that were designed with the learning styles of women, who work beautifully cooperatively, work in that way, where generally boys don't. Boys work and we try to force a female model, and then by averaging it, we may be averaging it down, because we are now finding the strongest students in leadership, and I defy you to find a president of a student's council that's male....

There was a major assumption made by this participant that females required a lower standard than males, and that by having a method at a particular standard that was the same for both genders, boys were being discriminated against. A standard for boys was therefore superior to a standard for girls. This was an obvious gender bias.

The main feature of gender bias was that there was an essential element of gender, which meant mathematics and the physical sciences, and in particular, physics, had to be

presented differently to females, as though the subject had a gender. It was difficult to separate the subject studied from the gender bias, especially when the intent of the participant was to communicate that the school was doing all it could do to accommodate females within mathematics and physical sciences. The following quote illustrates this point in regards to the presentation of physics:

It probably has to do with the nature of the way it is presented, and/or the presentations itself; the nature of the material, the stuff the kids have to deal with, but a school can make a difference. Because if you have teachers as we have, who are perceived as very flexible, and very accommodating, you will notice the differences in participation was not nearly so great.

Although the participant was discussing the subject matter, he was also discussing how the subject was being taught differently, being “flexible,” and therefore accommodating essential gender differences. This participant communicated a gender bias that females had to be accommodated, that they could not be taught the subject as boys could be taught the subject. The perception of mathematics and physics is presented in its own section, because the view of the subject as having a male gender, by nature, is also evident in this aforementioned last quote.

And secondly, gender bias was also evident in relation to life options. An assumption of a difference between males and females was made by many participants, as to why fewer females participated in physics. The fact that females give birth to children was used by many of the participants as a reason that fewer girls went into physics. The female students’ actual biology was deemed different from the male

students' actual biology. There was a gender biased assumption that the biological ability of females to get pregnant meant that, by virtue of this fact, there was justification to have a belief in a legitimate life option, to not pursue higher education and Doctoral degrees, in areas where females are in minority, as articulated in the following:

I wonder about, when I look at Doctoral degrees, and the amount of school required, to get a Doctoral degree, I would be interested in, how many, I mean obviously women are very capable, why would they not pursue a Doctoral degree, I wonder about their family choices. Whether the choice of having a family, it takes many years [for] a baby or two, and pursue a Doctoral degree, that is a huge amount of work.

Life options were communicated as though the female, by virtue of her gender, had no choice but to choose either a career, or giving birth. The life option of having children was not presented as an issue for males. Life options, in terms of gender bias, were also presented in regard to career choices. The participant had also stated that he felt these life options were indicators that females were "not willing to sacrifice" in order to have a career. He also stated they lacked "passion" for the subjects where they were the minority, and that many of the attempts he said he and others had made to instill passion of a subject into females had failed. Liking the subject matter or disliking the subject matter, according to this participant, was innate. The following quote demonstrates this type of gender bias communicated by another participant:

The provincial data is very similar at our school in that it has not changed very much over time. I feel that this is what you will have seen going back many years.

There are more females in chemistry as it is required for nursing, environmental sciences, other health related careers such as occupational therapy, and dental hygiene. The females take this course because they think they might need it later on.

Gender bias formed the framework through which female gender disparity was justified. The view that gender steered an individuals' choice and life options was bold, and without question was held by many of the participants. The participant who articulated the last quote did not question gender bias in terms of life options for females whatsoever.

Another participant stated that it may be the role of society, as well as the role of the school, to change gender bias within the school and its community, as evident in the following quote:

I am frequently making aware, to young people, and even their families, because sometimes gender bias is a reflection of another age, perhaps the traditional fifties when the good wife was in the kitchen or doing secretarial duties, if she went to work. It may not solely be the role of the school, but it may be a broader role that the society, the (name of the western province ethically withheld), the Canadian society, need to look at ways of changing those pockets, that say, *you are a girl, so you will do this*, as opposed to, *well, let's see what can you do*.

The issue herein presented is that women's roles have already changed, as evident in the Charter of Rights and Freedoms (1982). Society has already changed, even though gender

bias and female gender disparity is still a problem. As communicated by the participant, it is the role of the school to change gender bias and practice equality, but other people outside the school itself also play a role in changing their gender views from gender bias to gender equality. There is a necessity for resolve of gender bias in all locations of Canada where it is being practiced. The participant did raise another point, that of having to the issue that gender bias is something of the past, when it is still believed by some people today.

It was apparent that gender bias and how individuals view gender, whether as equals or unequal, are problematic in resolving female gender disparity, especially when individuals are not aware that they have a belief system that is gender biased; and that they are viewing the genders as unequal. Along with the lack of awareness of gender bias is the view presented by some of the participants, that the girls simply were not choosing to study physics. Pointing the blame at the girls is a gender view, where girls simply do not choose physics. If females do not choose physics, then they would not choose to study physics anywhere.

The perspective that girls did not choose physics was contradicted in the school that embraced a view of gender equality. In the school that had been experiencing a change towards gender parity, and where female gender disparity was being reduced, the following observation was made by one of the participants as follows:

We do not reflect the provincial difference to the degree that the provincial figures show. We have more of an equality of presence and achievement by both male and female students. I have only theories as to why that may be so, but having

been in the school for 15 years I am aware that there is a consistent and strong encouragement of both young women and young men, to be the best they can be.

What is evident in this quote is that the practice of equality means “consistent and strong encouragement of both young women and young men.” There is no special accommodation given to either girls or boys. Accommodation is the product of gender bias, where females need to be accommodated with special treatment in order for them to participate in mathematics and physical sciences.

The dialogue in the aforementioned quote was inclusive of both genders, and the practice that was claimed to be occurring in the school was equal. The results indicated by the participant were that this practice was actually reducing female gender disparity in mathematics and the physical sciences. No accommodation was necessary, just equality and encouragement for all students.

But this gender view was not shared by all participants. An example of the perspective that accommodation was necessary is evident in the following: “... flexible, accommodating, and accommodate the different learning styles, and one of the differences is male and female gender, being more sensitive to issues that would be of concern, in physics and otherwise.” This is an example of the type of gender bias that assumes, first, that there is a difference between males and females, and that accommodation of female concerns is necessary in order to be inclusive of females. Females, in this instance, are viewed as having innate needs, which means they have to be treated with more sensitivity. This is a gender biased perspective.

A fourth gender view that was communicated was in regard to changing gender views regarding females as the weaker sex. The following quote best states this perspective:

Why do some boys bounce a ball, here better than some girls? That is not true here, because we have a very active athletic program for both girls and boys. We have the largest girl's [sports] program (type of traditional male field sports program withheld for ethical concerns) in the province ... because we do not do the weaker sex game, we do not play that here.

The point of bringing in this quote about sports was not to change the topic from mathematics and physical sciences, but to demonstrate a pride in regard to viewing genders as equally strong, and that being equally strong is as attractive to females as it is to males. The program was supported with a gender view that did not depict girls as the weaker sex, and the result was that the program became very popular. This same attitude and belief was carried over into mathematics and physical sciences.

In comparing the gender bias of requiring a special accommodation of the female gender and poor participation of females in physics, with the popularity of a sport that has been traditionally male, it appears that when a program is not presented equally, and if it is presented with a gender bias, the program is less attractive to students who are female.

And fifth, how females are attributed natural traits and made to feel comfortable expressing themselves in non-traditional subject areas was a gender view that was articulated. If the reader recalls, according to the Women's College Coalition (WCC) in Guzzetti and Williams (1996):

Girls in elementary school are ambitious, outspoken, and usually receive better grades than boys. But beginning around age 12, girls tend to lower their goals and muffle their voices. (Encouraging girls to take charge section, para 1-2)

According to the WCC, young females are loud and then they become quiet. Clearly gender bias has something to do with females losing their voices, because not all girls become quiet. The following quote illustrates a female student who has been permitted to keep her aggressive character and who also performs well in mathematics as follows:

One of our current students is an intellectually aggressive girl who is passionate about mathematics. Here she is comfortable about being different. Socially, our school is very open and this is a strong point.

What is evident about this quote is that the girl was permitted to be herself, and she was also noticed in regard to her passion for mathematics. Having stated that, there was still some gender bias evident in the observation because the participant still thought that the girl was being different. But what was she different from? The participant observed that she was comfortable being both aggressive and passionate about mathematics. This behaviour was normal for the girl. What was crucial was that she was permitted to be herself, her voice was not muffled, and she was free to express herself and her passion for mathematics, and therefore to learn and explore her intellectual abilities in mathematics. What was evident in that interview was that the participant was not entirely comfortable with the observation and yet he was proud of the fact that the girl was comfortable and

did not interfere. What may be happening in situations where females are not expressing themselves, such as in mathematics or the physical sciences, is that people may be intervening in girls' behaviour and impinging their gender bias.

This brings up the sixth point of gender view, that of a swaying back and forth between articulating equality and then articulating gender bias. The swaying back and forth was so apparent, that, at times, it was confusing because it appeared that the participant was trying to practice equality at the school, and normalize gender equality, but then resorted to sweeping generalizations and gender bias, as follows:

Again it seems boys excel at the high end, but the weaker are the boys as well.

Girls can end up being middle somewhere, and if they are not in our advanced math placement, they are taking the terminal Math 11, and they are doing it to get into university, and they have no hope of ever doing it again. A large number of our girls take Biology 12, rather than Physics 12 or Chemistry 12. Boys are just taking whatever biology they have to get through the grade 11 qualification.

What this portrayed was a difficulty to practice equality when the individual held a belief system that attributed different qualities and abilities to males and females. Fennema (2000), as reviewed in the literature, discussed some of these differences; however, according to her, they were not significant, did not describe the entire population, and by no means did these ever-decreasing measured differences mean that females had inferior intellectual abilities. The individual who made this statement in the aforementioned quote also made the prior statement regarding the "aggressive" girl who was "passionate" about mathematics.

In summary, the commonly held gender view of almost all of the participants expressed lack of awareness of gender issues, and gender bias was pervasive. There was a lack of awareness that the gender views that each held was actually gender bias. Although gender bias did pervade most of the interviews, there were moments when observations of equality were made, and in one of the schools, equality appeared to be emerging.

### *Role Modelling*

There was an overwhelming agreement amongst all the participants that role modelling was crucial in why female gender disparity persisted in mathematics and physical sciences. The main issue regarding the continuation of female gender disparity was stated by the participants as through multiple means of role modelling. This section will review seven different ways in which role modelling was perceived, starting first with organized role modelling; second, media and role models; third, the teacher factor; fourth, poor role modelling; fifth, peers and role modelling; sixth, good role models; and seventh, visiting role models and summarizing the lack of role models.

First, organized role modelling was perceived to be important by many of the participants. The organization of role modelling, as the number one method of reducing female gender disparity in mathematics and physical sciences, was communicated best by the participants in one school which was employing a multi-faceted strategy to change the school from a situation where female gender disparity in mathematics and physical sciences was a problem, to attaining gender parity. As a factor in the organization of the

school, role modelling was seen as the best method to reduce disparities. All constituents were therefore included in on the importance of role modelling.

The main points presented hereafter demonstrate these points, but also include aspects of role modelling as shared amongst other participants in this investigation. Role modelling, as a part of the entire school, included not only those individuals who were considered internal to the school, but also those who were external to the school. Role modelling was included as a strategy and a goal at the same time. All constituent groups, as portrayed in Figure 1.1 in Chapter I, were part of organized role modelling as well as males and females.

Secondly, the media and role models were stated to be very important in achieving change. Students were considered “media savvy.” Media included all types of media, but examples were television shows and movies. How females were portrayed, or not portrayed, was considered either a problem or a part of the solution. If females were observed playing roles that normalized a female in a non-traditional field, and treated the female performing the role as normal, then this role modelling was considered to be the type of role modelling that would contribute to change and practicing equality.

One of the participants stated that there was a complete lack of female role models in all types of engineering, and that there had been very few shows with females in any fields of mathematics and physical sciences. Furthermore, the types of shows watched by students had role models that did not fill the need. This was evident in the following quote:

Our kids are media savvy and they see a lot of movies where they have role models and I think having a female role model engineer would make a difference.

It would make a difference if we had visiting female role model engineers to speak to all students, not just the girls, so that it is normal. Girls do not like to be segregated. They like normalcy...

What was proposed by one of the participants was, that if the media were to have a female playing a realistic role as an engineer, for example, this would make a difference. At issue was not only the notion that girls would watch the show and see female engineers as normal, but that parents, teachers, brothers, mother, uncles, and everyone else would watch the show, and begin to see females in an engineering profession, and then see this type of role for females as normal. The following quote emphasizes this point: "Our kids are media savvy and they see a lot of movies where they have role models and I think having a female role model engineer would make a difference."

Thirdly, the teacher factor was considered critical for affecting change. Many of the participants directed the attention to the teacher factor. In schools, the teacher makes the difference. Teachers attract the students to their classes. The following quote is intended to illustrate how convinced one of the participants was about the importance of the teacher in resolving female gender disparity in his school:

The courses the students take very much depends on who is teaching and how good and popular the teacher is. Charismatic! The reputation of the teacher precedes them. If the students do not like the teacher, they will only take the course if they have to. This school has some popular teachers, such as our physics teacher.

Role models have reputations, and all students will talk about what the teacher does. If the role model is good, they will like what they hear, and be inspired to learn. Of course, inspiration is not the only aspect of role modelling that the participants found important, but as a quality, the ability to attract students to the subject was considered very important. Although having a balance of male and female role models was considered important, and there was a perceived real problem of insufficient female mathematics and physical science teachers, what was important in regard to teachers was that the teacher, regardless of his or her gender, taught all students as equals.

Fourth, poor role modelling was an issue for both male and female teachers. This was an issue that was considered important both inside and outside the school. Internal to the school, poor role models were seen as undermining equality because their position, as well as their gender, was perceived by students as examples of someone portraying gender bias. Observations of female teachers in positions requiring them to teach mathematics, and not enjoying teaching mathematics, were described in the following quote:

... primarily female teachers, ... delivering a message to their students, and I have seen it so many times ... going into a class and saying, we have to get this math over with, or the message is, *I was never good in math, but at least I got my degree, so let's get our math done and move on to English, art or music project.* They are setting something up that math is difficult, math is something, that I, your role model, the person that you love in grade 2, 3, 4 teacher ... has struggled through it, has got through it, and did not like it, was not very good at it, hated, I

*am showing you all my phobias and not showing you, based on the principles of learning,*

By standing up in front of a class and stating that math is no fun, two issues are coming forward. The first issue is that all students are getting bad reinforcement about mathematics. The second issue is that male students are seeing a female complaining about mathematics, and females see a female role model not enjoying mathematics. In terms of child development, boys see females as unlike, therefore the behaviour would be attributed to the other gender. Girls see female as like themselves, therefore attribute it to themselves. Of course, poor role models are not only female teachers who do not like teaching mathematics, but also include male teachers as depicted in the following quote:

There was one math teacher, who I had a lot of concerns about ... so I have done a lot of work over the years with girls, and that particular teacher, who is a very, very skilled and talented teacher ... and it was not the boys who came in discouraged, it was the girls.

A good role model, therefore, inspires both male and female students. Being a poor role model has a detrimental effect on the students and this also reflects badly in relation to the person's gender. In relation to female gender disparity, poor role models of both genders were implicated by participants as contributing to female gender disparity in mathematics and physical science.

Fifth, peers and role modelling were areas that had either a positive or negative impact on female gender disparity. To begin with, participants in two schools pointed out

the importance of students being good role models to other students. The difference between the two schools was that, in one school, female students who were performing in mathematics and physical sciences were encouraged to be leaders and role models; whereas in the other school, it was thought a good idea but not practiced. In the other school, female students who were performing well in mathematics and physical sciences were strategically identified by administrators and counsellors, and their leadership was nurtured. The following quote illustrates this perspective:

I am pleased and proud of the leadership taken by young girls at this school ... young woman stepped forward as a role model, stood before assemblies, in a non-arrogant fashion, and simply held the torch up. And my suggestion would be quite simply that people in the position to influence young children, who are educators and counsellors, should take every opportunity they can to nurture the truly strong young women in the area of math and science, so that she will step forward as a role model for other children.

A 'girls-in-science' group was also strategically started, in order to introduce the concept of females in science. This program was considered essential, because the school administration recognized that girls had not been entertaining ideas of careers in science. The girls' peer group, by helping successful female students in mathematics and physical science to organize, was so successful that many times they had to relocate the group to larger rooms.

By the same token, other participants recognized that peers did not always present the right role modelling. Sometimes, quite the opposite occurred, and this was considered

not just bad role modelling but also bad behaviour. The following describes the type of bad role modelling that peers portrayed:

... the kind of ribbing that goes like this, *Oh yes, she is so smart, you know that she is taking Physics 12, Math 12, Chemistry 12?* And it is said with some admiration but there is a negative connotation as well.

The chief concern is that students, including both males and females who were not achieving, and the reference above was heard articulated by a female student, would bully and discourage the student who is trying to achieve.

Sixth, good role models were considered very important. At the core of good role models, regardless of an individual's gender, is their gender view. All members of a school, including parents, end up being role models. In schools that were not reducing female gender disparity, and which were not aware that females were not going into mathematics and physical science, have gender views. They do know what their gender views are, even if they do not declare them openly, or consider that perhaps the way they look at gender is the problem. When pushed for an answer in interviews, the response does come forward. Gender views are role modelled. Responses are not always what one wants to hear, especially when one wants to hear that gender equality is in practice and is a part of the belief system. The following gender biased quote stated by one participant emphasizes this point:

Girls and boys are not the same, they don't think the same way, they don't reason the same way. Now you say why? Biological perhaps, I don't know, there is a difference the way we look at things. Girls and boys are different.

Whoever speaks with a gender bias is actually role modelling inequality. Role modelling conceptual equality is equality when spoken. The following quote is an example of spoken conceptual equality:

... there are no boundaries in maths, physics, chemistry, and biology that are defined by gender. Similarly, I and other counsellors go into the career and placement classes and we actually do discussions on opportunity that isn't bounded by gender.

Clearly there are differences between the last two gender views in the last two quotes. The individuals who communicated these two different perspectives shared many things in common. They were about the same age, same gender, in schools with students of similar demographics. They were both certified teachers, both were counsellors, and were both involved in administration. Both were charming and pleasant-mannered people; however their gender views, and how they communicated gender, how they role modelled their views, were as night and day. One was a model of gender bias, while the other, a model of gender equality.

Seventh, visiting role models were considered important by most of the participants. There appeared to be a desire for the schools to connect with the world

outside of school, so that students could see and interact with someone who had an interesting career. The following illustrates this perspective:

It would make a difference if we had visiting female role model engineers to speak to all students, not just the girls, so that it is normal. Girls do not like to be segregated. They like normalcy....

Having a female role model who was performing in a non-traditional field was considered important for all students. Seeing a female role model engineer was as important for a male student as it was for a female student, because it created social acceptability of females to be engineers within the social community of all students.

To summarize role models and role modelling is to summarize the complexity of role modelling. Organized role modelling was part of the strategy to reduce female gender disparity, and the lack of organization in and of role modelling was part of the problem regarding the persistence of female gender disparity. Media role models were considered important because of the importance of media in students' lives. The teacher factor, in relation to attracting and teaching all students, was an area illuminated as part of the problem as well as the solution. Poor role modelling by teachers was perceived as a problem. In regard to peers and role modelling, role modelling could be either good or bad behaviour. Good role models were considered role models, not just how they looked, but what their belief system regarding gender was, and that they spoke in terms of equality. If, on the other hand, the belief system held by a role model was gender biased, then the role modelling by the individual, especially in regard to what they uttered, was poor role modelling. Visiting role models, those who role modelled females in non-

traditional professions, were considered important for both male and female students. A problem mentioned by most of the participants was that there was a clear lack of sufficient good role models and role modelling throughout the mathematics and physical science education system.

### *School Philosophy*

School philosophy, and specifically a philosophy of equality that was formal and part of the school doctrine, was considered fundamental in regard to practicing equality within a school. The philosophy of equality was only spoken about directly by two of the participants of one school, but was indirectly mentioned by a few other participants. There were seven main points in regard to school philosophy of equality, including: first, the philosophy of equality itself; second, equality strategies; third, the removal of boundaries; fourth, establishing equality of presence; fifth, knowing the history of female gender disparity; sixth, the role of the school; seventh, promoting equality and supporting females; and eighth, knowing what not having a philosophy of equality means.

First, the philosophy of equality itself means that gender determines which washroom a student uses, and not what subjects they may or may not be studied. Equality by gender means “gender barriers” are openly spoken against. Equality is evident throughout the school. Males and females are considered intellectual, political, social, and cultural equals.

In terms of the second point, the philosophy is the conceptual guide through which education is provided to all students. This concept does not exist without a focus of operation, and a denial of what is actually occurring in a school. For this reason, equality

strategies were communicated by two schools as being important in resolving female gender disparity. Part of the strategy is knowing the situation within which the school is providing an education.

The following quote emphasizes the link between the philosophy of equality and the strategies employed:

My comment would be that this approach, that is systemic, it is through the math teachers, it is through the counsellors in the CAP classes, we are all supporting the same philosophy, and I believe the children are picking that up, gender difference pretty much applies to the washroom you use and not the subject.

The philosophy of equality is the framework through which strategies to resolve female gender disparity are designed and implemented. The guarantee of equality, as stated in the Charter of Rights and Freedoms (1982) is not just a document with words stating persons have the guarantee of equal benefit theoretically, but are actually to have concrete equal benefit.

Third, the removal of gender boundaries was considered crucial. What this meant was that, in order to teach both male and female students, the artificial boundary between what was considered a male subject and what was considered a female subject was completely removed. This occurred in one of the schools where participants were interviewed.

One other school applied a different tactic, they did not completely remove the boundaries. The result was that they did not have the same kind of success as the other school that did remove the boundaries. The reduction in female gender disparity had

occurred, but over the past few years, the change had stalled. There were some areas that were still not considered male and female fields of study, such as structural engineering.

The following quote illustrates this point:

I am thinking of geological engineering, where it is, I guess the maths and physics is important, but not as structured as structural or mechanical engineering, or robotics, that tend to have more males. So there are opportunities in engineering that girls don't (think about), girls think of the typical jobs in the field of engineering, and say, *I don't want those*, but they do not think outside those typical things where they see people building things and structural engineering, and they don't think outside those things such as environmental engineering, for example, less traditional.

This quote clearly emphasizes a cognitive barrier dividing structural engineering as a male interest. The participant would speak to girls about the options in engineering, and the importance of taking physics, to keep options open, but did not break down the barrier between non-traditional engineering and traditional engineering.

Fourth, establishing equality of presence was considered important from a school that was changing towards gender parity in the physical sciences, as follows:

We do not reflect the provincial difference to the degree that the provincial figures show. We have more of an equality of presence and achievement by both male and female students. I have only theories as to why that may be so, but having been in the school for 15 years I am aware that there is a consistent and strong encouragement of both young women and young men, to be the best they can be.

Although this term sounds as though it is philosophical, it is actually equality in reality. The philosophy of equality is there, and the changes in the school towards actualizing gender parity means, in a concrete sense, that males and females actually experience equality in the presence of each other.

Fifth, knowing the history of female gender disparity was considered important in response to why there is a female gender disparity today in mathematics and physical sciences. The changes that have been observed in the political, social, and legal aspects of society and equality, have a history. Changes in the role of women, and therefore girls, as well as men and boys, has occurred, and people need to know this history so that they can understand what role education plays in the lives of boys and girls. Girls are no longer educated so that they may live a life of domesticity. There is no option to not educate females or an area of education that is not available to females. The following quote illustrates the importance of educating females equally and not robbing them of that opportunity:

How do we know what we have deprived her of and in the broader level, what we have deprived the Canadian society. It's a lost opportunity. Like I said in the conversation earlier, it is like finding a precious metal and not polishing it, just leaving it as a rough piece of rock.

It is not just about keeping options open, it is about exercising a right to an equal development as a human being.

Sixth, the role of the school is fundamental in regard to ensuring the rights of all students, that they benefit equally from their education, and that equality is practiced.

This evidence was presented by a participant who was exercising that role through his leadership position within the school, as follows:

I am frequently making aware to young people, and even their families, because sometimes gender bias is a reflection of another age, perhaps the traditional fifties when the good wife was in the kitchen or doing secretarial duties, if she went to work. It may not solely be the role of the school....

The quote above came from an individual within a school that had a formal policy of equality, and had recognized many years ago that the school played a role in practicing equality.

Seventh, promoting equality and supporting females through encouragement goes hand in hand. This was best communicated in the following quote:

If a young woman is ever so subtly guided in the area of study and possible future career which isn't going to allow her to be the best she can be, surely she loses, and society. Metaphorically, we may have had gold, and we left it as a rough chunk of earth. Perhaps a very happy chunk of earth, when she should could have been shiny gold. And my comment on the provincial statistics is that any encouragement that is missing is contrary to good educational practice. I simply believe it is encouragement that is required, and frequent.

Equality, if it is to be equality, applies to every aspect of the school. It is about breaking the barriers for males as well as females. It is also about supporting females in areas where they have been participating in poor numbers. Encouraging all students

equally means that wherever there is a minority by a particular gender, those who are in the minority will show a greater increase in participation if encouragement is applied equally in a school within the subjects of mathematics and physical science, as described in the following quote:

One of the big factors is a strong conscious effort, on the part of the school, to make all academic areas, including the science and mathematics, as attractive to all students as possible. Caught in that net, we might be picking up more females than males. But we have made a conscious effort to encourage them in supporting them in taking those subjects, rather than, in discouraging them.

When encouragement to participate is applied to all students, without gender bias, a change towards gender parity is observed. The section on role modelling has described this support in some detail, but the support is more than role modelling. The support is also in teaching the perspective that there are no boundaries by gender, and that there are no intellectual or physical barriers to complete participation. The evidence was presented by one participant in the following quote:

Gender barrier is openly spoken against. In mathematics classrooms you will find posters about opportunities for females. We have a very strong women's group in the school that advocates the philosophy that there are no boundaries in maths, physics, chemistry, and biology that are defined by gender. Similarly, I and other counsellors go into the career and placement classes and we actually do discussions on opportunity that isn't bounded by gender. My comment would be that this approach, that is systemic, it is through the math teachers, it is through

the departments, it is within the philosophy of the school and it is through the counsellors in the CAP classes, we are all supporting the same philosophy, and I believe the children are picking that up

As described in this quote, practicing equality is organized within the school itself. The organized practicing of equality is the support that is more than just role modelling. The actual practice of equality is performed by all members of the school.

### *The Perception of Mathematics and Physical Sciences*

This theme is very similar to gender views, except that the focus is on gender bias as it is interpreted in regard to females, and the attribution of gender in regard to mathematics and the physical sciences. Male, in gender bias, is identified innately with mathematics and physical science. The work associated with the subjects that have been identified as male is also linked to innateness of gender. The gender focus of the subjects is a bias against females. A boundary is created through the concept of male innateness that reinforces inequality in practice. The practice of associating the subject with the male gender and the exclusion of females is evident, first, through the association; second, through stereotyping; third, through embellishing the science with false properties that detract females; fourth, considering material itself male; and finally, by linking gender, through subjects, directly to careers.

First, the association of a subject as either being male or being female is the framework through which gender inequality is justified and practiced. The following

quote illustrates the association of the female gender with subject of biology and the male gender with chemistry and physics:

I think biology is popular because it deals with living things and I think there is still those inherent notions of woman as the care-giver and they care about living things so they are more attracted to that than they are chemicals as such or physics as dealing with levers and fulcrums.

By reinforcing the idea of “woman as the care-giver,” the role of woman as the one who cares for the living, and as domestic, is considered innate. The innateness of the female is automatically linked to the subject of the study of the living. Innateness, attraction, and subject become associated by virtue of the observation that there is a female gender disparity in mathematics and physical sciences, but there is no gender disparity in biology. The subjects that are not naturally considered living are stated as encompassing elements that are considered to be naturally male. In being considered male, males therefore are more attracted. The association of subject by gender is a gender biased view of the subject for the justification of inequality.

Second, the idea of the association of subject with gender is taken one step farther through gender stereotyping. Gender stereotyping the subjects, and the type of study leading from those subjects, is presented with attributes that, again, are presented with a false association of attraction and innateness of gender. The following quote emphasizes this point:

Science is a cold thing, is generally lonely, not social, and I think for a lot of young women, they enjoy the social, their friends and doing things together and

being in courses that kind of promote that kind of opportunity, they are attracted to. Some of the courses are heavily laden with content, and so there is less active learning, less interaction, and they do labs, and they enjoy labs, but I think other courses are more popular because there are more opportunities for them to have more control over the subject matter and how it is explored.

It is clear that there is a gender bias against females along with a bias against science. The notion that females are unable to control the subject, and that science is considered inherently linked to males, presents a view of mathematics and physical science as being something that females can not feel a part of, due to a perception of emotional coldness, and furthermore, cannot control. The following quote further describes the association of a notion of gender and the subject studied:

Biology requires the memorization of a lot of material, whereas physics is cumulative. Physics deals with core learning. Physics is more for careers such as engineering, whereas biology lends itself to careers such as nursing. Physics is more for the applied sciences.

This also presents the third point, that of embellishing the science with false properties and female powerlessness, by separating females from studies that are considered non-human, by virtue of these false gender properties. These false properties are stated to automatically detract females. In some instances, the false properties are animated. Incidentally, attributing “queen mother” to a subject, denotes great difficulty, and not an association with female, as illustrated in the following quote:

Physics is considered the queen mother of the sciences. Whether it is because it is harder, I do not know....Chemistry is a bit more human but physics is the queen mother. Perhaps it is because it might take longer to study than chemistry.

Fourth, by considering material itself male, females are set outside an artificial boundary, because they are not males. Concepts associated with male include “core learning,” and “technical” abilities, and “structure,” and furthermore, “computers” as male, and anything computerized, as excluding females. Males are considered equal to the intellectual challenge, and females too sensitive, too needing female company and people “like” them, to be able to study and work in mathematics and physical sciences. This is a gender bias.

Finally, by linking gender, through subjects, directly to careers, females are pushed out of the education that would lead to careers proceeding from mathematics and physical sciences. The linking of gender to the subject and to careers, by cognitively restricting females from these subjects, the onus of actual investment into making improvements, by providing resources, both human and otherwise, is completely undermined. The following quote illustrates the female as being innately uncomfortable with material resources:

I think that is a factor for girls because they are not as technically literate, they are not as technically comfortable with technology as the boys, and it might be just because boys are playing more computer games, and all this kind of stuff, and girls are doing different things. When they arrive at school, the boys continue on, because it is huge, we have financially invested in it....

The gender bias is evident in the aforementioned quote. If a person, by virtue of their gender, is told that, according to their gender, they will not be comfortable with performing a task, that the other gender does it better, does it more, and has been invested in that regard, much more than their gender, then how are they going to perceive themselves positively when working such material. How might that make the person feel? Are the genders being valued equally in such a circumstances? These questions are deliberately obvious for a reason.

The association with being male and “having an edge” on material resources and being females as being considered ‘clueless’ is very clear in the following quote:

A lot of the sciences, there is a component of computer science knowledge, that is pretty important and I think that the guys have the edge on that....And so many of the guys, there was an affinity, because when I started CAP, we really tried to get the girls to become computer literate, and the number of girls who just did not have a clue, and just about every guy knew his way around the computer, but the girls just had no idea.

This association of male gender with a natural pre-disposition to mathematics and physical sciences was also described by a participant as being connected to certain pleasure in fear of material and pleasure in the power in material, as follows:

Physics is, I think it is mysterious to some people, where it is a game, for the boys, some of the problems and the experiments, such as, how much stress will this bridge take? It is like a challenge or a contest so there is much more competition and I do not think the girls are attracted to competing, and I am

generalizing, I do not think this is not what they are looking for, like the boys, who want bigger, better, faster, stronger, type of thing, whereas physics, there is the possibility of the explosion, and the power of force and the power of chemical reaction, and with girls, it is not the same value, they do not value it the same way. They do not hold it in the same regard, whereas in biology, fish, animals, plants, life, they are more predisposed to their interest.

The association of males seeing mathematics and physical science as pleasure in fear, and associating this fear of matter and fear of power, that females are not able to cope with power, energy, and reaction, is a gender biased lie that creates an illusion of female weakness, physical weakness, emotional weakness, and intellectual weakness and inferiority. The perception of mathematics and physical science as male is a gender biased view that supports the exclusion of females from the study and therefore careers progressing from these subjects. There is no such thing as gender in mathematics and physical science. The view of matter, as male, is a confabulation. Matter and energy has no such gender properties. Life is no more female than it is male.

A gender equal perspective does not create false boundaries by gender. A school philosophy of equality does not assume female gender inferiority. There is no necessity to accommodate by gender, but rather a necessity to apply equality. An application of gender equality in school means seeing and knowing what all students can learn to do without applying false gender biased assumptions.

### *Summary*

Gender view, in terms of female gender disparities in mathematics and physical sciences, is a matter of gender bias. Gender bias is a matter of whether males and females are believed to be equals. Believing males and females are equals depends on which philosophy a person has, whether one of equality or non-equality. If a school does not support the belief that males and females are equals, then they will view female gender disparity as natural and not a problem, when it is actually a failure to educate males and females equally.

Role modelling is the foremost means by which a school may reduce female gender disparity. It is also the means by which female gender disparity is produced, from modelling the gender views to stating gender inequalities, and considering the accommodation of females as a lowering of standards. The difference between whether female gender disparity remains a problem or is resolved depends on the role modelling that is being portrayed by all members of the school. Good role models who model gender equality are crucial in implementing change.

School philosophy, in particular, the philosophy of equality, was implicated in resolving female gender disparity; at the same time, the philosophy and belief system in inequality and gender bias was implicated in not resolving female gender disparity in mathematics and physical sciences. In order for the school to resolve female gender disparity, all the members of the school had to embrace the philosophy of gender equality. This philosophy of equality was then applicable to every corner of the school, and crucial in resolving female gender disparity, and providing a framework through which many strategies to reduce could be designed and implemented.

The perception of mathematics and physical science as male is connected directly to the philosophy and belief that there are innate aspects of mathematics and physical science that are male. By attributing an innateness of the subjects studied as male, a boundary is created, wherein females are excluded. The attribution of innateness of female as being more inclined to study living things reinforces females as care-giver, as domestic, and as not having the intellectual or physical abilities necessary to study matter and energy, control power, and be comfortable with material. The view that female gender disparity in the subjects of mathematics and physical science is a natural occurrence removes the responsibility of educators to address the situation, through justification that the situation is normal and beyond their influence. Males are also attributed to experiencing pleasure in the study of mathematics and physical sciences, something females are excluded from in the view of innateness. Furthermore, by creating a natural justification for female gender disparity, the perception of mathematics and physical sciences as male, also fixes blame for the disparity onto females themselves, by not being male in the first place.

And, the view that the female gender cannot study mathematics and physical science due to biology and innateness pushes females away from studying these subjects, through this exclusion. Because they are discouraged, they leave the subjects, and therefore lose an opportunity to study these subjects and participate in careers leading from these areas.

The proceeding Chapter V contains the discussion, conclusion to the discussion, and the recommendation sections. The discussion relates the findings on the major themes back to the professional literature, in regard to what is already known about

female gender disparity in mathematics and physical science. The recommendations are those of the participants.

## CHAPTER V

### Discussion

#### *Introduction to Discussion*

The data from the interviews were presented comprehensively in Chapter IV and represent the awareness and perceptions of participants on female gender disparity in physical science and mathematics and career choices, as well as the participants' combined recommendations. This final Chapter is a discussion of the findings. Interpretation and conclusion are based on these findings, which have led to their recommendations. The Chapter is arranged according to the four themes that emerged during the analysis of the data including: gender views, role modelling, school philosophy, the perception of mathematics and physical sciences.

The discussion will relate the literature reviewed in Chapter II to the findings that were presented in Chapter IV.

#### *Gender Views*

Gender bias against females has been considered an historical issue (SCWIST, 1983). It is also known that, because of discouragement, females have dropped out of programs (Hicks, 1991). The professional counsellor position is that gender bias is the product of a belief system, and that the application of gender bias is detrimental to students (Gold & Hawley, 2001). We also know that both male and female counsellors have been found to have gender bias when it comes to females entering male fields (McCormick, 1990). The same issues regarding gender bias and gender views were not

found in the review of literature in relation to administrators because no literature was found regarding their view of females in mathematics and physical science or male fields. The closest literature in regard to the view of administrators and female gender disparity in mathematics and physical science was the reference to administrators and their responsibility (Mewborn, 1999).

Given this knowledge, it is no surprise then to have interviewed ten participants, five principals and five counsellors, and found a prevailing gender view of gender bias in regard to female gender disparity in mathematics and physical science. Furthermore, the finding of lack of awareness amongst administrators in this study about their gender biases, and their lack of awareness in regard to ensuring that the issue in their schools was addressed, and the lack of knowledge regarding the actual equality of males and females, as perceived by administrators, explained in part why female gender disparity persists in mathematics, science, and career choices.

### *Role Modelling*

Role modelling was a major theme and participants discussed role modelling as an issue for girls in the study of mathematics and physical science. Role modelling was perceived in seven different ways as shown in Chapter IV, including: organized role modelling, media and role models, the teacher factor, poor role modelling, peers and role modelling, good role models, and visiting role models.

The main problem identified was the lack of good role models. There was no literature found in relation to role models in regard to all constituents in the school. The closest the professional literature came to dealing with the problem of insufficient good

role models was about removing girls from classes so that they could finally study mathematics and physical science without distraction (Kruze, 1992). This is unrealistic in a world where females are not segregated and should not be segregated.

There are also organizations, such as WISE, that have been created in order to address problems females face while studying mathematics and physical sciences, and entering fields leading from these subjects, but no professional literature was found that addressed the issue of good role modelling and the entire school, as well as the community.

Gender equality means males and females are equal, and the role of a teacher, regardless of gender, is to teach male and female students. This means that every teacher is a role model, every peer is a role model, every parent is a role model, every counsellor is a role model, and every administrator is a role model. It is one thing to state that there are not enough female role models in mathematics and physical science, but quite another to claim there are none.

Without a doubt, more female teachers and visiting female engineers are necessary, but what this perspective does is place the entire responsibility of half the population on those who are in the minority in these subject areas, and where there is a problem of general gender bias. It is gender biased to suggest that when there are more females that the problem will resolve itself. This logic is flawed. Males and females are equals, therefore the male educator is a role model for both males and females. The question becomes not if they are role models, but whether they will view themselves as equals with an equal necessity to provide equal leadership in education that is non biased

for all male and female students. The same applies equally to female educators as role models.

The quality of being a good role model includes debunking gender bias and gender stereotypes regardless of the individual's gender. This was strongly described by a participant in the following quote:

One thing I say over and over again, because I get girls who will not choose physics, that they don't like that and I say, as long as you realize that you are cutting out, and I will often open up a University calendar, and say, *look at the things you will cut out if you do not have Physics 12....*But, astronomy, engineering, to major in biology at university, one needs at least Physics 11. There are lots of things that require physics....

Seeing males and females as equals means also acknowledging what is known about people and what they may not know, which includes passing on the knowledge that there is no physical or intellectual inequality between males and females, and that therefore if equality is being viewed, the result will be a balance of numbers of males and females in educational positions within all areas of education. What must be addressed is the issue of good role modelling in every aspect of the school. The important role of leadership is to ensure that the current role models know what gender bias is and what gender equality is so they may perform as the role models necessary to practice gender equality in mathematics and physical science, as portrayed in the aforementioned quote.

### *School Philosophy*

A school's philosophy of equality was stated by the participants as fundamental for the resolve of female gender disparity. There was no literature regarding a philosophy of equality in relation to a school's philosophy of equality and female gender disparity in mathematics and physical sciences. There has been, however, the Charter of Rights and Freedoms (1982) on *Equality Rights*, which states:

3. Every individual is equal before and under the law and has the right to the equal protection and equal benefit of the law without discrimination and, in particular, without discrimination based on race, national or ethnic origin, colour, religion, sex, age or mental or physical disability. (Part II, Section 15)

This is the legal basis for equality in Canada. Within this framework is the principle that all individuals are equal, that each of us has the right to equality, to have protection and equal benefit.

In Canada, males and females are to have the same benefits. Included in these benefits is an education. There are no legal boundaries regarding education, therefore school philosophy should reflect equality, and therefore school practice should reflect no boundaries to study by gender.

The findings demonstrate that the archaic gender biases may still exist. School philosophy was stated by the school that was reducing female gender disparity as the belief in equality that went from the concept of equality itself, through to every single student. School philosophy of equality, therefore, is imperative in the conceptualization

of equality, for the implementation of the rights of students, to access equal benefit of education in mathematics and physical sciences.

*The Perception of Mathematics and Physical Sciences*

The view that mathematics and physical sciences are male was a part of the gender bias of most of the participants. The linking of the male gender with mathematics, physics, and chemistry, was open. The review of literature covered many topics, and gender stereotyping of subjects, such as the dividing of fields into a male field or a female field (Wilson, 1991, p. 3–4). This stereotyping, that links the innate ideas of males and females as bounded in different fields, such as the field of mathematics and physical science as male, has been considered an area in which all state parties of the United Nations, Part III, Article 10 of the *Convention on the Elimination of all forms of Discrimination Against Women*, (1979) should eliminate, as stated in the following:

States Parties shall take all appropriate measures to eliminate discrimination against women in order to ensure to them equal rights with men in the field of education and in particular to ensure, on a basis of equality of men and women.

Section 15, p. 1)

The perception of mathematics and physical sciences as being male is a stereotype that is discriminatory to females. The effects of stereotyping have been known for some time, and yet according to the findings in this investigation, the view that mathematics and physical sciences are male persists. The aforementioned quote does not specifically break down each and every area of education, but does state as referenced above “and in

particular to ensure, on the basis of equality of men and women,” meaning the fundamental principle herein is gender equality. The reference, “in particular” means that males and females, as equals, is the standard.

The school that had strategies for change and a philosophy of equality was working on establishing an “equality of presence.” An equality of presence, in regard to how mathematics and physical science are viewed, is necessary for achieving resolve of female gender disparity in these subjects. There is an obvious necessity for an acknowledgement within schools not practicing equality to acknowledge that stereotyping of men and women is wrong (Holbrook, 1992, p. 313), and that the linking of materials and technology with male gender (Clegg, 2001) is false. There simply is no such thing as male mathematics and male physical science, the same as there is no such thing as female mathematics and female physical science.

The findings of stereotyping and the viewing of mathematics and physical science as male are consistent with historical findings where other subjects have been viewed exclusive according to gender (Phillips, 1990). Furthermore, educators with gender bias may interpret on the basis of their biased belief system, that females need to be taught mathematics and physical science differently. If females are gender biased and thought of as different, then they may be taught through the gender bias and therefore differently. These preconceptions may explain why Boaler (2002) perceived females performing mathematics differently than their male peers.

This may occur in the similar way that gender bias has been found to influence counsellors' counselling of males and females, as in the improper limitation of life options (Gold & Hawley, 2001). What this may mean is that educators may also limit the

ways in which they teach male and female students, thus conditioning males and females differently, and therefore treating males and females unequally. This may lead to different learning styles by gender, different choices, different ways of looking at and interpreting material. It may even lead to the necessity, in some situations, to make special accommodations in order to address the results of unequal practices. Boaler (2002) found females in one study were taught without deep understanding, whereas boys were conditioned to problem solve. That this was not substantiated in the study by Mason (2003) may be explained by considering the gender biases that may have been employed in the various contexts. This explanation further illuminates other contradictions in the professional literature and gaps in knowledge.

Enman and Lupart (2000) found that females experienced negative dissonance and dropped out of advanced fields of science. Although they knew that the world views of females had changed, and that they had experienced negative dissonance, there was no explanation given, beyond blaming the prior education system and the females themselves, for leaving these fields. Nothing was mentioned about how they were being taught in their field, or what the gender views were of the people they were learning both from and with, or whether there was an interpretation of their field as male. The study was performed with females as the focus as though no one else within their field or environment existed.

Although Enman and Lupart did not implicate a possibility of gender bias in regard to the view of the subject studied and cognitive restrictions through views of mathematics and physical science as male, and therefore false boundaries, studies of counsellors have linked the issue of gender bias and counselling in relation to the counsel

of students. According to McCormick (1990), both male and female counsellors' had equal gender bias against females in mathematics and physical sciences, specifically in regard to females in male fields. These findings of gender bias were consistent with the gender views of the participants as well as their perceptions of mathematics and physical sciences. Whereas counsellor bias has received attention in regard to gender bias, the other constituents in schools, including administrators, appear to have not received the same kind of attention.

Since it is professionally necessary to not be gender biased and to therefore practice equality in reference to the counselled students, it is reasonable to accept that it is also professionally necessary to acknowledge that it is unprofessional to view mathematics and physical sciences as male. The view that mathematics and physical sciences are male is a false perception that arbitrarily divides females from the pursuit of intellectual development in mathematics and physical science.

### *Conclusion of the Study*

This study has been an investigation to discover what the perceptions of principals and counsellors are on female gender disparity in mathematics and physical sciences. The purpose of this study was to investigate the perceptions of principals and counsellors on female gender disparity in high school physical science, mathematics, and career choices. The lack of good role modelling, school philosophy, gender views, and the perceptions of mathematics and physical sciences were the four major themes that emerged in the analysis.

Role modelling by all constituents in a school, in terms of good role modelling, as well as the lack of role modelling, and poor role modelling, was implicated in female gender disparity in mathematics and physical sciences. A school's philosophy of equality was found to be central in resolving female gender disparity in these subjects, and the lack of a philosophy of equality, or a philosophy of inequality, was found in schools that were not resolving female gender disparity. Gender views, specifically in regard to how males and females were viewed, whether as equals or as unequal, was also implicated in whether educators were aware of female gender disparity in mathematics and physical science, had strategies to resolve the issue, and whether there was any success. The gender view that males and females have innate qualities, and that males and females require completely different teaching methods, was a gender biased view held by most of the participants. The gender view that males and females are equal, as substantiated in the literature, was implicated in resolving female gender disparities in mathematics and physical science.

### *Recommendations*

The intent herein is to provide recommendations for resolving female gender disparity in mathematics and physical science, as communicated by the participants. Female gender disparity in mathematics and physical science was identified as a problem for females in terms of losses in opportunities for employment and contribution to society, but was also considered a problem in terms of losses in opportunities for equality of intellectual development in these subjects. The findings indicated a need, which cannot be overstated, for professional development. Furthermore, there was a need for

knowledge on female gender disparity in mathematics and physical sciences, as well as a need for finding strategies for dealing with the issues and how to view gender in terms of equality. The following are the recommendations of the principals and counsellors who participated in this study.

Clearly the philosophy of a school, to support equality, permit equality, and facilitate equality, is essential for reducing female gender disparity. The important message conveyed by some of the participants was that a school could change towards gender parity if there was a philosophy based on a belief in equality, and if that philosophy was put into practice in all areas of the school. The philosophy was a framework for seeing the possibilities for change. For change to happen it was communicated that there must be a unified will amongst all constituents, led by the educators. In order for a school to change and reduce female gender disparity, the teachers must believe that change in female gender disparity can happen, must envision how it can happen, and must actively engage in making that equality happen.

Although not every school was having success at implementing change, almost all of the participants had recommendations for resolving female gender disparity. First, and perhaps foremost, the gender views of the people in the school are what mirror the school philosophy of equality in practice. Equality in school practice means role modelling and this includes everyone. This is evident in the following quote:

My comment would be that this approach, that is systemic, it is through the math teachers, it is through the departments, it is within the philosophy of the school and it is through the counselors in the CAP classes, we are all supporting the same

philosophy, and I believe the children are picking that up, gender difference pretty much applies to the washroom you use and not to the subject.

The evidence above was also presented again, yet in a different way, in the following quote:

I mean that is the intent, to have a one-one ratio in terms of gender balance, because that would suggest that the curriculum itself, the external factors from society and the teaching factors are all the same for males and females. By all the same, I mean, it meets the needs of males and females, and it is not biased or skewed towards the aptitudes or the attitudes of one or the other.

What this communicates is that support for equality has to be throughout a school's community, from both within the school itself, and from the external community. If, on the other hand, the gender views are gender biased, little change occurs, as evident in the following quote:

The provincial data is very similar at our school in that it has not changed very much over time. I feel that this is what you will have seen going back many years. There are more females in chemistry as it is required for nursing. The females take this course because they think they might need it later on. And for dental hygiene.

There is an assumption communicated in the aforementioned quote that particular careers are specifically for females, such as nursing or dental hygiene. There are assumptions

about what girls think, what careers are for females, and what girls need to take at school. Gender bias was clearly understood to be a problem and that change towards equality simply had not happened.

The recommendations of the participants are presented in concrete terms with sub-headings, starting with what may be done within school, such as, encouragement, knowing how to change and developing strategy, knowing what female gender disparity is, gender audit, professional development, advice to students, assuming responsibility, achieving balance, making science attractive to all students, news media, and seeking professional development.

*Encouragement.*

Encouragement was stated as necessary. Not only for one special student or every now and then, but repeatedly for all students. The following quote emphasizes this recommendation from a participant in a school that had employed a multi-faceted approach, who stated “I am aware that there is a consistent and strong encouragement of both young women and young men, to be the best they can be.” Equality pervades the encouragement. Another participant stated: “... any encouragement that is missing is contrary to good educational practice. I simply believe it is encouragement that is required, and frequent.” Encouragement was considered to be so crucial due to the pervasive discouragement to participate equally inherent in the practice of gender bias.

Individuals pursuing subjects where there is a history of gender bias along with current poor participation simply need more encouragement. If students do not get support and encouragement, they may be overwhelmed by the negative messages uttered by individuals who are gender biased. Without ongoing encouragement and support,

these messages may be internalized. The following quote communicates this concern regarding encouragement, as follows:

It makes a huge difference, keeps all of the doors open. Not only does it keep the doors open for careers for these students, it keeps their minds open, they do not have a mindset, *I am a girl, I don't do this, or he is a boy so he does that. I am a student, so therefore I have these opportunities and this is my potential....*

Provincially, I think you run the risk of having students feel that they are stereotyped. Not only that but they have internalized being stereotyped. They have internalized it and indeed they accept that as their role, and I think that that is wrong....

Even many of the participants who professed to support equality in the education of girls and boys also expressed belief systems that were gender biased. Encouragement is necessary in order to not only undo the negative effects of gender bias, but furthermore to combat any gender biased messages amongst educators. If encouragement is non-existent, and a message of gender bias against girls prevails in mathematics and physical science, boys will not be the ones who will be discouraged. Under such a circumstance, girls will be discouraged, and low participation by girls will be the result. Because the school cannot control for all the gender biases within the community at large, all members of the internal school community must be engaged in encouraging all students, so that no one student fails to benefit from an education.

*Gender audit.*

A within-school gender audit in mathematics and physical science is vital for every school to perform. Without a gender audit, the situation of female gender disparity cannot begin to be known. A gender audit is both quantitative and qualitative. In relation to female gender disparity in mathematics and physical sciences, it is important to know in-depth details, such as how many courses are being taken, and not just the sum total of all students studying subjects in general. Just because a school has an equal number of males and females in the total school student population does not mean that they do not have a gender disparity in mathematics, in the different mathematics courses taught, or in the physical sciences.

The need for the gender audit is important because of the change in population of students that occurs naturally over time. Furthermore, if an administrator does not know there is a poor participation rate by females in mathematics and physical science, or is unconcerned, he or she may not address the issue. Each course, as well as each student, and the number of courses each student takes in mathematics and science, is very important in knowing and describing what students are studying. Not knowing the trends in the school also means an administrator is out of touch with the school, as evident in the following quote:

I have no idea....What careers people are choosing in their lives? In terms of degrees, and why three males to every female in mathematics, I have no idea why that would be....And I wonder about the social, that people may make to pursue a family. To proceed to advanced degrees, and then to a career. Females may feel that they are not willing to make that sacrifice.

Performing the gender audit also means thinking about the school, and therefore initiating dialogue when there is an imbalance, to gather the information necessary and disseminate the right message, to ensure all students have an opportunity to an education that is not gender biased.

*Knowing history of female gender disparity.*

By knowing the history of female gender disparity, and the changes that have occurred within Western society, and the incorrect assumptions regarding female intellectual ability, educators may better inform school constituents regarding the inappropriateness of gender bias. Knowing the history of female gender disparity, especially in relation to what transpired up until and including the *Canadian Charter of Rights and Freedoms (1982)* and thereafter, means that educators may educate both the school's population regarding what is available for study and careers for both males and females, but also their families, as depicted in the following quote:

I am frequently making aware, to young people, and even their families, because sometimes gender bias is a reflection of another age, perhaps the traditional fifties when the good wife was in the kitchen or doing secretarial duties, if she went to work.

Knowing the history of female gender disparity means that educators may know when an utterance of gender bias requires correcting, and therefore gives them the background information they need to challenge, resolve, and remedy situations where gender bias has been uttered.

*Knowing how to change and the use of strategies.*

School participants in the school that was implementing change towards gender parity began with the concept of gender equality. The school philosophy embraced gender equality. Through the gender audit, it became known that there was a problem of poor participation of females in mathematics and physical science, and strategies, such as gender committees, girls-in-science group, in-class speaking, addressing the entire school, including parents in on the information, parents' advice in relation to study options available to all students, counselling students in class and with one-on-one counseling, were implemented. Strategies were not gender biased. Role modelling, as stated in the sub-section on role modelling, was incorporated in the strategies.

Participants in schools that were advancing the state of equality and reducing female gender disparity in mathematics and physical science used strategies in all areas of the school, as stated "it is through the math teachers, it is through the departments, it is within the philosophy of the school and it is through the counselors in the CAP classes." Participants in schools that were not applying strategies to reduce female gender disparity in mathematics and physical science in their school often stated that the issue would resolve only if there were more role models. Although the need for more role models was identified, as well as the need for change, and agreeing that there was a real problem of female gender disparity in mathematics and physical science, the lack of knowledge regarding strategies and knowing how to change the school and how to use strategies meant that the problem was not resolved. The following quote best describes this need for knowing not merely that change needs to occur but also the need to know how to actually implement strategies, often strategies that are already known and reduce gender disparity:

It would make a difference if we had visiting female role model engineers to speak to all students, not just the girls, so that it is normal. Girls do not like to be segregated. They like normalcy....I think it would make a difference if the grade 12 students went to speak to the younger grades to talk to them about their selection. The clubs do not get involved but it would be good to have both male and female role models speak about going into chemistry, biology and physics.... There is no women's group at the school. There used to be but the group lost interest.

Knowing how to implement strategies furthermore meant having an administrative committee within the school, as evident in one of the schools undergoing change towards gender parity, as portrayed in the following quote:

Gender barrier is openly spoken against. In mathematics classrooms you will find posters about opportunities for females. We have a very strong women's group in the school that advocates the philosophy that there are no boundaries in maths, physics, chemistry, and biology that are defined by gender. Similarly, I and other counsellors go into the career and placement classes and we actually do discussions on opportunity that isn't bounded by gender.

Although the women's committee, known above as the women's group, was very important, and also part of the school's strategy to resolve female gender disparity in mathematics and physical science, the application of strategies throughout the school was fundamental for change to occur.

*Advice to students.*

In regard to female gender disparity and counselling, it was clear that those in positions to directly influence students must be aware of their own belief systems, and of being part of the resolve of female gender disparity. The challenge to know comes first; to challenge personal gender biases, and then consider advice to students because the advice is provided through individuals to the students, as evident in this quote:

...it is through the math teachers, it is through the departments, it is within the philosophy of the school and it is through the counselors in the CAP classes, we are all supporting the same philosophy, and I believe the children are picking that up, gender difference pretty much applies to the washroom you use and not to the subject.

Advice to students, within a framework of equality, should be to all students, and encouraging students to not accept false boundaries by gender and to consider all life options, so they may find out what they can do, and develop intellectually. Good advice does not impose gender bias, and as portrayed in the aforementioned quote, is therefore the same for boys and girls.

*Assuming responsibility.*

The responsibility to address female gender disparity within a school is part of the role of the school. Not addressing female gender disparity, and not providing a complete education to all students, was equated to inconsiderately permitting someone to continue through their education without receiving equal benefit. The following quote illustrates this recommendation to assume responsibility:

If a young woman is ever so subtly guided in the area of study and possible future career which isn't going to allow her to be the best she can be, surely she loses, and society. Metaphorically, we may have had gold, and we left it as a rough chunk of earth. Perhaps a very happy chunk of earth, when she should could have been shiny gold.

Assuming responsibility for gender equality at the school level is critical because, if the responsibility is not assumed at the school level, the implied social structure authorized in the Charter of Rights and freedoms (1982) will not be practiced.

*Achieving balance.*

Many participants believed balance was necessary. Implementing gender equality in school is clearly implementing balance. Resolving gender bias by achieving gender equality is the actualization of balance. The following quote describes the belief for equality as stated in the following quote that emphasizes how balance is achieved, "We work as a staff, for a balance." The balance in relation to having an increased participation rate of females towards gender parity was also attributed in another school, to having a balance of gender on staff as follows, "the only thing I can think of is that we have a balance on teaching staff in those areas." In the school that was implementing change towards gender parity, the following statement was made regarding balance:

I mean that is the intent, to have a one-one ratio in terms of gender balance, because that would suggest that the curriculum itself, the external factors from society and the teaching factors are all the same for males and females.

A gender balance is therefore something a school must achieve in order to resolve female gender disparity in mathematics and physical science.

*Making science attractive to all students.*

The challenge of inspiring all minds to develop intellectually in mathematics and physical science is no different from inspiring all minds. The key to addressing female gender disparity in mathematics and physical science is to consider the academic needs of all students. Critical is the recognition and acknowledgement that there is no such thing as female intellectual inferiority and that mathematics and physical science are not bounded by the male gender, as described in the following quote:

....there are no boundaries in maths, physics, chemistry, and biology that are defined by gender. Similarly, I and other counsellors go into the career and placement classes and we actually do discussions on opportunity that isn't bounded by gender.

An aspect of the academic needs of students in a situation where there is a female gender disparity in mathematics and physical science is recognizing the power of girls' groups in communicating the message that females are equally capable of performing mathematics and physical science, and that there are attractive careers leading from these subjects, as stated in the following quote:

The young women's group I have talked about is called [name ethically withheld] openly generated by the students. It became huge, they could hardly fit into the classroom a bunch of times.

The girls became attracted to careers in science and mathematics and, through increasing numbers of females in mathematics and physical science, began a group that provided girls with their own mechanism for addressing female gender disparity in mathematics and physical science. This group formed in the school that was undergoing change towards gender parity, and with the support of staff within the school.

*News and television media.*

A few of participants shared the view that providing local news media with articles, displaying information about programs, and highlighting role models as a part of the role of the school to influence beyond the school, was a positive strategy. For one, it was considered an excellent method for normalizing gender equality within the community as depicted in the following quote:

Local papers periodically struggle for material, and it may well be a potential for leadership by the counsellors in the district or even department heads to provide success stories as a small feature article to a local paper, thus providing the elevation for any gender success in the community.

Furthermore, media articles were also considered important to the individuals who were covered in the articles, especially when the material covered was encouraging, recognizing role modelling leadership and normalizing girls in the fields of physical science and mathematics, as depicted in the following:

Our kids are media savvy and they see a lot of movies where they have role models and I think having a female role model engineer would make a difference.

Furthermore, media articles provide a logical mechanism for reaching families in regard to the practice of gender equality, before and while their children attend the school.

*Seeking professional development.*

Most of the participants who were not involved in any strategies to create equality within their schools communicated frustration regarding the persistence of female gender disparity. There have been no established best practices, and no one has gone into the schools to help with analysis, or to assist with understanding gender equality, as opposed to gender bias, and to work on leadership development as communicated in the following quote:

Nobody came in, as they have done, to do teacher training workshops, on bullying, nobody came in for gender equity. This is a very interesting question, and I would think that it was more of a grass roots thing by the young educators, and I would be cautious with my words, but there were some senior science teachers who were reflecting some surprise and amusement that more and more girls were going into their classes. They have retired. They are retiring, and again, it may well reflect the broader society, there is undeniably been a movement for gender equality. At the ministry of education, there are documents that we are obligated to present our material in a gender neutral manner, and those documents exist....

There was also an appearance of an absence of the advocacy of gender equality by some of the senior science teachers, as stated in the aforementioned quote. Without

professional development within the schools, change was left to the grass roots even though there is a known obligation that education be presented as gender neutral.

The need for professional development was evident in many of the responses made by the participants, not just in understanding the issue, but also how to talk about the issue without being gender biased. Many of the participants appeared to experience difficulty discussing gender outside of gender biased concepts, including biased generalizations of boys and girls. It seemed easier for some to get drawn into the gender biased concepts, and it was difficult to draw attention to a gender equality framework once dialogue commenced in a gender biased framework. The following best describes this issue as follows:

...the boys, who want bigger, better, faster, stronger, type of thing, whereas physics, there is the possibility of the explosion, and the power of force and the power of chemical reaction, and with girls, it is not the same value, they do not value it the same way. They do not hold it in the same regard, where as in biology, fish, animals, plants, life, they are more predisposed to their interest.

When reading the aforementioned quote, the physical sciences of chemistry and physics are portrayed as being more attractive to males, and biology, the life science, as more attractive to females. The quote was communicated in such an extremely gender biased manner that the argument appeared logical. The belief system was coherent but strongly gender biased. By dissecting the argument one can clearly see that gender biased beliefs were underlying the response, in that females were depicted as being more fearful of what may be powerful and explosive than boys, and that physical sciences, by nature, are

considered more dangerous than a life science. Furthermore, boys are gender biased against biology, as though one had to be female in order to truly appreciate and value living things.

Only one participant managed to answer most of the questions in the interview without using gender biased concepts. There did not appear to be a complete lack of will to resolve female gender disparity by most of the participants, but there was a lack of awareness and knowledge, shared by most of the participants, that female gender disparity was a problem that needed resolve, and that they, those in positions of leadership, were the ones who needed to do something about the lack of resolve. The following quote emphasizes this point:

To make improvements, I guess I would have to say, is there a need for improvement...? If you are seeking balance, and that would be the goal of the employer? Or I am wondering who that is a goal for?

Clearly, not knowing why female gender disparity in mathematics and the physical science is a problem for females in society today demonstrates a fundamental need for professional development.

Professional development was not only stated by two individuals as being important for educators at all levels, but critical in relation to developing an understanding of equality, without which students would not receive the education they required to participate in today's society. Change, from being gender biased to practicing gender equality, was perceived as difficult and complex.

A comment was made by a participant who stated: "it has become very clear to me that what we have done in the elementary school sets the stage for what we do and

perpetuates the same kind of thing.” Gender bias gets perpetuated. But blaming elementary school as the culprit of female gender disparity does not make sense when there is an opportunity to make change happen at any point in time throughout the education system. Another participant stated that pointing fingers at other people in other schools, as sources of the problem, removes the responsibility of the resolve from the school, and the person doing the finger pointing. This, blaming the other school, was identified as something that needed to be avoided; otherwise there would be no resolve at all. Blaming other schools while not working on resolve at all is an indicator of the necessity of professional development.

The problem with making change is that in order to see what needs to be changed, the problem has to be observed. The problem cannot be fully observed while an individual believes in the concepts of gender inequality that underlie gender bias and then blames someone else for the problem. The time to actually deal with the issue, to achieve resolve, is the present, through each person in the school, through an understanding and belief in equality. This is furthermore a matter of professional development.

Lack of knowledge about female gender disparity, and gender bias, is an issue for professional development. The difference between participants who had knowledge about the subject and those who did not have even a little information was clear. The following quote is intended to show to the reader the difference between knowledge on female gender disparity and making changes in the school with some success, juxtaposed to the participant quoted below, who appeared to be without the same knowledge base in a school that was not perceived by the participant as having made any changes in female gender disparity over the past few years:

I have no idea....What careers people are choosing in their lives? In terms of degrees, and why three males to every female in mathematics, I have no idea why that would be....And I wonder about the social, that people may make to pursue a family. To proceed to advanced degrees, and then to a career. Females may feel that they are not willing to make that sacrifice.

And so, without a knowledge base, without a perceived school doctrine, philosophy, and practice, the participant did not have an answer to why female gender disparity persists, even though it was verified that the school had indeed a lower female gender disparity in physics. Still, there was a disparity. Although the school appeared to be without a school philosophy and practice on gender equality and gender equity, the other participant at the same school had stated that there were two strategies being carried out by some of the staff and counsellors to reduce female gender disparity. This appeared to be going on without the knowledge of the other participant. It may also be that the participant was aware of the program, but may have not made a conceptual link between the programs and female gender disparity as discussed in the interview. The participant did claim to possess a belief in gender equality, but did not see female gender disparity as an issue that needed his immediate leadership attention. During the interview, he flipped from being somewhat defensive and unable to do anything about it, to being supportive of the need for balance within society.

From the findings in this investigation and through the review of literature, a gap in the literature was discovered in relation to perceptions by principals and counsellors of female gender disparity in high school mathematics and career choices. The findings

indicated a strong need for professional development. Furthermore, there was a need for knowledge on female gender disparity in mathematics and physical sciences, as well as a need for knowing what strategies worked for dealing with the issue, and how to view gender in terms of equality.

Therefore, recommendations are that such knowledge and information be consolidated within a framework of equality and provided to educators for facilitating the resolve of female gender disparity in mathematics and physical science. The intended goal is to remove gender bias for the purpose of resolving female gender disparity in these areas, establish best practices of equality, and ensure that females benefit equally in education in Canada in these subject areas. At issue is the concern that knowledge gained through this investigation will not reach principals, counsellors, or educators unless something concrete is developed; therefore, the researcher recommends that knowledge of issues, best practices, and how to strategically implement resolve be arranged and disseminated through a manual for all educators.

The modes of distribution may be through hard copy or through the Internet. Critical is that the development of this manual be shaped within a framework of equality. The overriding goal of this recommendation is to resolve female gender disparity in mathematics and physical science, so that females may have equal benefit to education in these subject areas.

Furthermore, as gender bias and an unclear understanding of gender equality appears to be at the root of the issue of female gender disparity and the persistence of female gender disparity in mathematics and physical science, and, given the enormity of the issue of female gender disparity, an interactive website should be developed so that

educators may access and assess their own gender views. The interactive aspect of the website would also provide a means of both monitoring the situation through surveys, information-gathering through the interaction of educators with the website, and indicating how specifically extensive the issue is within various regions and provinces in Canada. This interactive aspect of the website would mean educators from every region would have access to specific information and feedback in regard to the resolve of female gender disparity in all different locations.

### *Advocacy*

Clearly, the advocacy of equality is at the heart of resolving female gender disparity in mathematics and physical sciences. The researcher acknowledges the need to return the information back to the constituents. Without advocacy, female gender disparity will persist, and the guarantees made in the Charter of Rights and Freedoms (1982) will not be respected within Canadian society. A mechanism to link equal rights and practice is necessary. Although a manual and a website would provide knowledge and feedback to a wide audience, commitment to resolving female gender disparity at the political and social level of society is critical, without which further resolve within all schools which have a female gender disparity in mathematics and science may not manifest. Therefore, the researcher has committed to the pursuit of advocacy, and invites others to join the pursuit, and to implement social and political change in order to resolve female gender disparity in mathematics and physical science.

### *Limitations*

Time was a limitation in the collection of data, as permission to conduct the interviews was limited to less than a semester for both the pilot study and the main study. The interview time was limited by the amount of time available for participants to participate in the study within a part of a semester at the end of a busy school year. The study was conducted in respect of the participants' limited time to participate during regular school hours. Furthermore, scheduling interviews had to be coordinated within each school, to coordinate travel by the researcher. Fiscal resources for travel were also delimited by the limitation of the researcher's own travel budget.

### *Future Research*

Because of the seriousness of the issue of female gender disparity in physical science and mathematics, the presence of gender bias as communicated by most of the participants, as well as the pervasiveness of female gender disparity, and in regards to the lack of knowledge regarding gender bias and administrators, research is recommended to determine the scope of gender bias amongst administrators in the general population of education administrators. Furthermore, since both administrators and counsellors appeared to have gender bias, further research to determine the scope of gender bias amongst counsellors is also recommended, in regards to gender bias and the perception of female students in mathematics and physical science. The researcher also recommends research be performed to determine the extent to which gender bias is observed amongst teachers, students, parents, and the community at large, in relation to females in mathematics and physical science, as well as careers leading from these subject areas to

non-traditional occupations. Research as such may wish to look at the extent to which females are affected by the gender bias within or amongst any of these constituent groups.

Specifically, researchers may wish to test the extent to which educators have a gender bias or not, and how this affects what they see, and envision an appropriate action to take in classes or counselling in regard to encouraging female students in mathematics and physical science, or not encouraging female students in these subject areas.

Researchers may also wish to focus on whether the application of gender neutral and therefore gender equal practices are being undertaken in individual and in group settings.

Research, regarding gender bias, may also be useful to determine if the lack of a philosophy of equality also has an impact on whether schools in general have greater differences in participation rates of males and females in mathematics and physical science.

Furthermore, researchers may wish to examine whether the lack of a philosophy of equality, amongst all school members, shows up definitively as greater discouragement of females taking either mathematics and physical science, or whether such discouragement shows up in gender stereotyped career choices, or avoiding mathematics and physical science altogether.

Another research area, that may be useful, may be determining the gender views of girls and boys in different schools and testing whether there is a correlation with the gender views of the other constituent groups.

Long term studies may wish to look at the outcomes of participating in a school that practices a philosophy of equality, to the future success of both participation and achievement in mathematics and science.

Similar studies in universities and colleges in areas of mathematics and physical science may also provide useful knowledge regarding policies on resolving gender disparity in those programs leading to careers that have persistent female gender disparities.

Finally, research regarding gender bias and careers leading from mathematics and physical science, in relation to a presence or absence of a philosophy of equality and therefore the practice of equality, may be highly useful in determining best policies for encouraging more talented females into areas where they have not been participating in expected numbers, given the Charter of Rights and Freedoms (1982) and the known intellectual equality (Fennema, 2000).

### *Summary*

The recommendations to reduce female gender disparity had specific aim at moving the school from a situation where females were not having equal benefit in their education. The recommendations were extensive, from philosophy of equality to changing gender biased belief systems; understanding the role of the school in promoting good role models; influencing every corner of the school through strategies, including encouragement; using the media; student advice; having a good knowledge of female gender disparity including the history of female gender disparity; performing school gender audit; and seeking professional development. Professional development was

considered very important in order that members of the school, those in positions to influence, understood themselves and the role the school played in guaranteeing that the rights of female students were actualized in mathematics and physical science, and acceptance of the responsibility for change.

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## Appendix A

The five Tables used in the process of informed consent

Table 1

*Participation rates of male and female student's participation in mathematics biology chemistry and physics in grade twelve BC education 1999.*

Course	number of Males(M)	number of Females(F)	ratio of M/F
Physics 12	5,999	2,392	2.5:1 <sup>1</sup>
Principles of Mathematics 12	12,630	10,687	1.2:1
Chemistry 12	6,928	6,912	1.0:1
Biology 12	5,729	10,572	0.5:1

BCed Report TRAX642A on line at: [bcd.gov.bc.ca/exams/trax/99\\_trax6420a.txt](http://bcd.gov.bc.ca/exams/trax/99_trax6420a.txt) Female's grades were higher on all final grades than their male counterparts. Biology enrollment is typically higher for females than for males in secondary education. This trend is reversed in observation in post-secondary studies in Masters degrees and further enhanced in Doctoral degree qualifications (Gaskell, 1993).

<sup>1</sup> Calculations of ratios were performed by the researcher and not included in the BCed Report.

Table 2

*Male and Female ratios in the experienced labor force over 15 years of age in 1996 in Metropolitan Victoria, BC.*

Male and female ratios by Occupation

Occupations	number of Males(M)	number of Females(F)	ratio <sup>2</sup> of M/F
Management	16,295	5,735	2.8
Business, Finance, and Administration	31,825	23,280	1.4
Natural and applied Sciences	9,270	1,605	5.8
Health	9,740	7,395	1.3
Social science, education, government, and religion	12,890	7,375	1.8
Art, Culture, recreation and sport	5,215	2,840	1.8
Sales and Service	46,915	25,130	1.9
Trades, Transport, and Equipment operators	18,005	1,045	17.2
Primary Industry	4,095	840	4.9
Processing Manufacturing, and utilities	3,460	810	4.3

Note. Statistics are from Statistics Canada (2000). Equipment operators and Primary Industry plus Natural and Applied Sciences includes all related occupations (Statistics Canada 2000).

<sup>2</sup> Calculations of ratios were performed by the researcher and not by Statistics Canada (2000).

Table 3

*Community college diplomas in careers programs in 1997 by gender*Field of Study by number of Males and Females enrolled in 1997

Field of Study	number of Males(M)	number of Females(F)	ratio <sup>3</sup> of M/F
Business and Commerce	7,726	15,601	0.5
Engineering and Applied Sciences	14,976	3,303	4.5
Social Sciences and Services	4,119	12,119	0.3
Health Sciences	2,165	9,453	0.2
Arts	2,964	4,227	0.5
Natural Sciences and Primary Industries	2,880	1,939	1.5
Humanities	375	860	0.4
Arts and Science	1,053	1,478	0.6

Note. Figures rounded. Data demonstrates overall gender discrepancy for males and females. (Statistics Canada, 2000)

<sup>3</sup> Calculations of ratios were performed by the researcher and not by Statistics Canada (2000)

Table 4

Male / Female ratio for mathematics, biology, chemistry, and physics in Canada in 1989University Degrees by Mathematics, Biology, Chemistry, and Physics

Subject	Bachelor's	Master's	Doctoral
Mathematics	1.55	3.21	5.75 <sup>4</sup>
Biology	0.92	1.42	3.23
Chemistry	1.73	2.60	3.17
Physics	5.90	6.92	14.57

Note. These trends concur with current observation in post-secondary education (Gaskell, 1993).

Furthermore, according to Statistics Canada, these figures have not changed significantly (<http://www.statcan.ca/Daily/English/000914/d000914c.htm>)

<sup>4</sup>Calculations of ratios were performed by the researcher and not by Statistics Canada

Table 5

University degrees granted by field of study by sex in 1998University Degrees by males and females enrolled in degree program

University Degrees	number of Males(M)	number of Females(F)	ratio <sup>5</sup> of M/F
Social Sciences	27,993	39,026	0.7
Education	7,565	18,391	0.4
Humanities	7,589	13,227	0.5
Health Professions and Occupations	9,144	3,514	2.6
Engineering and Applied Sciences	10,121	2,709	3.7
Mathematics and Physical Sciences	6,876	3,116	2.2
Fine Arts and Applied Arts	1,735	3,521	0.5

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 Statistics Canada (2000)

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<sup>5</sup> Calculations of ratios were performed by the researcher and not by Statistics Canada

## Appendix B

## Letters to invite Principals and Counsellors

## Letter to the Principals of Qualifying Schools

Date

Confidential

Principal Name

School Name / School District #00

Address

Re: *Gender Disparities in High School Mathematics, Science and Career Choices: Principals and Counsellors Perceptions.*

Dear Mr./Mrs. Principal,

I am writing to you to invite you to participate in an exploratory research on *Gender Disparities in High School Mathematics, Science and Career Choices: Principals and Counsellors Perceptions*. Furthermore, permission is requested to invite your school counsellors to participate in this study. Your school has been selected as one high school from five school districts. The purpose of this research is to obtain your perception and one of your counsellors perception as to why gender disparities exist in mathematics, chemistry, physics, biology and computer science and how this phenomenon impacts students, in particular, female students' future career choices.

The intent of the research is to gain insight into the issues and propose recommendations for improving completion rates for female students in mathematics, computer science, chemistry, physics and biology. Interviews will proceed only with your complete informed consent, with full disclosure of the purpose of the research, which has been subject to ethical approval by the University of Victoria (copy enclosed) and approval from the office of the superintendent of schools, school district # (copy enclosed). Participation is entirely voluntary; anonymity is assured, with complete respect to confidentiality. Results of the research will be made available to the involved school districts on completion. No individual schools, principals, counsellors or school districts will be named on any of the documents in the final report.

If you have any questions, please do not hesitate to contact me at either my home at 386-0832, my work at 356-1979 or through my supervisor, Dr. Martin at 721-7813. Thank-you so very much for your time, and most of all, your consideration.

Please attach a note of acceptance to this letter, keep the original copy for your personal records, and mail your response confidentially to myself to the mailing address.

Sincerely,

Nicola Thea Stanford  
Graduate Student  
Department of Educational Psychology and Leadership Studies  
Faculty of Education  
University of Victoria  
Tel: 386-0832 ext \*2 (hm) 24 hrs/day or 356-1979 (wk)

Mailing Address: 987 Tattersall Drive  
Victoria, BC V8X 2X1

E:mail: [stanford@uvic.ca](mailto:stanford@uvic.ca)

Enclosure (Tables 1-5, Copy Approval University of Victoria, Copy Approval School District)

## Letter to the Counsellors

Date

Confidential

Mr. Mrs. Counsellor

Re: *Gender Disparities in High School Mathematics, Science and Career Choices: Principals and Counsellors Perceptions.*

Dear Mr./Mrs Counsellor,

I am writing to you to invite you to participate in an exploratory research on *Gender Disparities in High School Mathematics, Science and Career Choices: Principals and Counsellors Perceptions*. The purpose of this research is to obtain your perception as to why gender disparities exist in mathematics, chemistry, physics, biology and computer science and how this phenomenon impacts students, in particular female students' future career choices.

The intent of the research is to gain insight into the issues and propose recommendations for improving completion rates for female students in mathematics, computer science, chemistry, physics and biology. Interviews will proceed only with your complete informed consent, with full disclosure of the purpose of the research, which has been subject to ethical approval by the University of Victoria (copy enclosed) and approval from the office of the superintendent of schools, school district 00 (copy enclosed). Mr. / Mrs. Principal has given his authorization for me to proceed with research at High. Participation is entirely voluntary; anonymity is assured, with complete respect to confidentiality. Results of the research will be made available to the involved school districts on completion. No individual schools, principals, counsellors or school districts will be named on any of the documents in the final report.

If you have any questions, please do not hesitate to contact me at either my home at 386-0832 or through my supervisor, Dr. Martin at 721-7813. Thank-you so very much for your time, and most of all, your consideration.

Please attach a note of acceptance to this letter, keep the original copy for your personal records. You may either mail your response confidentially to myself to the mailing address, or call me directly so that we could meet at a time convenient to you.

Sincerely,

Nicola Thea Stanford  
 Graduate Student  
 Department of Educational Psychology and Leadership Studies  
 Faculty of Education  
 University of Victoria  
 Tel: 386-0832 ext \*2 (hm) 24 hrs/day or 356-1979 (wk)  
 Mailing Address: 987 Tattersall Drive  
 Victoria, BC V8X 2X1

E:mail: stanford@uvic.ca

Enclosure (Tables 1-5, Copy Approval University of Victoria, Copy Approval School District)

Appendix C  
Letter to invite school districts

Date

Superintendent  
School District # 00  
Tel: 123 456 7890

Re: Gender Disparities in High School Mathematics, Science and Career Choices:  
Principals and Counsellors Perceptions.

Dear Mr. / Mrs.

I am writing to you for authorization to approach senior counsellors and principals, professionals with more than five year experience, who work in secondary schools that have been offering graduation for a minimum of five years, from your district, to participate voluntarily in a case study on *Gender Disparities in High School Mathematics, Science and Career Choices: Principals and Counsellors Perceptions*. As well, I am seeking permission to run a pilot test of the questions with a principal and a counsellor who work in one of the three Grade II and IX senior secondary schools. A brief summary has been provided for your review. This inquiry is partial fulfillment of my MA program in Leadership studies and has been subject to committee approval and also ethical approval by the University of Victoria.

**Purpose**

The overall intent of the research is to gain insight into the issues and propose recommendations for improving completion rates for young women in mathematics, computer science, chemistry, physics and biology and to assist them to develop their talent and abilities in an increasingly technological society. The primary purpose of this exploratory study is to discover Grades XI and XII completion rate by gender for mathematics, computer science, chemistry, physics and biology. A secondary purpose is to obtain high school counsellors' and principals' perceptions as to why gender disparities exist in these disciplines. A tertiary purpose is to examine in some detail how this phenomenon impacts on female student's future education and career choices. The final purpose is to propose recommendations for improving both participation and completion rates for female students in mathematics, computer science, chemistry, physics and biology at secondary and post-secondary levels of education.

**Significance of the Study:**

It has been observed that females are opting out of such activities that are prerequisites to most programs and subsequent careers that are both beneficial to the individual and society at large. Furthermore, if this trend continues, more and more females may

encounter longer periods of unemployment as a direct result of low participation in science, mathematics and computer technology in secondary education. This will be detrimental to the individual, their families, and society at large (See tables 1, 2, 3, 4 and 5). Recommendations to ameliorate this situation, from a deeper understanding of the issues, will be of direct benefit to students and professional educators, developers of curriculum, educational counsellors and society at large.

## **Method**

Five school districts from will be invited to participate in the study. Ethical approval has been acquired from the University of Victoria to initiate the inquiry. With your consent, I may send a letter to the qualifying principals and counsellors, or use another method of contacting the principals approved by yourself, to identify the potential counsellors and principals. Depending on the number of counsellors and principals that fit the criteria, either all or a randomly selected percentage of the population pool will be invited to participate. Those who agree to participate will be asked to sign an informed consent form, prior to the interview that will include the initial research questions. The pilot test portion requires one school with a volunteer principal and counsellor to be interviewed individually. The purpose of the pilot test is to test both the questions as well as the method of analysis. Deception will not be used at any point in this study.

Participation is entirely voluntary, anonymous and confidential. No individual schools or districts will be named on the final document, or at any point throughout the research. Only the researcher will have access to this information throughout the entire process. Results of the research may be made available to schools and school districts on completion, committee acceptance and submission to the University of Victoria.

## **Additional Information**

If you have any questions regarding the research, please do not hesitate to contact me at either my home at 386-0832, e-mail: [Stanford@uvic.ca](mailto:Stanford@uvic.ca) or through my current supervisor Dr. Martin. You may also make inquiries regarding this study to the Vice President of research at the University of Victoria at Tel: 472-4362, [vpr@uvic.ca](mailto:vpr@uvic.ca). Thank-you so very much for your time, and most of all, your consideration.

Sincerely,

Nicola Thea Stanford

Cc: Dr Martin

Enclosures (Tables 1-5, Ethical Approval, Sample of Research Questions, References)

Appendix D  
Letter of Informed Consent

**Female Gender Disparities in High School Mathematics, Sciences and Career Choices**

Supervising Professor: Dr. Martin (250) 721-7813

Researcher: Nicola Thea Stanford (250) 386-0832

Please print

I, \_\_\_\_\_ have been invited to participate in a study entitled *Female Gender Disparities in High School Mathematics, Science and Career Choices*, that is being conducted by Nicola Thea Stanford, a Graduate Student at the University of Victoria, in the department of Educational Psychology and Leadership Studies. The Primary purpose of this exploratory study is to discover Grade XI and XII completion rates by gender for mathematics, computer science, physics, chemistry and biology. A secondary purpose is to obtain High school counsellor's, with more than five years experience in high schools that have been offering high school diplomas for more than five years, perceptions as to why gender disparities exist in these disciplines and how this phenomenon impacts on future career choices. The final purpose is to propose recommendations for improving completion rates for female students in mathematics, computer science, chemistry, physics and biology.

Research of this type is important because female students are apparently either not choosing education in mathematics and science, or are not choosing careers in science and mathematics. This phenomenon suggests that many students are avoiding science and mathematics based courses in High school and therefore limiting their future success and career choices. As a consequence to advances in technology, there has been a significant change in job opportunities emerging in the Canadian labor market. Low skilled jobs are disappearing while high tech jobs are increasing. Many female students who do not possess an adequate knowledge of mathematics and science may find themselves unemployed for extended periods of time. This situation is detrimental to the individual and to society at large.

I understand that my participation in this research is completely voluntary and that the research will have no effect on my employment status. I may withdraw my participation at any time with no repercussions and that any of the data collected up to the time of withdrawal will not be included in the research thereafter. I understand and have read the research questions. I also understand that my anonymity and confidentiality will be maintained throughout the research and that I have been selected from five school districts and from the total number of secondary schools in my district. The first

interview is not anticipated to require more than twenty minutes of my time. My identification will not be possible to determine from the final report, confidentiality is guaranteed, my anonymity is completely assured, and all notes that bear references that may be traced to myself will be kept in a locked cabinet at the researchers residence until the final submission of the report to the University of Victoria, at which time, they will be destroyed by fire. There is no deception involved in this research.

The interview will take place at a time and location convenient to myself. I have seen and read the research questions. I perceive no risks, costs or inconveniences as a result of my participation. Before final submission to the University of Victoria, I understand that I will be given a copy of the data that has been collected from myself for my review and approval after which time it will be analyzed and submitted to the University of Victoria. I understand a copy of the final report will be given to each of the five school districts involved in the research.

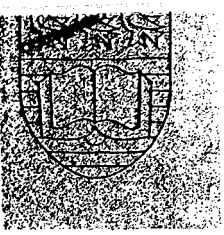
The researcher will be the only person to have access to my identity. An inter-rater, a professional educator, will review one set of data and may determine whether my voice has been reflected in the analysis. This may occur if my data is randomly selected as one out of all the participants in this study. I may, as well as others, benefit from the interview. In addition I understand that I may contact the researcher at the above phone numbers and that I may verify the ethical approval of this study, or raise any concerns I may have, by contacting the Associate Vice President Research University of Victoria (250 721-7968) or the Research Supervisor Dr. Martin at (250) 721-7825.

My signature below indicates that I understand the above conditions of my participation in this study and that I have had the opportunity to read and understand the research questions.

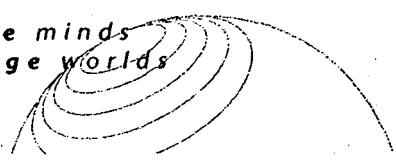
_____	_____
Participant's Signature	Date
_____	_____
Researcher's Signature	Date

**A COPY OF THIS CONSENT WILL BE LEFT WITH YOU, AND A COPY WILL BE TAKEN BY THE RESEARCHER.**

The End.



challenge minds  
change worlds



UNIVERSITY OF VICTORIA - HUMAN RESEARCH ETHICS COMMITTEE

**CERTIFICATE OF APPROVAL**

<u>PRINCIPAL INVESTIGATOR</u> <b>Nicola Thea Stanford</b> Graduate Student	<u>DEPARTMENT/SCHOOL</u> <b>EPLS</b>	<u>SUPERVISOR</u> <b>Dr. Peter Murphy</b>
<u>CO-INVESTIGATOR(S):</u>		

**TITLE: Female Gender Disparities in High School Mathematics, Sciences and Career Choices**

<u>PROJECT No.</u> <b>266-01</b>	<u>START DATE</u> <b>9/19/2001</b>	<u>END DATE</u> <b>9/18/2002</b>	<u>APPROVAL</u> <b>9/19/2001</b>
-------------------------------------	---------------------------------------	-------------------------------------	-------------------------------------

**CERTIFICATION**

This is to certify that the University of Victoria Ethics Review Committee on Research and Other Activities Involving Human Subjects has examined the research proposal and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.

**This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions/minor amendments may be granted upon receipt of "Request for Continuing Review or Amendment of an Approved Project" form.**

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