TRANSFORMING SCHOOLS:

TEACHER AWARENESS OF GENDER ISSUES

IN MATHEMATICS, SCIENCE, AND COMPUTER LITERACY

BY

WENDY LOUISE WEIGHT FIDKALO

A Thesis
Submitted to the
Faculty of Graduate Studies
in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF EDUCATION

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ABSTRACT

Female students continue to be underrepresented in significant areas of science and computer literacy in secondary schools and to be less confident and less interested in mathematics, physical sciences and computer literacy than male students. These facts have significant implications for their future career choices, economic status, and the extent to which females will be able to influence the future directions of our society.

Eighty-three teachers at the Elementary, Junior High, and Senior High levels currently teaching mathematics, science, and/or computer literacy in a suburban Winnipeg school division participated in answering a questionnaire designed to examine the extent to which they believed their role to be one of creating an egalitarian school, the extent to which they viewed the current system as inequitable, and the extent to which they were responding to sexism.

The results suggested that, although teachers voiced a strong belief and commitment to equality, they were largely unaware of the ways in which gender bias is operative in schools. Younger teachers were less able to recognize bias than older teachers. Female teachers appeared to have more commitment to equality than male teachers, however, they were not more likely to identify bias. Few teachers, all women, reported having participated in professional development or coursework on gender issues.

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I would like to acknowledge the support and contributions of my thesis advisor, Jon Young, the members of my thesis committee, Keith Louise Fulton, Sharon Bailin and Betty Johns, and the teachers who participated in this study. I have chosen to dedicate this work to the feminist educators who served as inspiration through their commitment to transformation and their belief that teachers can make a difference.

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This study is located within the emerging field of critical feminist work on gender and schools, and gender and science. Its purpose is to explore the connections and conflicts between these forces and the role which teachers play. Increasingly, women are coming to see that inequities of gender are complicated for many by inequities of race and class and in these areas research is only beginning to explore the interplay of forces. This study is not intended to deny or conceal that both science and education can be implicated in racist and classist practice and that these contribute significantly and compoundingly to the realities of many women's lives. The intentions of this study are limited to a discussion of the relationships between gender, mathematics, science, and technology education and the awareness of teachers from a single school division, in the hope that other comprehensive works will explore further dimensions in this new feminist tradition.

Feminist research begins its investigations from a grounded position in subjective knowledge; thus, feminist research admits to and embraces its bias. The feminist critique challenges the traditional notion of objectivity, which is seen not as "truth", but, as male-biased subjectivity. Female subjectivity leads feminist researchers to a sensitivity to power relationships and oppression. A feminist critique places an emphasis on the lived experience and the significance of everyday life. This type of research rejects the positivism which proclaims the naturalness and inevitability of the status quo. Feminist research often makes use of different methodologies and attempts to value people involved in the research as participants.

Most importantly, the feminist critique is politically committed to changing the position of women in our society and to bringing to light the social realities of being female. In so doing, feminist research sees the ultimate test of knowledge, not in whether it is true according to an abstract criterion but in whether or not such knowledge leads to progressive social change (Weiler, 1988).

CHAPTER ONE

RATIONALE

The report of the Science Council of Canada in 1984, Science For Every Student, argued that scientific literacy is a pre-requisite to informed citizenship and that the knowledge and skills associated with studies in mathematics, science, and technology are vital to future workforce participation. Science and technology continue to dominate change and to drive social and economic trends. Those students excluded from these areas will not be in a future position to direct or choose change and this will have far-reaching implications, including determining the ends to which science and technology will be aimed and how public priorities will be determined (Canadian Teachers' Federation, 1988).

Canadian and international studies from the past decade reflect important global patterns in science education for girls: girls appear to be less successful in the sciences and participation rates decline as they progress through the grades; girls do not see science and technology as relevant or appropriate either as a course of study or as future employment; occupational stereotyping is still prevalent and works to direct women into "humanistic" and short term career choices regardless of their potential (C.T.F., 1988).

Science For Every Student particularly emphasized the importance of increasing the participation rate of young women in mathematics, science, and technology because it chronically lags behind that of young men. 1985-86 statistics from Canadian Universities indicate that while 52% of the undergraduates were women, enrolment in the natural sciences was only 32% female. In addition, the "seepage rate" of women in science is 50% higher than men in the same field and the leaving group includes top academically achieving females (Nevitte, Gibbins and Codding, 1988). Faculties such as engineering continue to have enrolments which are often less than 10% female.

Statistics from the 1989/90 calendar year at the University of Manitoba substantiate these discrepancies and their continued existence. In first year Engineering, there were 37 females and 310 males enroled. While enrolment in General Science is 42% female, enrolment in the Honours stream is only 30% female. Attrition rates increase for females throughout successive programs and by the Ph.D level, females represent only 23% of the students. In faculties such as Dentistry and Medicine, male students continue to outnumber females by almost two to one. Females continue to be concentrated in the less prestigious schools of Occupational Therapy, Physiotherapy, and Nursing (Institutional Statistics, 1990).

Secondary school statistics from 1988/89 in Manitoba show significant differences between male and female participation rates in key subject areas. Overall, Physics 300 classes were 39% female and 62% male while Computer Science 305 enrolments were 23% female and 77% male. Advanced Mathematics and Calculus courses at the grade twelve level ranged from 40% to 43% female. In contrast, enrolment in Biology 200 and 300 was 58% and 60% female respectively (Watt, 1990, p. 18). This should not be viewed as surprising given that Biology is prerequisite to traditional roles in the Health Care field, most notably that of Nursing.

In the suburban Winnipeg school division where this study was conducted a similar pattern emerges. In the 1989/90 school year, 52% of grade twelve students were female, however, females accounted for only 39% of the Physics 300 enrolment and no females were enroled in Advanced Placement Physics at this level. Thus, overall, 102 males graduated with Physics 300 or better, in contrast to only 63 females in a year when more females than males graduated in total. While 152 females were enroled in Math 300, compared to 122 males, males outnumbered females in Math Topics 305, Math/Calculus 355 and Advanced Placement Math. It appears that capable females are less likely to enrol in what are perceived to be the more challenging mathematics courses. Computer science options, offered to a total student body roughly equivalent in female/male ratio, had an overall enrolment which was 23% female and 77% male and by grade 12, only 1 female was enroled in Computer Science 305 in contrast to 18 males. In Data Processing options, females accounted for 35% of the enrolment while males accounted for 65%, and by grade 12, 4 females were enroled in Data Processing 302 in contrast to 11 males. Only where keyboarding and word processing were offered as separate options at the grade ten level, did females outnumber males respective to relative enrolments and then only by a slight margin. Overall, the likelihood for enrolment in computer option courses in Senior High was significantly greater for males at every level and became increasingly male-dominated by grade 12 (Appendix 1.1).

Research on female achievement in mathematics, science and computer literacy appears to reflect two significant patterns; girls do as well as boys when school grades are used as measures of achievement; and standardized tests appear to give males an advantage (Haggerty, 1987; Pederson, Bleyer and Elmore, 1985). The literature generally assumes standardized test results to be truer indicators of achievement and ability. Standardized tests, however, are based on the concept of standardized experience, and if the informal learning experiences of girls and boys differ, then such tests contain substantial bias (Linn and Hyde, 1989). Secondary student marks from the school division where this study was conducted indicate that where girls are enroled, they do as well or better than their male counterparts. Using mean course marks in mathematics, science, and computer literacy courses by sex for the 1989/90 school year, in 31 cases girls outperformed boys, in 13 cases boys outperformed girls, and in two cases they performed equally (Appendix 1.2).

Even where enrolment figures indicate equal participation, it is likely that more in-depth, qualitative study would reveal differences in the self-confidence and interest of females in mathematics, science, and technology. Equal enrolment cannot be viewed as assuring that females are participating equally and will continue to participate equally in the future. Linn and Hyde (1989) report that U.S. national studies consistently show high school females are less confident about their ability to do mathematics and science than males even when both groups perform equally. In a recent Canadian study prepared for the Department of Education in Newfoundland and Labrador, where no significant differences were found in enrolments, males were still more likely to regard mathematics as a male activity, and females reported significantly more anxiety and lower levels of confidence in their ability to do mathematics (May, Boone and Hopkins, 1988). At present, no data is available to assess whether female students in the division surveyed in this study have thoughts and feelings consistent with this pattern.

The importance of knowledge and skills related to mathematics, science, and technology cannot be underestimated. These areas of study have become known as the critical filter in future career choice because, without successful completion of these courses, up to 85% of post-secondary opportunities are closed to prospective students (C.T.F., 1988). Recent estimates of the impact of technology in the workforce project staggering job losses in clerical, sales and service occupations, exactly the areas where 3.3 of Canada's 5.6 million women working outside the home are now employed. In contrast, a shortfall of 30,000 engineers is expected in Canada by the turn of the century (Rainbird, 1990, p. 9) and career opportunities related to computer-assisted design, manufacturing, and systems management are rapidly expanding. Thus, the economic future of young women who are assuming traditional careers will be available to them is increasingly imperilled while young men are continuing to gather the experience and skills in science and technology which will lead them to economic independence in the 21st century.

Scientific and technological literacy are also important as part of a general education, and not everyone who studies these areas in school will use these qualifications in their working life. This knowledge does, however, give people a sense of control over their environment by ensuring they understand that machinery and technology work in comprehensible ways. In present day society, science and technology are powerful forces. Those who are excluded from an understanding of the nature of these forces will be further marginalized by their inability to direct the role of scientific and technological development.

The traditional male view of science and technology is one based on prediction and control. Planning, as a central activity in the male view, assumes that the social contexts in which science and technology are applied are constant, stable and predictable when in reality these contexts are highly changeable and unpredictable. As a result the present technological order has succeeded in escalating human oppression, ecological destructiveness, and global militarism. As care-givers, women often become aware of the many elements of life and growth which cannot be controlled, thus, women develop an approach of coping which seeks to minimize disaster and is extremely sensitive to context. Hence, it may be considered that not only do women need science and technology, but, that science and technology are in great need of a feminine view, sensitive to the social and human effects of their applications (Franklin, 1984, p. 86).

> Further, the greatest contribution of women lies precisely in their potential to change the structures by critiquing and changing the very parameters which have excluded women (Franklin, 1990, p. 104).

In order for women and men to be equal, women must play an informed part in decision-making surrounding the applications of science and technology in our society. It is imperative that education provide young women with the confidence and interest to pursue careers in mathematics, science, and technology if females are to claim equal status and opportunity with their male peers in the future.

Statement of the Problem:

Female students continue to be underrepresented in significant areas of science and computer literacy in secondary schools. Female students also continue to view studies in mathematics, science, and computer literacy differently than males. These facts have significant implications for their future career choices, economic status, and the extent to which females will be able to influence the future directions of our society.

Research has shown that teachers play a part in perpetuating patriarchal structures, in accepting sex role stereotyping, in presenting a male biased curriculum and in unconsciously favouring male students. This study examined the extent to which a sample of teachers of mathematics, science, and computer literacy in a suburban Winnipeg school division believed their role to be one of creating an egalitarian school, the extent to which these teachers viewed the current system as inequitable, and the extent to which they were responding to sexism. Based on Margrit Eichler's work on sexism in the social sciences (Eichler, 1987), an attempt has been made to ascertain whether teachers are maintaining the status quo, including women in a male view of scientific education or developing and teaching a feminist view of mathematics, science, and technology. This study also explored teachers perceptions of the barriers and constraints which limit their ability to transform schools.

Methodology:

In keeping with the philosophy of feminist critique, which emphasizes the need to base research within personal experience, this research began with the interviewing of two female teachers whose responsibilities fell primarily within the disciplines of mathematics and science and whose teaching experiences varied across Elementary, Junior, and Senior High levels. Information gathered from these teachers' experiences and from the current literature were coalesced to generate a review based on personal experience and research expertise (See Chapters 3 and 4). Using this information as a basis for the study, a questionnaire was developed to gather descriptive information on the beliefs of teachers as they related to equality in general and more specifically to the participation of female students in mathematics, science, and computer literacy. The questionnaire was distributed to a selection of teachers from a suburban Winnipeg school division at the Elementary, Junior High, and Senior High levels currently teaching mathematics, science, and/or computer literacy. A descriptive analysis, including grouping respondents by age, sex, and teaching level, was then undertaken to provide insights into the views and responses of the teachers surveyed. The following questions are addressed in the analysis:

1. Do mathematics, science, and computer literacy teachers believe they have a responsibility to create an educational environment free of gender bias?
2. Do mathematics, science, and computer literacy teachers believe the current system is gender biased?
3. Are teachers of mathematics, science, and computer literacy responding to sexism and if so, how are they responding?
4. What levels of feminist consciousness or awareness are indicated by their responses?
5. What do teachers believe are the most important factors in the underrepresentation of females in mathematics, science, and technology?

Assumptions

This study, as with all research, is based upon certain underlying assumptions of the researcher. In my experience as a Caucasian female, as a teacher, and as a student, I have developed certain beliefs which in turn led to the choice of this topic as an issue for study. I believe that teachers can facilitate change in the attitudes and behaviour patterns of students, and further, I believe that teachers have a responsibility to endeavour to provide an equal opportunity to all students, regardless of gender, race, social class or other identifiable characteristic which may result in discrimination. I believe that our educational system, as an institution of a patriarchal society, is male-biased and continues to perpetuate and maintain the socialization and streaming of females and males into different and asymmetrical roles. I believe that the illumination and understanding of the means by which females are socialized and compelled to accept less powerful and more restrictive roles is fundamental to the eradication and dismantling of sexual inequality in our schools and in our society.

Limitations

As descriptive research, the purpose of this study was to obtain information which describes the attitudes of a sample of mathematics, science, and computer literacy teachers by using statements of opinion. Attempting to infer attitude from expressed opinion has limitations as people may choose to conceal their real attitudes and instead, express socially acceptable opinions. Closed questions do not allow respondents to express their full views and create artificially simplistic categorizations which cannot, and should not be expected to, account for contextual differences and individual interpretations of questions. In some cases, respondents may not have given a particular issue serious consideration. Voluntary self-selection and self-reporting are also confounding factors, thus, the results of this study cannot be generalized beyond the actual respondents themselves. This study was not designed and is not considered to explore the complicated and often hidden examples and causes of gender inequity in schools. It does attempt to illuminate some of the thoughts and feelings of mathematics, science, and computer literacy teachers involved in the study and to provide insights in identifying areas requiring more in-depth research and/or professional development for the target population.

Definitions

For the purposes of this study, gender and sex are used interchangeably, as they are in much of the literature. Masculine and feminine are used to describe the socialized characteristics which come about as part of our experience in a gender differentiated society.

Transformation, as it is used in this study, involves the development of a critical perspective through which teachers and students can begin to see how social practices are organized to support male interests, and the process whereby this understanding is then used as a basis for active political intervention directed toward social change and the dissolution of gender inequities.

CHAPTER TWO

EDUCATION, MATHEMATICS, SCIENCE, AND TECHNOLOGY IN CONTEXT: A FEMINIST CRITIQUE

In the past two decades, the struggle for equality between women and men has been gaining acceptance in Canada, yet, the structures which have historically created and maintained inequities exist in virtually unchanged forms. Feminists, today, are not only involved in a struggle for equality, but, also, in a struggle to understand patriarchy and its tenacious grasp on humanity. Patriarchal cultures can be described as cultures which seek to control women, exclude women, and attempt to control all those things women produce - from children to manufactures (French, 1985, p. 72).

According to French, the unequal status of women and men is maintained through the processes of stratification, institutionalization, and coercion. Stratification legitimizes male dominance by separating the spheres of women and men, and placing men in controlling positions, asserting that males are naturally more capable. Institutionalization sets up formal and informal rules and laws which favour male privilege and control women. Coercion, both covert and overt, ensures that women who attempt to assume powerful positions are sanctioned and that subtle reminders of women's dependence on men, whether economic or physical, are always present. French states that patriarchal dominance can be demonstrated both physically or symbolically, by reality or by ritual, and that both are powerful forces against women's equality.

A fundamental precept in sustaining patriarchal values is the creation of the illusion that male dominance and gender roles are "natural", however, the definition of what constitutes masculine or feminine behaviour varies considerably from culture to culture (French, 1985, p. 74). Thus, male and masculine are not synonymous terms, nor are female and feminine. As a result of the intense socialization processes surrounding gender, however, male and masculine are certainly related terms, as are female and feminine. Masculine and feminine are social and cultural constructs which have been altered over time and used to secure male privilege in different societies.

The historical development of patriarchy has been difficult for feminists to trace because an important aim of patriarchy has been to diminish and ignore the societal contributions of women and women's experience.

> Documents that are preserved usually serve the interests of the preservers, and all events are reported from a personal - that is

> to say, biased - perspective (French, 1985, p. 43).

In <u>Beyond Power</u>, French presents the view that matricentric values preceded patricentric values as a way of life. She argues that in early societies, before paternal involvement in conception was understood, human infants were totally dependent on their mothers for food, transport, and nurturing, and, therefore, the nucleus of the society was the mother-child bond. It is probable that early communities revolved around sustaining and supporting life.

French maintains it is likely that these humans were mainly harmonious groups who wandered from place to place foraging for food and small animals. Early technologies, digging tools, and containers found by anthropologists can now be dated back to a much earlier time than any known hunting weaponry, and it is probable that women, in providing food for the group, are responsible for these developments.

> It is likely that social order was fluid and permissive with no chiefs or leaders, merely fluctuating groups where quarrels resulted in someone leaving one group to join another (French, 1985, p. 36-7).

Contrary to traditional thought, French asserts that early societies were matrilineal, possessions and teachings passing from mother to daughter. Most of the work of the group was done by women who provided food, shelter, and education for themselves and their children. Men, responsible for other culturally defined tasks, had far more free time than women and were more excluded and alienated from the community.

Growth in the population and changes in the supply of game or vegetation must have led to the increasing unwillingness to migrate and to the development of horticulture. Since, to grow crops, humans had to control and manipulate nature, horticulture advanced a new relationship between humans and the earth. In addition, the discovery of the male role in procreation may have led to the new belief that men also controlled procreation, and that, women, like soil, functioned as receptacles for the seed.

Over time this new idea of control over nature probably began to replace the traditional matricentric values:

> To value control, power-over, means that any form of control seems a good simply because it is a control (French, 1985, p. 68).

The idea of control, once established, is contagious: a person interested in control will gain power fairly quickly over others who do not value it. French asserts that in order to maintain oneself, there are only two choices, to value power or be eradicated by it.

As society incorporated the values of control, technology and technique, the operational knowledge, practices, procedures and devices used to accomplish tasks, were gradually developed to serve the new purposes of power-over. This was seen in the development of early weaponry whose purpose was to increase the force by which humans could control both nature and other humans.

> Technology has always been a powerful enabling factor, from the time humans first made tools. However, the history of technology has been one of control more than one of liberation (Menzies, 1982, p. 9).

According to French, the positing of control as a value superior to the old values of fertility, continuation and sharing can be evidenced by the shift of worship from goddesses associated with nature to a transcendent god. The emergence of the ideology of control over nature had severe consequences for women:

> Because women had for millennia been associated with nature, had been seen as having a special relationship with it to which men were marginal, the new value gave men a centrality and power they had lacked. In addition, since the new god was transcendent, having power over nature without being touched by it, those who worshipped him claimed the same position: as their deity had power over the earth, men had power over the creatures of the earth, animals and woman (French, 1985, p. 69).

In positing that men were superior to nature and women, women's generative processes and their perceived closeness to nature were diminished. Volition, freedom from nature, and the illusion of control over nature were embraced as superior.

In the development of patriarchy, the concept that women and men were two different categories of people was the necessary prerequisite for stratification. Even today, theories that women and men have different abilities and inabilities are widely accepted and propagandized as fact. Females and males were and are ascribed different "natural" qualities, however, these have always varied somewhat from culture to culture. Particularly in Western cultures, masculine qualities were deemed to be those which demonstrated aggression, control and transcendence, and the epitomizing act of maleness and courage has been to kill. Male control and power has been exercised by individuals through competition and rivalry. The masculine values associated with permanence, structure, and immortality are part of controlling time, experience, and life.

Feminine qualities were associated with nature, therefore, considered sub-human, to be controlled. Nurturing, compassion, and love, emotional aspects, are all considered to be feminine and at the same time indicative of weakness. The epitomizing act of being female is that of giving birth, the polar opposite of "maleness".

These categories were and are translated into actions and attitudes in society; the men most esteemed through history are those who controlled the most, whether people, territory, ideas, or wealth. Women who are esteemed, where they exist, are those considered beautiful, or those having found fulfilment through giving and love. Even in symbolic ways, cultures have reinforced gender differences by assigning gender identities to non-human entities such as hurricanes and mountains, ships and nations. These artificial categorizations have been reinforced throughout time, in every aspect of Western culture - art, philosophy, education, literature, law, religion, and politics. They have been reinforced through rituals, tradition, and institutionalization, through legitimized "knowledge" and everyday practice.

The dichotomizing of human characteristics into gender categories has led to the different and asymmetrical social roles which women and men have filled in our society. It is likely that the major prescribed role for women, that of mothering, reinforces women's understanding of the world as connected and interrelated. Women's life experiences have often been relegated to the private sphere and concentrated upon care-giving activities while men's experiences have been in the public sphere and concentrated on abstracted learning. Women have been dependent on men for their economic survival and men have been seen as autonomous and independent despite the fact that women have been responsible for providing for their basic needs. This has meant that women's experiences and men's experiences in the same culture and environment have been very different.

Women's studies reveals that, in contrast to current belief, patriarchy has been contested throughout history. Feminism is not a construct of the twentieth century and may more accurately be viewed as having risen and fallen in waves over different periods of time. For example, the status of women was a political issue in the fourth century before Christ when the repression of women was at its peak in Greece. In the early tenth century feminist women in Europe regained some control over their lives and remained active in bettering the condition of women until the twelfth century. During this period in Germany, women appear as judges, military leaders, chatelaines, and controllers of property (French, 1985, p. 157).

The formal education system in North America today has its roots in Christian/European tradition. Christianity institutionalized male priests in the position of moral leaders and educators. As the Christian church shifted from the monastic system to the papacy in Rome, the church became increasingly hierarchial and exclusive. During this period of time, women were completely excluded from schools and universities, which were, increasingly and in time exclusively, controlled by the church. Common practices of women, for example, in medicine and healing, became regulated professions and women were forbidden to participate.

> Ancient and primitive medicine people were often women and many of them were burned as witches by an increasingly patriarchal society, eager to promote its own aggressive and divisive view of the world (Overfield, 1981, p. 242).

Nowhere are sanctions against women so vivid as in the witch trials at the end of the fifteenth century which effectively purged women who were not submissive and conforming.

The move to centralization in the church had great consequences for women in education. The centralization of power required uniformity and such uniformities confined rather than enriched culture. The rigid concept of curriculum, first manifested in these times and which now forms the basis of our North American education system, did create a shared communal perspective among those who were chosen or allowed to be educated, however, it is an approach to learning which excludes far more than it can ever include. It trains those given access to a particular way of thinking and separates those trained from those who are not. By clearly defining what was considered knowledge, and further by institutionalizing it, knowledge of a certain kind became power; and other types of knowledge were discounted. In this case, men's, particularly European men's, knowledge became power; the abstract, quantitative discourses of mathematics, geometry, astronomy, music, grammar, rhetoric, and logic formed the fundamental education. The experiences and knowledge of non-male, non-white, and lower class populations were rendered invisible and unimportant. In almost all cultures, patriarchy has historically denied women access to men's knowledge, either legally or by practice, and discounted women's own knowledge and experience by not including and valuing it in the curriculum.

The discourses included as a necessary part of being "educated", were not only exclusive in terms of what was chosen as knowledge but also in terms of how knowledge was delivered, the activities which defined the teaching/learning process. Men's education has concentrated on developing the masculine view, where problems are presented and solved as linear and rational, and where concentration has been placed upon arriving at the right answer through a standardized method.

Mathematics, for example, has often been taught through one standardized method of finding a correct answer. An alternative view of mathematics is in presenting the opportunity to find many different yet correct methods or algorithms to arrive at a solution. It is also possible to explore how different mathematical solutions might be correct depending on an individual interpretation of the problem.

When women were first formally educated in Europe, after the Protestant Reformation, they were subjected to a narrow vocational education designed to suit them solely for household duties. Women were not the only group who were subordinated by religion and its control over education. The history of Western colonization is replete with examples of how religious doctrines were used to diminish the spiritual beliefs and values, the knowledge, of many other cultures. The education of women has often been diminished both by race and by gender.

The emergence of "modern science" proved to be another powerful force in supporting patriarchy.

> Science has played a role in the social construction of gender and sexuality, with a masculine dominated social order legitimating scientific authority (Harding, 1986, p. 134).

In the sixteenth century, European artisans, shipbuilders, mariners, miners, and carpenters introduced new, modern technologies into their trades by inventing tools and machines through a combination of educated intelligence and the manipulation of instruments and materials. This new concept of experimental observation was used and refined by Galileo, Bacon, and Newton as a method of inquiry which has come to be known as the scientific method.

The scientific method is a way of separating knowledge from experience. It derives a generalization from particular events and then applies the generalization back to the particular. A requirement of the successful use of the scientific method has always been the separation from context, hence, the move to laboratory science. While useful as a model of understanding the world, the scientific method is much less successful when generalizations are achieved, as they often are, by omitting the essential considerations of the contexts in which they are applied. In seeking to simplify, science negates the interplay and interrelationships of powerful forces. It also negates human experience because it is focused solely on the development of knowledge through logic and reason (Franklin, 1990, p. 39).

In the seventeenth century, "The New Science Movement" in Puritan England had radical social goals. Early science was anti-authoritarian, emphasized control of knowledge by the common man rather than the aristocracy, and was directed at furthering the public good. In Galileo's words, scientific knowledge was to be for the people. Scientific endeavour gained support because its goals were coherent with the struggle to overthrow the political and intellectual authoritarianism of the time. However, the Restoration of the monarchy marked the end of a reformist science. Science was quickly institutionalized and the scientific method was standardized by Charles II. Scientists were thereby restricted to the creation of cognitive facts, which were to be kept separate from social and political programs.

Science, as it developed and has been institutionalized, is based on the assumption that rational, objective thought, free of emotion and personal or societal bias, can exist. In presupposing the scientific method to be objective, what is forgotten or ignored is that science is carried out by particular individuals who hold certain ideas and assumptions, and who proceed in their work by hunches, guesswork and fits and starts (Overfield, 1981, p. 240), and that what constitutes the body of scientific knowledge is controlled by who the scientists are, the limits of their resources, who supplies these, and who decides how the results will be used.

Another important origin of scientific bias occurs in the selection and definitions of problems for inquiry. The plethora of scientific studies on biological sex differences, and the dearth of research on sex similarities and educational sexism amply illustrate how this type of bias serves to legitimate social and personal views. Likewise, the determination of what is to count as evidence and of how much evidence is required to support or disconfirm hypotheses is a matter of judgement, not of fact.

Science, as it emerged, also presupposed that the natural world, like the world men had structured, was structured hierarchically on the premises of dominance and submission and not as a system of mutual interdependence and cooperation. There was an underlying assumption that all things were dichotomous and could be simplified and categorized when, for example, the world might be more adequately viewed as complex and interrelated and ideas thought of as on a continuum (Overfield, 1981, p. 246). Science presupposed the existence of laws of nature, which held true in all circumstances, as opposed to, for example, an order in nature which could also be spontaneous or self-generated, and dependent on context.

> Laws of nature, like laws of the state, are historically imposed from above and obeyed from below. By those who first used the term, laws of nature were viewed as commands imposed by the deity upon nature (Keller, 1985, p. 131).

The implicit and uncritiqued assumptions upon which our view of science has been based are consistent with a masculine world view.

Scientific metaphors have commonly characterized nature as female, passive and submissive to the male scientist. The language of science is in itself inherently sexual, and female and male are used as descriptive, qualitative, and fixed categories which are based on cultural stereotypes.

> In engineering, male parts are those which are active and penetrate; female parts are passively penetrated. Dominance and subordination/slavery are also used in biology and engineering (Overfield, 1981, p. 245).

In this manner "scientific" and "masculine" became mutually reinforcing constructs, and sexism as interwoven into the daily practice of science as it is in most engineering faculties today.

Because this particular vision of "science" was formulated in a white, patriarchal society, traditional science emanated from a European male world view. This "science" excluded both women's experience and other culturally different experiences, thus, the underlying assumptions of science as we know it are male biased, as well as culturally and racially biased.

At the same time the scientific discourse of value-neutrality, objectivity, and social impartiality have created a powerful rhetorical device for legitimating science's own biases and their adoption into equally biased laws and policy (Harding, 1986, p. 67). Scientific knowledge, or facts, are presented as the truth and are, therefore, largely unavailable to the critical examination of political and historical influences. This "sacredness" has been accomplished by separating science from its social uses, by instilling a view that science is progressive, regardless of whether its use is to support murder, racism or sexism. The harnessing of science to support military aims and develop nuclear weaponry can clearly be considered such an example.

The process of separation between the scientist and the application of scientific knowledge means that scientists may have the least understanding of the implications of their own activities.

> Science is seen as a collection of pure and objective facts. What individuals choose to do with these simple facts is their affair. Science is not [seen as] a political form of knowledge. Individual scientists are both absolved from blame and prevented from seeing science as a political force and as having some responsibility for how it is used (Overfield, 1981, p. 241).

Science, like other forms of knowledge and power, was harnessed by patriarchy in the political fight to legitimize the position of men and women in society. In its claims of discovering the objective "truth", science, since its inception, has successfully found ways to determine women to be inferior. In different times, scientists have studied the frontal lobe of the female brain to find it smaller, therefore, inferior to men's, and later larger, therefore, inferior to men's

(Fausto-Sterling, 1985, p. 38). Science has documented "proof" that women who were educated would become sterile.

> Woman, as the object of nineteenth century science, was gentle, not profound, the holder of moral order...Developing from this poor, frail, moral woman whose failure to reason was produced through incapacity not oppression, we came to the arguments which see it as psychologically dangerous for women to reason. They were endangering the future of the species by engaging in the strain produced by such an unnatural activity (Walkerdine, 1987, p. 42).

Felter argued in 1906, that for girls to use up their energy at puberty in intellectual activity would endanger the development of their reproductive organs, producing the possibility of infertility, thus, endangering the species (From Walkerdine, 1987, p. 42) In fact, the emergence of threats to existing gender order have often been followed by new scientific discoveries of women's inferiority (Harding, 1986, p. 68).

The scientific revolution steadily produced new technology and legitimized the notion of applying science to a specific purpose. In Europe, the Industrial Revolution brought a new era of factories and heavy machinery. Individual lives were substantially changed by a move from cottage industries to factory work, regulated and controlled in rigid, hierarchial structures. Long apprenticeships and unions kept women, who might work for less wages, out of factories under the guise of physical ineptitude. Women's participation in the technical work force during war years has long since proven this an unjustified and false claim. In Western cultures, and later in many other cultures, instrumentalism and industrialism manifested a new mechanism of power-over, power over the time and labour of others.

Over the course of the twentieth century women have forced educational institutions to remove many restrictions on their access and participation. The continuing existence of differential participation between females and males of all races is proof, however, that powerful barriers to equality still exist within the educational system.

Women have been more systematically excluded from serious science than almost any other social activity (Harding, 1986, p. 31). Few women have achieved eminence and the majority of women in science are still found working at technical and assistant levels. When scientific institutions were threatened by an increasing presence of women, women were marginalized in the name of "higher standards". Women were not legally eligible for funding in Universities until the early nineteen hundreds and even today face systemic discrimination in qualifying. Because part of the male gender identity is to view whatever women do as inferior, scientific work done by women has remained invisible and is often not cited even when it has been objectively indistinguishable from men's work (Harding, 1986, p. 64).

During the last century the social use of science in the West has shifted from assisting to generating economic and political accumulation and control. The attempt to dominate nature for the betterment of the species has become an effort to gain unequal access to the world's resources for the purposes of social and economic domination. Individuals and corporations have increasingly directed science to the ends of exploitation (Overfield, 1981, p. 243).

Scientists are now part of a vast work force, where 99% of research is expected to be immediately applicable to social projects (Harding, 1986, p. 16). These industrial empires are based on the overwhelming credibility of scientific rationality in twentieth century cultures, despite its intrinsic and documented biases.

Since the industrial revolution, technology and technique have gained prominence alongside science as mechanisms of power in our society. The technical world view with its emphasis on facts, control, rationality, and distance from emotion or personal consideration is the current successor of the traditional male power structure. It is not surprising that the role of governments in the promotion and support of technology has increased radically in the last century. Publicly financed infrastructures ranging from telephones to nuclear research have emerged only as a result of powerful, political influences.

Recent technologies, particularly the computer microchip, are transporting us into the information age. Just as science was harnessed to replace manual labour in the industrial revolution, so automation is replacing mechanical labour. Computer technology is absorbing skills and control over the work process into machines and leaving people with much simpler jobs to do. It reinforces a new degree of social isolation and mitigates against reciprocal human contact. This new technological milieu has established and perpetuates its own values: efficiency, with no regard for what is being done efficiently, and productivity (Franklin, 1984, p. 82).

> With respect to the relationship between science and technology, it has often been assumed that science is a pre-requisite for technology. Science has stimulated the development of technologies, however, science is not the mother of technology. Science and technology today have a side by side parallel relationship - they stimulate and utilize each other. It is appropriate to regard science and technology as one enterprise with a spectrum of interconnected activities (Franklin, 1990, p. 38).

The political institutionalization of technology has meant that a certain group of males are in the position to decide what technology is developed and what it will be used for. The dominant male view typically operates on a logic of profit and control, thus, technology, like science, has been harnessed by business, industry, and the military at soaring rates. In the technological order, tasks are fragmented, specified, predictable, scheduled, and carried out regardless of context.

> As we learn more about the biological building blocks of the natural environment, we are coming to realize that the universe is, like a machine, made up of standardized, interchangeable parts (Rybczynski, 1983, p. 226).

Humans and indeed the natural environment are not, however, made up of interchangeable, produced parts. We are growing and changing individuals, interconnected through a myriad of different relationships. Growth is not synonymous with production, for production assumes the emergence of predicted and controlled products, while growth is both unpredictable and uncontrollable. Growth is a creative and unique process, requiring nurturing, with unique and incalculable results. The increasing use of production based technology to perform growth oriented functions, as in the application of the production model to education, is inappropriate, yet, no schemes exist to judge or control the appropriateness of such technological applications (Franklin, 1990, p. 126). Instead, it is assumed that the technological and production model will be superior, both in process and product.

Those involved in the development of technology have attempted, as with science, to promote all development as progressive. The social institutions which support technology attempt to disenfranchise outsiders by making personal experience appear marginal and irrelevant.

> We no longer rely on our own experience and senses. The decibel reader tells us whether or not we have a headache. It is sometimes necessary to discount science instead of our own experience (Franklin, 1990, p. 40).

In the face of criticism regarding technological development scientists and government present technology as an uncontrollable and inevitable force. This positivist view of technology is one of the major obstacles in the formation and implementation of public policies to safeguard the integrity of people and of nature (Franklin, 1990, p. 127).

Authority in the technological milieu is derived from access to, and control of, the various levels and interfaces of the structure. In this sense, technology's main function has been prescriptive, reinforcing external control and internal compliance rather than holistic, reinforcing creativity and empowerment. Today, technology is being applied in a way which will reduce the number of employees necessary and bring labour savings to management, not in ways which will stimulate new and enriched employment opportunities or increase job satisfaction. Fundamental tools and techniques which would support human interaction, sustain the environment, and enhance cooperative efforts at non-violent conflict resolution have yet to be developed or sustained, however, we have had the technology to destroy the world for several decades.

> Technical innovations rarely eliminate oppression and poverty, but tend to displace the locus of such injustices. Technological changes by themselves do not produce more freedom, but often result in different and frequently more stringent constraints, though sometimes for different groups of people (Franklin, 1990, p. 83).

Technology has emerged as the twentieth century symbol for masculinity and power.

> Domination over nature, i.e. control over the physical world, is a central feature of present day technology. Part of the technical world view (which is the male norm) is the belief in one's right to control the material world. Part of the successful socialization as a man in our society involves gathering confidence in one's actual ability to exercise that control (Benston, 1988, p. 20).

Women are excluded from experiences with tools and machines, but, more importantly, from an understanding of technique, the knowledge of how to construct and use equipment, and of the physical principles by which machines and tools operate. As history demonstrates, women's exclusion from powerful forms of societal knowledge coupled with the diminishment of traditional female values works in the interests of sustaining patriarchal inequalities.

In the twentieth century, a new wave of feminists are continuing the effort to secure equality as a legacy for future generations. What the history of patriarchy does not record is that individual women and men have always functioned outside gender restrictions; women have been scientists and men, nurturers. The barriers to such experience, however, have largely confined women and men to separate and asymmetrical spheres and in the face of many waves of feminism, patriarchy has proved tenacious.

Education, mathematics, science, and technology are all interwoven in this fabric of patriarchy. Studious, deft, and unceasing work is required to understand and change the nature of this fabric so that our society can fully reflect all the dimensions of being human.

CHAPTER THREE

EXPLANATIONS OF DIFFERENTIAL PARTICIPATION: THE EXPERIENCE AND THE EXPERTS

Introduction

Women and men participate and contribute differently in our society according to sex. In education, girls and boys continue these patterns in the same stereotypical ways despite perceived increases in opportunities. The explanations for the underrepresentation and differing attitudes of female students in mathematics, science, and technology can be discussed under three themes: ability, socialization, and cultural production.

Ability - The Nature/Nurture Argument

In 1991, we should be able to reject suggestions of the biological superiority of males without discussion, but the tremendous publicity and propagandizing of biological differences is a central feature in understanding why women do not participate equally in scientific study.

> Early in this century, scientists argued that there might be more male than female geniuses because male intelligence varied to a greater extent than female intelligence. This "fact" provided proof positive of the overall superiority of the male mind. Hypotheses in defense of these

> positions still pop up from time to time. They consist of old ideas in new dress (Fausto-Sterling, 1985, p. 59).

This past year, the Winnipeg Free Press reviewed a book entitled, Brain Sex: The Real Difference Between Men and Women. The review suggests that studies have conclusively shown hormones in the fetal brain produce differential ability and are responsible for women and men excelling in different areas. It also suggests that interference or obstruction produces, "of course, masculine women, effeminate men, and homosexual behaviour". The reviewer states:

> For at least three decades, now, we have been told that except for certain obvious and undeniable physical discrepancies, there is no difference between men and women. We have been told that the apparent differences in abilities, characteristics and emotional qualities between the sexes is largely a result of a sexist, male-dominated social system that has traditionally relegated women to certain roles, largely for the benefit of men. This is now accepted as writ, it is taught in our schools and it is being used to reorder society. It is also wrong and unfair to everyone involved. (Oleson, 1990).

This book review is an excellent illustration of the "scientific" publicity surrounding sex differences. In a society dominated by patriarchal thought, selections for publication overwhelmingly support the dominant view. As a result, studies confirming sex differences are published and a significant body of other research, reflecting no sex differences or attributing differences to environmental variables, is ignored.

When differences are found, the results are often grossly misinterpreted and exaggerated. Relatively small differences are used to explain the almost total absence of women in some occupational fields. Differences are assumed to be innate, therefore, attempting change is presented as futile, or worse, damaging. Overgeneralizations abound, to the point of using sex difference research to explain sexual behaviour. Women, who achieve in masculine areas, are viewed as "masculinized" and unnatural, thus, gender is viewed as a construct of nature, not society (Fausto-Sterling, 1985). The language used in these reports suggests that those who question the research lack intelligence. Assumptions are often presented as fact, research on animals applied to humans when it fits the purposes of the researcher and forgotten when it does not. In his thinly veiled support of equality, which he defines as different but equal, Oleson goes so far as to imply that women today are being victimized by a women's movement which suggests they can succeed in male dominated areas.

Thousands of studies have been attempted by educators, biologists, and psychologists around the world to prove there are innate intellectual differences between women and men, yet, nothing conclusive has been found. Attempts to provide proof have been continually dispelled by vigilant, mainly feminist researchers over the past few decades. "It would be difficult to find a research area more characterized by shoddy work, overgeneralization, hasty conclusions, and unsupported speculations (Julia Sherman, 1977; from Fausto-Sterling, 1985, p. 13). Despite such work, the publicity of sex difference research aimed at legitimizing the status quo has the effect of denigrating the purpose of educators working for equality and is often used to legitimize the unequal participation of students in the sciences. Perhaps more importantly, females, too, hear and read these messages which are presented by the media as proven fact. The impact of these continuing messages in creating self-fulfilling prophecies and expectations of failure cannot be discounted.

Current biological arguments for women's lack of representation in mathematics, science, and technology are based, roughly, in three areas, genetic inheritance of a recessive gene on the X chromosome, the influence of hormones on brain structure and function, and differences in lateralization/specialization of the two hemispheres of the brain. While early studies reported correlations that fit those predicted by the X linked hypothesis, subsequent studies have found correlations which do not (Science Council of Canada, 1981, p.54).

Of major significance is that no causal relationship was ever established. Further, some scientists now concede that one of the two X chromosomes women carry quickly becomes silent and, therefore, cannot be implicated in spacial ability differences.

Bleier (1984) has discussed at length the subtle processes which occur with biochemical conversions of hormones within the body and the lack of reliability in current hormone measurement techniques. Levels have been documented to change radically, and be ignored, in control groups. She supplies evidence that sociobiologists base their work involving hormonal influences on behaviour by selectively extrapolating from animal behaviour without substantiating any relationship to human behaviour. Observational research has been used in an attempt to document behaviours, however, these behaviours are often defined in stereotypical and biased ways and are subject to the perceptions of the (male) observers.

Like sociobiology, brain lateralization research, the newest of this long-standing tradition, is highly selective. For example, men's right-brain dominance, the present assertion, supposedly supports analytical ability, but the right brain appears equally as likely to support holistic and gestalt thinking, a characteristic more often associated with women.

Studies have also shown that cerebral lateralization and specialization is not immutable during childhood and it appears plausible that the developmental environment of children may play an important role in adult capacities (Bleier, 1984, p. 49). Further, the technology to adequately test which areas of the brain are responsible for different types of cognition is still extremely marginal. One might more importantly ask why sex difference research has been among the first of its applications.

There is a plethora of studies attempting to measure the differential achievement and abilities of girls and boys, many of which have tried to suggest that girls are innately less able to do mathematical and scientific work than boys. These studies overwhelmingly use test instruments, in particular standardized test instruments, to measure achievement.

Recently, Carol Gilligan (1982) has been studying the competitive ethic of boys and comparing it with a more nurturing and cooperative ethic which develops in girls. Testing and examinations are based on an individual and competitive learning style and may argue for inherent sex bias within the activity of testing itself.

The experience of one of the teachers interviewed in the course of this study provides an interesting insight,

> "Grade four is when we first saw it. Girls cried because they couldn't get their speed tests done. In a testing situation, they just broke down."[1]

These types of observations reflect the need for research to examine and include new measures of achievement such as academic conferencing in order to account for testing bias. There is clear evidence to support that a contradiction exists between national standardized test scores in the United States, where boys outperform girls by the secondary school level, and report card grades, where girls outperform boys (Sadker, Sadker, & Steindam, 1989, p.47).

In 1974, Maccomby and Jacklin published a landmark analysis of sex-difference research, concluding that girls demonstrated less visual spacial ability than boys.

> Visual spacial tests have a similar developmental course. The male advantage emerges in early adolescence and is maintained in adulthood (Maccomby & Jacklin, 1974, p.94).

Visual spacial ability has been defined as the ability to visually manipulate images without the aid of verbal mediation. The most common tests to measure this are

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[1] *Quotation marks are used to indicate statements taken from interview transcripts.*

the embedded figures test, the block design test, and the folding blocks test (Science Council of Canada, 1981, p.50). Despite the fact that studies consistently show little or no difference in childhood and the greatest differences when they were found were very small, .4 of a standard deviation, Maccomby and Jacklin attributed the differences to a biological predisposition in males. Further, they based this conclusion primarily on the unsubstantiated X chromosome theory, and have since been frequently cited as <u>having established</u> a biological basis for sex differences.

Benbow and Stanley (1982) studied a select population of high-achieving mathematics students in the U.S. and concluded, on the basis of Scholastic Aptitude Test (S.A.T.) results, that males had innately superior mathematical ability. Girls were found to have obtained scores on average between 7 and 15% lower than boys. This study relied heavily on S.A.T. performance as a measure of innate potential ability although it was never designed as such. Linn and Hyde (1989) found that on U.S. Scholastic Achievement Tests, the test question with the greatest differential between girls and boys required students to calculate the number of basketball games required to obtain a 55% winning percentage for the season. Further, since

S.A.T. results are timed, students who did long calculations, rather than making educated guesses based on personal experiences, may have been penalized even if they determined the correct answer. Evidence strongly suggests that test bias can exaggerate sex differences by selecting context which favour either males or females, thus, no conclusions as to differential ability can even be considered without systematic, item by item review of the measurement instruments. The test itself included many questions related to sports and scientific activities, clearly favouring boys. The use of S.A.T. results in determining University entry in the United States is a clear example of systemic bias.

In addition, Benbow and Stanley made no attempt to control for the formal or informal mathematical and scientific experiences of the two groups, significant confounding variables. Fennema and Sherman (1978) found that when studies controlled for the number of related courses taken there were no discernible differences. In reviewing the Benbow and Stanley study, Tobias (1982) found that Fox and Cohn, two researchers who also participated in the study, reported that boys in the program had systematically studied mathematics and science textbooks with a parent or teacher before entering the program. Further, she found that in similar situations boys' parents were more likely than girls' parents to help prepare their children for such programs.

In their meta-analysis of sex difference studies since 1974, Linn and Hyde (1989) conclude that significant differences in girls' and boys' performance on spacial visualization or quantitative tasks no longer exist, although there is some evidence for differences favouring males in mental rotation tasks. While some trends have shown females are superior at computation and that differences favouring males on problem-solving applications emerge at high school (Linn and Hyde, 1989), Fennema and Sherman conclude there are not universal sex-related differences in mathematics learning (Fennema and Sherman, 1978, p. 197) and results appear to be heavily contextual.

According to Linn and Hyde (1989), U.S. studies on science achievement show that males do outperform females, especially in physical science. At the same time, males reported substantially more informal experience with these concepts than did females. Overall, gender differences in science were larger for scientific knowledge than for processes and reflected the formal and informal learning experiences of females and males. In a recent worldwide assessment of science achievement, males outperformed females in every country, including four Canadian provinces, although the greatest difference was only 8% of total scale points and in many cases females from one country outperformed males from others (Lapointe, Mead, and Phillips, 1988, p. 40). Similar to the studies on mathematics achievement, Parker and Offer (1987) demonstrated that, when the number and type of science courses are controlled for, a clear demonstration of sex differences effectively vanishes.

Despite exhaustive research on sex differences in achievement and ability, there is no proof that the small differences are related in any way to biological factors.

> In summary, recent research in history, anthropology, and psychology has converged to make completely implausible the assumption that gender and sexuality are determined by the sex differences necessary for reproduction (Harding, 1986, p. 134).

The fact that females have excelled in mathematics and science, that females of one culture outscore males in another (Lapointe, Mead, and Phillips, 1988, p. 19 and p. 40), and that top achieving females are among those who leave mathematical and scientific fields of studies (Nevitte, Gibbons, and Codding, 1988, p. 31) mitigates strongly against biological reasons for sex stratification in education or in the work force. In addition, recent studies support the view that differences in mathematical ability have effectively disappeared over the past few decades, whether because of less bias in research or increased course taking by females. It appears that differences still exist in the number and type of scientific concepts which males and females have incorporated and this is consistent with their differential experiences. Even these differences, where they exist, are far to small to begin to explain why faculties such as engineering are still 90% male.

Socialization

Theories of socialization share the underlying view that individuals are shaped by their experiences to internalize or accept a subjectivity and position that leads to the reproduction of existing power relationships and social and economic structures. Theorists focus on the ways in which certain groups are legitimated through the language, knowledge, and patterns of interactions which are sanctioned as "proper" and valued (Weiler, 1988, p. 9).

In practice this has meant that girls and boys are identified and treated differently from the moment of birth.

> Parents see daughters as more delicate, weaker and smaller and their sons as firmer, large featured, more alert, sturdier and hardier. The sex-typed parental responses occur in spite of data confirming no sex differences in physical or

> health characteristics (Bean; from Sprung, 1978, p. 97).

Even the same baby will be described differently depending on whether people are told it's male or female (Pogrebin; from Sprung, 1978, p. 115).

Similarly, the early learning experiences of children are often extremely sex-typed. Toys and play frequently provide boys, and not girls, with pre-scientific and practical experiences of educational value. In a 1975 study, Rheingold and Cook (from Sprung, 1978, p. 115) found that rooms occupied by six-year old girls contained dolls, dishes, arts and crafts, and passive games. Boys of the same age, had trucks, blocks, and sports equipment. An Elementary teacher interviewed for this study stated,

> "That's where the building with blocks and models comes in - they [boys] see all the parts and they put them all together and it makes this wonderful, large thing; where girls see the whole thing and can't get into the pieces and parts of it. I don't know if it's a different learning style that girls have or not, they just don't seem to be so analytical about it. Maybe that's where it all starts."

Studies of women who excelled in mathematics and science have shown that early exposure was a significant commonality (Fabricant, Svitak, and Kenschaft, 1990, p. 150).

In interviews with boys, Hart (1978) (from Sprung, p. 104) found that, although boundaries were set for boys as for girls, the boys were able to tell him what was beyond the boundaries and related that they exceeded boundaries with their parents knowledge even though they weren't supposed to. In observations of outdoor play patterns Hart noted that boys modify the landscape in play activities, often building structures and physically manipulating the environment. Girls in outdoor activities tended to build rooms and decorate the interior spaces. Further, Hart observed that when girls did begin large building activities, boys intervened and later dominated the activity.

The experience of a teacher is encapsulated in this comment:

> "I think it's just the fact that little boys when they walk into kindergarten have been pushed to explore everything. They can go off the street and play in the field. Their curiosity is at a much higher level. Girls will tend to stay back."

When children enter school they have already stereotyped science as a male activity (Harvey, 1980, p. 74) and their interests are differentiated along sex-typed lines, with girls drawn to biological science and botany and boys drawn to the physical sciences (Whyte, 1986; Kelly, 1987). During several recent visits to kindergarten, I found girls were rarely in building centres during free time and almost never approached the railroad centre. In contrast, they were predominant in the drawing and colouring activities as well as the house centre. These observations are consistent with our expectations of what females and males do in our society. Guttantag found that sex-roles were clearly defined in kindergarten regardless of social class or ethnic background (Guttantag, 1976).

In North America, as in most societies, there is a general concept of masculinity and femininity and of the behavioral traits which characterize each gender. Interest in science and mathematics is related to and mutually reinforces typical masculine competencies, rationality, objectivity, and independence. The degree of sex stereotyping varies from context to context depending on such factors as socioeconomic status, race or ethnic background, parental and family beliefs, teacher beliefs, and educational environments.

The feminine stereotype in North America places a heavy emphasis on passivity and responding to others needs. Therefore, it is relatively easy for parents and teachers to use approval and disapproval to control the behaviour of females. The result is that the focus of activities for girls, including education, may be placed on gaining the approval of others and not on gaining satisfaction from task completion. Eccles and Blumenfeld (1985) found that girls consistently reported that they would feel worse about violating procedural and moral norms than boys. In school, teacher approval is often demonstrated for neatness, organization, conformity, and following rules. This orientation has implications for the risk-taking behaviour necessary in scientific activity.

> When the girls asked questions of the teacher they were concerned about the right answers to questions or whether their experimental data were correct... If experimental findings were different than they had anticipated, the girls seem to be annoyed. The boys, on the other hand, were intrigued by the unexpected and often tried mini-experiments (which the girls tended to call fooling around) to investigate the unexpected results. These findings are consistent with the findings of Kahle et al (1985) who found that males reported doing more science activities in school than did females in the same classes (Haggerty, 1987, p. 277).

Scientific learning is based on exploration with materials, hypothesizing, testing ideas, and contains an element of risk. There is some evidence to suggest that, although this may not be the predominant way science is taught in schools, this is the informal experience that boys have by virtue of their socialization.

> Boys have a decisive advantage over girls in science due to their socialization. Girls have little experience with technical toys before they attend..many boys possess a chemistry set before the first lesson...Present day chemistry lessons are another problem... According to teachers, very few pupil experiments were being carried out due to lack of time and a high number of pupils (Wienekamp, Jansen, Fickenfrerichs, and Peper, 1987, p. 285).

The experience of a teacher supports this:

> "That's why we need to do more hands-on things with females, the building, and the construction, and seeing the patterns, because that has a link to experimentation in science. Girls don't want

to get in there and do the dirty work; they'd rather just stand back and watch."

If, as many educators have suggested, participation in advanced science depends on earlier grounding and achievement is based on cumulative knowledge, the lack of early experience with scientific and technical concepts clearly disadvantages girls. Further, the methods by which mathematics and science are taught in schools, when involving textbooks or demonstration, may work to reinforce this disadvantage and increase the likelihood that girls will not master the early building blocks for scientific and technical concepts. A mathematics and science teacher said this:

> "The textbook approach keeps girls from getting any other picture of what it [science] could be. I think that when you walk into a classroom and science is being taught through a textbook, the little boy who is curious about something will still want to explore some things and will probably go home and say, "What really happens if I put baking soda and vinegar together?" and try it when his Mom isn't watching in the kitchen. But the little girl will go, "Yep. That's what it's supposed to do. That's okay. I don't need anything further." So the tendencies which were part of these children before will go on. As a science teacher, I think we are reinforcing non-exploratory behaviour in girls. We're learning and reading about things being done but we never see it. It should be hands-on from kindergarten to twelve."

Even in active science classes, there are differences in what girls and boys learn; girls are more likely to take over the traditional helping or secretary role while the boys do the experiments.

> When left to their own devices in coeducational science laboratory teams, girls tend to assume the role of passive recorder and boys the active role of experimenter, according to a report by the American Federation of Teachers (AFT Bulletin, 1987; from Fabricant, Svitak, and Kenschaft, 1990, p. 152).

Thus, girls participation in science has been found to be different than boys, even in the same classrooms where everyone is responsible for the same work. A teacher explained:

> "I had a tendency to find that they [girls] wanted things done for them and the little boys would just go and do it. They [boys] would do a lot more than they were required to. If I left a scientific experiment on the table, every single time we'd do it - I'm thinking more of my grade five and six classes where I'd have them in a classroom all day and I could set up little stations all over the place - every single time the boys had nothing to do and were finished something, they'd throw themselves on the little science lab while the girls would take a book and read. They [the boys] would try things, they'd come and ask me if they could push it one more step, bring this from home and try that".

As part of developing masculinity, boys are expected to learn about machines, tools, and how things work. Ritualistic behaviours for young men surround cars, guns, and video games. Young women are not expected to display this social knowledge and further, they are taught to consider equipment as dangerous and unfeminine. Thus, they are often excluded from knowledge of how to construct and use equipment and from knowledge of the physical principles by which machines and tools operate.

> Men and women have access to different vocabularies, experiences and concepts around tools, machines and technique. Women are excluded from education and action in the realm of technology. They do not have the same access to technique or the same experiences with concepts and equipment that men do. They are not expected to act from a technical view of the world (Benston, 1988, p. 19).

Studies related to differential use of computers between females and males support that females continue to be excluded from knowledge surrounding technology, and in particular, computer technology. Collis (1987) found that 3-6 year old children already associate computers with boys rather than with girls. Sheingold et al (from LeBold, 1986, p. 71) reported that gender differences in computer use spanned all grade levels, with males having higher amounts of usage and access, both at home and in school. At Elementary levels, studies show significant gender differences in participation (Fetler, 1984; from Collis, 1987). In secondary schools computer access and usage were often polarized in mathematics and science areas where males predominate and are more comfortable. Gender differences in extracurricular computer use are also well-established (Collis, 1987). Gender differences in computer access and usage are found in homes as well, with fathers tending to bring the computer into the home and spending more money on computer software and peripherals for male children. (Muira and Hess, 1984; from LeBold, 1986, p. 71).

The result of greater experience in scientific practice means that boys exhibit greater self-confidence in these activities (LeBold, 1986, p. 72). In fact, Robertson argues that girls maintain a lower level of self-confidence generally and that this is a critical factor reducing their risk-taking behaviour (C.T.F., 1988, p. 11). Pederson, Bleyer, and Elmore (1985) found that confidence in learning mathematics correlated higher with mathematics achievement than any of the nine factors identified by the Fennema-Sherman subscales.

The experience of a teacher is related in this incident,

> "I remember teaching math in Junior High and I remember girls coming from grade six who were absolutely crying. I had two girls who came in first day of class right away and said, "I flunked math in grade five and six. Don't expect anything out of me." I said "That's nonsense. That's your attitude and your problem. We'll start from the basics and we'll see what you're lacking and we'll push you through it and then we'll start brand new." And they just loved math. They were top students at the end of the year but their attitude was the key to all this. They weren't working any harder or having any problems understanding. It's just all of a sudden math was fun and they looked forward to coming to the classes."

Tied to this is the development of a mythology that mathematical ability is not learned, but is innate. An interview participant said,

> "A lot of things need to change - the whole attitude that if you're not good at math, you'll never be good at math."

In a study of 2,553 American students from grade 6 to grade 11, Fennema and Sherman (1978) found differences between females and males in confidence in learning mathematics, stereotyping of mathematics as a male domain, perceptions of parental attitudes, and perceptions of the usefulness of mathematics. Armstrong and Price (1982) in studying American high school students, found that confidence, usefulness, parent's expectations, and teacher encouragement as well as grades and previous mathematical experience are highly correlated with taking mathematics courses.

Parent's expectations were noted by the interview participants as well.

> "Most of the kids who get identified as gifted kids in math are boys - parents don't see girls as mathematicians. I think parental attitudes is probably one of the most important factors."

Socioeconomic status was a significant variable for girls, but not for boys. Sherman (1980) found that, while achievement and attitudes of 200 American students were undifferentiated by sex at grade 8, by grade 11, girls attitudes, including their confidence about learning mathematics and the perceived usefulness of mathematics, had declined significantly in relation to boys.

Eccles and Blumenfeld (1985) reported that Junior High boys in the United States thought mathematics was easier to master and had higher expectations for success in future mathematics courses and in jobs requiring mathematics skills, and that, even when girls performed as well and teachers expectations were the same, girls still had less confidence in their ability. In a study of 89 high school students in Quebec, Mura, Kimball and Cloutier (1987) found that girls expressed less self-confidence than boys and attributed their success in mathematics more to effort than boys.

The tendency for girls to think of mathematics, particularly calculus, physics, and computer science as "hard", combined with their lack of confidence, seems to have an enormous effect. An interviewed teacher stated:

> "That persistence thing - I see girls giving up and I'm not sure why. We need to investigate that whole aspect."

If female students are less confident about their ability to do mathematics and science than males, even when both groups perform equally, equal enrolment in high school classes will not ensure that girls will in the long term maintain equal career opportunities.

> Even when the two groups perform equally, males overestimate their ability while females are more realistic (Linn and Hyde, 1989, p. 23).

Studies based on attribution theory link this to the fact that girls tend to attribute their success to luck or other external factors and their failure to lack of ability while boys do the opposite (Dweck and Elliot, 1983). These differences manifest themselves in early adolescence and are maintained into adulthood.

Morse and Handley (1985) studied 155 Middle school students in the United States over a two year period and found that student initiated classroom interactions in Science changed from 41% female in the first year to 30% female in the second year among the same group of students. In addition, disciplinary responses directed to boys increased from 53% - 86% over the same period and male student control of class business matters increased from 60% to 91%. Similarly, Wienekamp et al (1985) found in Grade 8 West German chemistry classrooms boys received more attention from the teacher than girls. Spender (1982), Crossman (1987) and Sadker and Sadker (1986) have documented the same male dominated communication patterns in British and North American classrooms; males tend to dominate discussion and often interrupt, or ignore, female contributions. Eccles and Blumenfeld (1985) found that the contributions and participation of female students varied according to the teaching style and climate in the classroom. Where teachers used less lecture and more conference-like activity and where teachers controlled lectures by directing questions themselves as opposed to relying on volunteer answers, girls were more likely to participate.

Science and other studies involving technical concepts have for a long time been viewed as male domains. As a result, much of the curriculum content, constructed by males for males, is more interesting to traditionally socialized boys than to girls. The experience of one science teacher was

> "When we had students doing science fair projects. they [the girls] said, "I'm not interested in anything." I said, "Well, how about the types of shampoos being used in your family and how that's effecting your hair? You can study that, the research of it, the science of it; how's that?" "This is not science." "Well of course it is. You have scientists being paid $50,000 a year to research this." I think they [the girls] have got to be made aware that parts of their lives are very scientifically oriented and they're not even aware of it."

Girls and boys do show different interests in school, interests which need to be considered and included in the curriculum.

> "If you look at the peace movement and the environmental awareness movement in this school they are mostly women and so they are attracted to this type of thing. If it's one way of pushing them to sciences, then, let's do it."

Surveys of male and female physics interests (Forg and Wubbels, 1987, p. 301) at the high school level indicated that females were significantly more interested in topics like ionizing radiation and weather and significantly less interested in electronics and electrical machinery, thus, it is important that topic areas through which physics concepts are studied include areas which appeal to females.

> The results can be regarded as confirming how important it is that a curriculum satisfies the specific interests of girls. The appreciation for units like Traffic and Ionizing Radiation, the contents of which are presented in the context of humans and safety, confirms the significance of such a context for girls. This is despite the fact that in the unit on Traffic, the main subject treated is mechanics, a hard part of physics (Forg and Wubbels, 1987, p. 304).

In addition, examples used by teachers to make subject matter relevant to everyday life all too often relate mathematical and scientific skills to activities with which boys can readily identify and girls cannot (Stanworth, 1983, p. 19).

Science resources and textbooks further reinforce the idea that science is a male domain. Biased language, presentations of scientists as male and textbook pictures showing only males involved in scientific activity are very common. Science history includes few females and almost no references to female involvement in science in the past. In examining five recently published, popular, seventh grade life sciences textbooks in the United States, Rosser (1990) found, that while overt sexism did not occur, that is, use of masculine pronouns as generic and exclusion of women from pictures, more subtle forms of sexism still pervaded all five texts. They all pictured males more frequently than females and when women were pictured they were more often in passive roles. Two of the books included no descriptions of women scientists and three included no pictures of women scientists. Only two of the texts contained information on topics specific to women's health, such as pregnancy or menopause and only one of these provided any detail.

The male orientation of the major portion of available computer software is cited by LeBold (1986) as one reason for the observed gender differences concerning interests and attitude to computers.

The tendency for science to present itself as objective and outside the realm of ethics and morality is also reflected in educational curriculum. If science is to reflect the dimensions of the feminine as well as the masculine world, then it must reflect a caring and relational attitude toward humans and the environment instead of an attitude based on control. This new attitude means that ethics must become an integral and explicit part of teaching science, and scientific developments must be based on values other than efficiency and productivity. A Biology teacher's experience supports the view that young women in the school division where this study took place do have a greater tendency than young men to be concerned with ethical issues,

> "I've had girls, and they were all girls, who've said, "I belong to the peace movement and I'm against this cruelty to animals." I gave my little speel. It has nothing to do with burning animals and testing them with chemicals. I had a whole lecture where we discussed that I wouldn't kill animals. More and more there are guidelines to be followed and these animals are not just killed in the fields and being brought into the class. And the guys will go "Aww, come on. Its just a pig and its dead." I taught over 240 students and I didn't have one [boy] come and say Whoa!"

Science curricula presents the scientific method as integral to the concept of science itself and focuses on obtaining "unbiased" results through quantitative study. Qualitative methods are absent, and considered less scientific. Problems are examined in laboratory settings and research is not presented to students as needing to be carried out in context where many forces are apt to influence the outcomes of applications and where unexpected consequences are likely to occur. Keller (1983) gives Barbara McClintock's view of the limitations of the scientific method,

> In her mind, what we call the scientific method cannot by itself give real understanding. It gives us relationships which are useful, valid, and technically marvellous; however, they are not truth. And it is by no means the only way of acquiring knowledge (Keller, 1983, p. 201).
>
> Too restricted a reliance on scientific methodology invariably leads us into difficulty. We've been spoiling the environment just

> dreadfully, and it's slapping us back because we didn't think it through (Keller, 1983, p. 205).

Along with this reliance on the scientific method as the only method of gathering scientific knowledge, the curriculum also artificially simplifies and categorizes the disciplines. If, as Gilligan (1982) suggests, women are more apt to understand and view the interconnectedness of concepts as important, a holistic or thematic view of science needs to be included in the curriculum. McClintock says, "What we do is make these subdivisions, but they're not real. Basically, everything is one. There is no way in which you can draw a line between things." (Keller, 1983, p. 205).

The experience of a teacher is recorded in this statement:

> "Any type of holistic view on anything is better than dissecting these little sciences into cubicles; you can just look at the biology program in the school. Not only have we divided physics, chemistry and biology but we've subdivided all these fields. Ecology. Botany. No one has anything to do with the others. They should all be somehow interrelated."

Technological activity is even more rigidly structured,

> One of the most powerful barriers to the creative participation of women in technological activities is the fragmentation of technological work and its rigid structuring - in contrast to women's historical experience of situational and holistic work, depending on personal judgement, knowledge of the work process and on the ability to discern what the essential variables are at any one time (Franklin, 1990, p. 104).

The fact that science and technology are so closely associated and related to masculinity means that girls who do pursue science are faced with a significant role conflict. This conflict emerges in adolescence when girls and boys become more aware of sex roles.

> Developmental psychologists describe adolescence as a time of intense sex role identification...It is during adolescence that sex differences in mathematical ability are detected; girls are asserting their femininity through disinterest just when boys are expressing their masculinity through scientific mastery (C.T.F., 1988, p. 11).

Studies of British schools (Omerod,1981; from OECD, p. 73) show that polarization of subject choices tends to be less extreme in single sex schools. A number of studies have found that girls from single sex schools are more likely to choose and continue in mathematics and science (MacDonald, 1980; from Fabricant, 1990). The pressure to adhere to sex role stereotypes appears to be more pronounced in mixed sex schools. If young women see science and scientific careers as incompatible with helping others and mothering, they are unlikely to be attracted to serious study in these areas.

Research on career selection had often neglected to address this whole issue of socially constrained choice.

> There are, however, other more routine ways in which an apparently free choice may be socially constrained. An open choice is not necessarily an easy one to make; it takes considerable more determination and support for a boy or girl to choose a subject or career which is not considered appropriate to their gender... But even the most sincere and energetic attempts to get boys and girls to re-think their choices of subject and career, to broaden their horizons beyond the traditional bounds of gender, will be thwarted to the extent that schools continue, in other areas of practice, to re-create gender divisions. The customary division of labour in many schools - with girls encouraged to comfort younger children while boys are expected to move the chairs for a meeting in the hall - does nothing to undermine stereotypical views of the competencies of weaknesses of one sex or the other (Stanworth, 1983, p. 18).

Schools cannot expect girls to take career talks seriously if they do not challenge everyday stereotyping which differentiates and segregates the sexes.

Studies on the career aspirations and expectations of Canadian students show that despite a tendency to view jobs in a more egalitarian manner, the actual selection of careers continues to be heavily based on present stereotypes (Ellis and Sayer, 1986). In interviews of 128 girls and 28 boys from 15 to 19 years old, Baker (1985) found that females made their occupational choices from a narrower range of jobs than males. The ideas held by boys were more congruent with what is likely to happen where girls were more unrealistic assuming they would be able to move in and out of the work force without penalty and that working for pay would be a matter of choice. Despite the fact that most of the girls in the study did not want to be full time homemakers, they saw housework as the major responsibility of the wife. Few boys pictured themselves doing housework in the evenings.

In considering socioeconomic status, this study found females from higher socioeconomic backgrounds to be more likely to aspire to non-traditional professional jobs. Girls from lower socioeconomic status focused on pink collar jobs, believing more in luck or fate and showing less confidence in their ability to control the future. Girls seemed less concerned with advancement than boys and typically expressed a desire to marry someone rich (Baker, 1985, p. 150).

Socioeconomic status can combine with role models to be a powerful determinant of occupational choices for women.

> The omniscient realities of impending marriage, family and the need to earn a living are always pressing for recognition. Hence the occupational and educational choice of those from the dominant class and sex implicitly take account of what is or has been typically possible for people with their ascribed position in the social structure (Stanworth, 1983, p. 14).

Another recent Canadian study of 364 girls and 342 boys from 6 to 14, using well matched populations, also confirmed traditional stereotyping and beliefs about appropriate activities for females and males. While

Computer Programming was selected as an occupational choice by 32 boys, it was selected by only 7 girls. Likewise, 20 boys selected Engineering while only 4 girls did, and 39 boys selected being a scientist compared to 20 girls. Of the girls surveyed 91 selected Nursing as a possible occupational choice, 153 selected Teaching and 102 selected Secretarial work. Boys choices were much more broadly spread out; 84 chose becoming an athlete, 64, a doctor, 66, a police officer, and 68, a pilot. The sex of the respondent was the overwhelming factor in determining occupational aspirations. In the same study, some correlations were found between aspirations and socioeconomic level for both girls and boys, however, the correlation was three times higher for boys than for girls (Ellis and Sayer, 1986, p. 50). In addition, Glaze and Ellis (1980) found that girls expectations are markedly depressed when compared to their aspirations, thus, a girl might aspire to be a lawyer but expect to be a legal secretary.

Small group discussions which were conducted as part of the Ellis and Sayer study revealed that girls tended to picture their adulthood as consisting of being stay at home mothers with small children. Girls did not see themselves as needing remunerative employment, expecting that their husbands would provide for the family. Similarly, Glaze and Ellis (1980), in surveys of 100 Ontario high school girls, found that the most common intention of girls was to marry, have children and work outside the home only after the children were school age. Some planned to be full time housewives even if there were no children. In addition, Glaze and Ellis found that more than 75% of the girls selected as true items which stated that 40% of women who graduated college never married and that divorce was more common among career women than among housewives.

A more recent study of girls across Canada by the Canadian Teacher's Federation suggests that girls are now aware they need an education to secure their future and believe there is a need for career plans (C.T.F, 1990). Careers ranked fifth out of 34 interests/concerns about which girls wanted more information. At the same time, they discussed the conflicts they would face as women, raising a family, having a husband, and having a career.

An insight into the thinking of high school girls is provided by this comment from one of their teachers,

> "They're not aware of what the requirements are. They'll say, "I want to be an accountant, a doctor or a neurosurgeon." As soon as they become aware of what the requirements are they say, "Maybe, I'll be an interior decorator instead where I can work at home and raise my kids.""

In Ellis and Sayer's study, students identified role models, adult encouragement, the nature of the work, and feelings about their own specific abilities as reasons for individual occupational choices. It is evident that all four of these factors work against females continuing to study and choosing careers in science and technical fields. Science, mathematics, and computer science teachers at the secondary levels are overwhelmingly male and the few women visible in these areas results in a distinct lack of role models for girls. One of the teachers who participated in the preliminary interviews said,

> "I think that I turned a lot girls on to science, opened their minds, because I was a female walking in a lab coat. We handled snakes in the classroom and we did all sorts of things. All of a sudden they saw somebody who has long hair and make-up who's doing all these things, and, I saw throughout a year a lot of changes in their attitude."

Evidence suggests that adult encouragement may be particularly important to girls who are socialized to view others approval as more significant (Science Council of Canada, 1982, p. 70). Females are not as confident in their ability to succeed in these areas which are perceived to be "hard". At the same time mathematics, science, and technology, as they are taught in schools and as they are practised, continue to sustain and reward masculine interests.

Cultural Production

Recent theorists, particularly feminist theorists, have begun to look at the way in which culture is created in societies instead of focusing on how it is reproduced. They argue that socialization, while being a pervasive force, does not explain the existence of groups such as feminists who have grown up within the culture, yet, have not accepted traditional views.

Weiler (1988) presents the view that power, as both the medium and the expression of wider structural relations and social forms, positions people within ideological matrixes of constraint and possibility. The resulting struggles and conflicts serve to limit and enable individual capacities and it is within these conflicts that culture is constantly being created.

> Production theorists are concerned with the ways in which individuals assert their own experience and contest or resist the ideological and material forces imposed upon them in a variety of settings (Weiler, 1988, p. 10).

Thus, the struggles and conflicts of girls and women who make choices to remain in areas of science and technology traditionally considered male domains and the processes by which they are excluded are not only a reflection of past culture, but are the instruments which create a new culture. The assumption is that changes in social relationships between girls and boys, or women and men, will not occur simply through the identification and changes of textbooks and teaching practices. In her work, Weiler focuses on the lived experiences of girls and the ways in which schools work to prepare girls to accept an inferior position relative to boys. The exclusion of girls from science is seen, then, as part of a larger picture which acknowledges that girls and boys enter the classroom with power relationships based on gender firmly in place. Mathematics, science, and technology form part of the definition of masculinity; these activities are what masculine beings do and, therefore, what girls must not.

> These kinds of thinking and motor activity [scientific, mathematical and engineering] are presented as skills that men need in adult life - no matter what their occupation, in order to become and remain men, whereas, for girls they are not only useless but detrimental to others' perceptions of them as feminine. Scientific and masculine are culturally reinforcing constructs. Women in science challenge not only the scientist stereotype but also male gender identities (Harding, 1986, p. 63-4).

Asymmetrical gender relations in schools have as much to do with what happens in the hallways and the cafeterias, as it has to do with what happens in the classroom. In a qualitative study, Batcher (1987) observed and spoke to adolescent girls in order to begin to gain an understanding of how and why girls delimit their futures. She found that within these adolescent groups, girls with individual talents were forced to choose between social isolation or diminishing their own talents. Girls who were successful in group pursuits were subject to double standards; boys who won the school championship were heroes, while girls played in an empty gym and their "victory" treated with amused tolerance. Thus, boys' knowledge was seen as real and important knowledge and boys talents as real talents. Boys were more likely to be found doing things and girls to be found cheering them on. Seemingly, the girls who followed the group norms of being politely acquiescent did so without questioning the validity of the rules.

Batcher found that girls did not seek power and influence directly, but, instead, attached themselves to boys who had it, thus, groups, whether male or mixed, were centred around boys. A successful group girl talked about eating less, buying and wearing clothes, make-up, hairstyles, and getting boyfriends. She reported that girls bonded first with their boyfriends and then with their friends, while boys' first loyalty was to their friends, and this fact seemed to give boys a substantial advantage. Girls made allowances for boys, to the point excusing overtly aggressive behaviour.

Girls who gave up popularity did so only with penalty. Labels were used as powerful means of bringing girls into line. "Hosebag", "sleaze bucket", "tomboy", and "slut" were popularly used to this purpose in Weiler's study. Girls who chose to be independent of groups and boys often became super-achievers in order to regain a sense of power. Weiler documented the use of academic achievement as a mechanism by which girls attempt to overcome oppression (Weiler, 1988). Unfortunately, this need may work to girls' disadvantage in the long run as they select easier courses in order to keep a high average. Girls in Weiler's study also spoke of previous physical assaults which appeared to serve as warnings about accepted and unaccepted behaviour. Boys used their positions as leaders to change the rules to suit themselves. What was acceptable and popular became quickly passe when it no longer served to identify the leaders.

Mahoney (1983) has documented boys monopoly of physical space in the classroom, spreading into aisles and encroaching upon space occupied by females.

> It is not uncommon to find a boy leaning across a girl's desk in order to 'flick' another boy, crumpling her work in the process. Neither is it uncommon, when this behaviour is challenged, to encounter a look of amazement and incomprehension from the boys. It is apparently usual for them to not notice the physical presence of girls, not to consider it important to do so (Mahoney, 1983, p. 108).

While socialization theory documents that teachers attend to boys more in the classroom, Mahoney advances the view that this occurs because male students demand the attention by threatening to be disruptive (Mahoney, 1983, p. 109). Thus, teachers may find themselves in a double-bind situation where they opt to further reinforce the assertiveness and visibility of males. To speak of teachers as a gender neutral group is also misleading. Student reactions to male and female teachers can be quite different. Female teachers are often expected to mother students and labelled if they attempt to be authoritarian. The same behaviour will be accepted and even admired in a male teacher (Briskin, 1990, p. 8).

Stanworth (1983) documents that boys see girls as a negative reference group and identify girls as individuals they would least wish to be like. There is a growing body of work to suggest that boys consistently put down girls in class. Eccles and Blumenfeld (1985) found boys were more satisfied in situations where social comparisons and put-downs established the dominant students and girls were less satisfied in such situations (Eccles and Blumenfeld, 1985. p. 91). Mahoney (1983) documents her experience of males jeering at females and engaging in public displays to embarrass and ridicule girls. Males also used less explicit mechanisms, such as bored sighs or quiet groans in order to encourage girls to be silent. Another powerful strategy used to achieve dominance was to make comments about girls appearance which were derogatory and often sexual. When girls attempted to take on roles defined as male they were subject to laughter, verbal abuse and even sexual harassment (Mahoney, 1983, p. 111). Further, Mahoney argues, that in their attempts to develop relationships with the boys, male teachers actively condoned, rather than challenged, such behaviour.

The links of such interactions between males and females to female participation in male fields are not yet well documented or well understood. The high degree of sexist behaviour among young male engineering students is, however, well-known, as is the low participation of females in these faculties. When slogans such as "No means tie me up" are hung in response to a University program against date rape (Lewis, 1990, p. 467), one is obliged to suggest that some very powerful social messages are being sent, and received.

Examining the Interrelationships

To view the factors which have been identified as important in the lower participation rates of females in mathematics, science, and technological careers separately would misrepresent the realities of female experiences. It is girls who come to school without early scientific experiences who are being jeered at as incompetent by boys and those girls who learn from textbooks which present only men as scientists. The cumulative and interrelated effects of all of the contributing factors serve to reinforce, compound, and magnify their individual effects.

> The importance of accumulative advantage/ disadvantage lies in its ability to amplify other differences, thereby giving other explanations greater effect (Long, 1986, p. 162).

Together, these experiences send a clear message to females about mathematical, scientific, and technological activity, perhaps encapsulated by this anecdote from one of the interview participants.

> "She has to be able to prove to the guys that she deserves to be there on a daily basis. She says it is an enormous stereotypical pressure. Nobody has ever come up to her and said, "you don't belong here", but she feels it. Involuntarily you react as if, I'm a female; I am not supposed to be here."

CHAPTER FOUR

TRANSFORMATION: THE ROLE OF THE TEACHER

Educational systems are profoundly conservative institutions. Despite the prevailing notion that education involves the objective uncovering of truth, schools are highly political institutions, which serve at least in part to socialize children to accept the power relationships they will be subject to as adults.

> Although not directly creating inequality, education helps to legitimate it - to make it appear natural and acceptable. As long as most people believe that education operates on a meritocratic basis - as long, that is, as privilege and disadvantage are supposed to result from fair competition in the educational arena and "natural" differences in aptitude - then inequality in society appears to be justified by different levels of educational achievement. Subordinate groups are encouraged to personalize their failure; that is, to regard their disadvantage as the inevitable outcome of their own limitations - of their individual lack of intelligence, ambition or effort (Stanworth, 1982, p. 15).

The curricula of schools, that which is selected as truth and knowledge, is socially defined and regulated by political power structures. Power relationships exist between and within all levels of the educational enterprise from superintendents to students, and in accordance with accepted social views of race, class and gender.

In order to redress gender bias, many school systems have undertaken measures to ensure equal access to all programs. Teachers are expected to treat female and male students in precisely the same manner, therefore, providing a "gender-neutral" or "gender-free" education. Although a superficial equality of access may be achieved in this way, such measures have not resulted in equality of outcomes. Gender neutrality ignores the need to address the deeply imbedded conscious and unconscious beliefs and behaviours of students and teachers which reinforce traditional advantages and roles. In some ways, the objective of "treating all students similarly" serves only to ignore and hide the underlying biases in the system, although it does seek to address the overt advantages which are given to males in our culture.

> The classroom is always a gendered environment and teaching practices and curricula always take gender into account - self-consciously or unconsciously, through presences or absences, in ways that empower students or disadvantage them. It is not possible, therefore, for schools or individual classrooms to transcend these power relationships and make gender irrelevant (Briskin, 1990, p. 14).

Transformation, however, depends on illuminating and addressing gender bias.

> If we want to make any significant difference to the educational opportunities of girls, we shall have to take cognizance of the precise nature of the femininity that the school is helping to construct, how it is aided or subverted by race and class influences, and how we shall have to map

> the consequences of alternative interventionist policies. It is misleading to think of gender as something which can be ignored or treated as irrelevant. Gender relations can be ignored, but only at the risk of entrenchment, and while they are changeable, it misses the mark to think of them as eliminable (Houston, 1987, p. 144).

Houston (1987) and Robertson (1989) build on Jane Roland Martin's argument for addressing sex inequity by calling for a gender-sensitive approach, which recommends that we pay attention to gender when it can prevent sex-bias or can further sex-equality (Houston, 1987, p. 145).

> What differentiates a gender-sensitive strategy from a gender-free one is that a gender sensitive strategy allows one to recognize that at different times and in different circumstances one might be required to adopt opposing policies in order to eliminate gender bias...A gender-sensitive perspective is a higher order perspective than that involved in a gender-free strategy. It encourages one to ask constantly: Is gender operative here? How is gender operative here? (Houston, 1987, p. 145).

A gender-sensitive approach is one which acknowledges the transitional problem of moving from a gender-biased education in a sexist culture to an unbiased education in schools which will continue for some time to be influenced by the wider culture. It provides a perspective that encourages a critical and constant review of the meaning attached to gender in our society and in our schools.

Pre-requisite to a gender-sensitive strategy in education is the development of an understanding of gender issues, in essence, the development of a feminist consciousness amongst educators. It is only through such an understanding that transformation, collective action to move women into a position of empowerment, can take place.

> Feminism implicitly challenges naturalism and rests on the fundamental premise that social change is possible and necessary. Feminism and the women's movement provide the reference point and the context for collective action. Feminist practice is central to feminist pedagogy (Briskin, 1990, p. 19).

Similarly, Briskin has argued for anti-sexist strategies which make gender an issue in all classrooms in order to validate the experience of all students, bring it into consciousness, and challenge it. Such practices make gender an official factor in classroom process and curriculum, thereby allowing us to understand and change it (Briskin, 1990, p. 14).

Teaching is a practice carried out in the context of a patriarchal system and under many constraints. Teachers are by no means singularly responsible for the system in which they live and work; this system is forged by our collective history and maintains systemic bias in ways which remain, in many cases, outside of a teacher's control. Teachers do, however, have access to a vital aspect of the educational system, the classroom. It is in their relationships with students, in their delivery of the knowledge, and in their critical presentations of this knowledge that they are capable of generating the energy to help transform schools. Ministries of Education, sometimes despite their best efforts, never manage to fully control what happens in the classroom, and virtually every teacher knows the elasticity of guidelines (O'Brien, 1983, p. 13).

The current research on the awareness of teachers in relation to gender issues is not well developed, however, the research which does exist supports a notion that gender bias continues to be pervasive and often unconscious in schools.

> Dweck reports that teachers may reinforce the stereotypical characteristics of boys and girls as much by the kinds of actions they overlook as by what is directly commented upon. We need to develop systematic understanding of how girls and boys themselves interpret classroom encounters, and how their experience of classroom life influences their views about the worth and capabilities of the sexes (Stanworth, 1983, p. 23).

Spear (1985) found that teachers expected boys to be better at and more interested in scientific, mathematical and technical subjects. Teacher expectations are importance influences in student achievement. One of the teachers interviewed spoke about her experiences.

> "I can remember teachers at the Junior High level saying because these guys have interest, let's push them to do something interesting. The girls can go work in books and go to the library instead. The teachers were scared, I think, to

push students who were not interested, scared of pushing girls to do something hands-on. The guys would be all hyper about doing some electronic projects for science and the girls would be allowed to go to surveys on your beliefs on AIDS instead of doing something hands-on. The topics could have been pushed back to doing something in a lab setting - The girls would be excused from doing something active in science because the interest wasn't there and it's easier to let them do what they want. They don't bug you. You don't have to spend three weeks explaining something to them. They were just expected not to do too much because they didn't have an interest in it."

Eccles and Blumenfeld (1985) found that teaching style and classroom climate correlated closely with sex-related differences in students own expectations of success. Girls were found to have significantly lower expectations of themselves in comparison to boys in classrooms where teachers were characterized as critical and sarcastic, and where teachers used a public teaching style relying heavily on volunteer answers. In contrast, girls' attitudes toward mathematics were more positive in classes characterized by a high proportion of private teacher-student conferences and by relatively high levels of teacher control over public recitation. This research suggests that:

> sex differences in student learning and in student attitudes could come about because similar environments affect boys and girls differently, primarily because boys and girls enter these environments with different views of the world and different learning histories (Eccles and Blumenfeld, 1985, p. 109).

While Sadker and Sadker and others (Crossman, 1987; Eccles and Blumenfeld, 1985) have documented the amount of teacher attention boys receive in classrooms, Spender (1982) documents more disturbing results in her work with teachers. She notes that when teachers feel they are being fair or showing favouritism to girls the empirical evidence shows otherwise. Teachers giving 35% of their attention to girls felt they were being unfair to boys. Students also shared this perception. For example, when a teacher tried to eliminate gender bias in participation by giving 34% of her attention to girls, who constituted half of the class, boys responded by saying, "She always asks girls all the questions"; "she doesn't like boys and just listens to girls all the time" (Spender, 1982, p. 55).

Similarly, those who champion the belief that change takes time and that younger teachers are more aware of gender inequity may be wrong. In a study of 131 preservice teachers in the United States who were enroled in a mathematics methods course, it was found that 22% believed "men were better at mathematics than women", and 63% believed that "some people have a math mind and some don't" (Frank, 1990, p. 11).

Casserley's work for the U. S. National Institute of Education in 1975 suggests that teachers can favourably affect girls' preparation for mathematics and science-related occupations if they provide active encouragement, exposure to role models, sincere praise for high ability and good performance, explicit advice regarding the value of mathematics and science, and explicit encouragement to both boys and girls and their parents regarding the importance of developing their talents to the fullest and aspiring after the best job they can attain (Casserley, from Eccles and Blumenfeld, 1985).

> Students start school with sex-differentiated goals and attitudes. These attitudes appear to consolidate into sex-differentiated beliefs regarding mathematical and scientific abilities some time around early adolescence. The role teachers play is very subtle. Although teachers do not appear to be the major source of these beliefs, they also do little to change them or to provide boys and girls with the types of information that might lead them to re-evaluate their sex-stereotyped beliefs. In this way teachers passivity reinforces the sex-typed academic and career decisions made by their students, thus, contributing to sex inequity in children's educational achievement (Eccles and Blumenfeld, 1985, p. 80).

It appears that teachers often fail to recognize gender inequities in schools. Not only can this be considered a lack of awareness but Celia Reynolds (1988) has begun to document denial and distancing reactions to sexism. Denial can present itself in a number of ways, however, it rests on the moral principle that gender should not make any difference in school life. Feminists whose focus is on access for women are often caught in the position of having to deny gender differences in order to gain acceptance and access to men's rights and privileges. At another level, denials can be based on disbelief or attempts to discredit information. Distancing, on the other hand, occurs when teachers see themselves and their students as individuals rather than as members of a gender group, and thus, express little empathy or understanding for the subordination of females as a group.

When teachers do recognize sexism in schools, they do so with varying responses. Eichler (1987) presents one model of responses to sexism designed to help illuminate the developmental patterns in social science scholarship. She illustrates four possible responses to sexism which can occur.

The first response is to consider sexism an issue of marginal importance and go on with business as usual. The business as usual response is typical of a scholar untouched by, or perhaps even hostile to, the feminist debate. She suggests that this response is the present response of the vast majority of social scientists generating knowledge today.

The second response is to acknowledge that sexism is an important issue and to deal with it by incorporating women into the existing framework. The concept of locating and including lost women in an otherwise unchanged version of science could be identified as such a response. This response derives from an awareness that there is a problem, but a lack of understanding of its true dimensions.

The third response starts with the premise that women have been excluded from consideration and that this cannot be remedied simply by adding them to otherwise unchanged ways of proceeding. This response, sometimes referred to as a woman-centred approach, starts from the position of women, acknowledging their subordination, and develops knowledge which is of concern to women in ways which are consistent with women's experiences.

The fourth response which Eichler identifies is the non-sexist approach. Sharing the premise of the third response, the fourth response calls for a transformation of social science itself such that it becomes non-sexist by fully integrating women in a manner which changes both the current sexist view and the incipient woman-centred view. Eichler states that the development of a non-sexist approach is contingent upon the exploration and understanding of a woman-centred view. She suggests that, while in most cases we will have to pass through a stage of female-centred thinking, there is no clear progression from sexist to woman-centred to non-sexist scholarship, because "we are describing a muddy, unclear, complex process which winds its way back and forth" (Eichler, 1987, p. 45). Thus, as our knowledge about previously hidden aspects of sexism continues to grow, our definition of what constitutes sexism will also continue to evolve.

In many respects, teaching is an overwhelming task. Teachers are expected to provide skills for future employment, prepare students for post secondary education and universities by supplying the knowledge required for entry, maintain order and discipline in their classrooms, keep students in their classrooms and off the streets, and prepare students to be happy and successful in life. It is not remarkable that in so doing they help to reproduce existing social structures which are inequitable.

Nonetheless, if teachers and school administrators as a profession accept the responsibility to provide an equal opportunity to all students regardless of gender; then, we must be actively engaged in a collective examination of gender bias in our schools which works toward its elimination.

CHAPTER FIVE

METHODOLOGY

Gender-sensitive education in our schools presupposes teachers have developed a high level of awareness and understanding of gender issues. This study was designed to examine teachers' awareness and commitment to gender issues. The study employed the traditional methodologies associated with descriptive questionnaire research. It involved an attempt to describe, analyze and interpret the levels of understanding regarding gender issues in female participation among one hundred and twelve mathematics, science, and computer science teachers in a suburban Winnipeg school division. Relationships between sex, age, and teaching levels were explored in the analysis.

Participants

Eighty-three teachers from the selected school division, all of whom were currently holding teaching responsibilities in the areas of mathematics, science, and/or computer literacy, chose to participate in this study by completing and returning the questionnaire. The questionnaires were distributed to all teachers at the Junior High and Senior High levels who currently teach mathematics, science, and/or computer literacy and to classroom teachers with teaching responsibilities in mathematics, science, and computer literacy at grades two and five at the Elementary level. This sampling allowed for the selection of participants from the Primary, Intermediate, Junior High and Senior High levels. Overall, the respondents included 53 female teachers, 69% of whom taught at the Elementary level, and 59 male teachers, 85% of whom taught at the Junior or Senior High levels. The respondents were predominantly Caucasian. Twenty-one percent of the respondents were in their twenties, 32% were in their thirties, another 32% were in their forties, and 12% were over 50 years of age.

Questionnaire Development

In an attempt to gather data regarding the attitudes and opinions of teachers about gender equality in mathematics, science, and computer literacy education, a four page questionnaire was developed (See Appendix 5.1). In the initial phases of the study, statements were gathered from current research which illustrated views about gender equality in education generally and more specifically as it related to the content areas in question.

In conjunction with the literature review and in keeping with the grounded nature of feminist research, two female mathematics and science teachers from the school division where the study was undertaken with combined experience ranging from Kindergarten to grade 12 were approached to take part in the study. They agreed to participate in open-ended interviews designed to gather insights into the everyday participation of female students in mathematics, science, and computer literacy. A set of open-ended interview questions was developed and sent to the participants two days prior to the session (See Appendix 5.2). The interviews took place at mutually agreed upon times in private seminar spaces within the respective schools in which these women worked. The interviews lasted approximately one hour in length and the participants' responses were taped for further reference.

Statements from both grounded experience and published literature were selected and combined to represent the various beliefs that teachers might hold about the participation of female and male students in mathematics, science, and computer literacy. An attempt was made to develop questions which would help to establish scales related to Margrit Eichler's stages of response to sexism. The Likert method of scoring was applied as a procedure by which the opinions of participants could be analyzed. Participants were requested to respond to one of five choices for each of twenty-nine statements given: strongly agree, agree, disagree, strongly disagree and no opinion. In the second section on teacher activities, they were asked to respond to six yes/no questions. In addition to closed form or restricted questions, the questionnaire was also constructed to include opportunities for teachers to respond to open-form questions.

To improve content validity and allow for face validity, a draft questionnaire was then presented to four members of the thesis committee for discussion and revision. Individual questions were analyzed for their clarity, wording, and the range of alternative answers offered.

Procedure

The questionnaire and an attached covering letter (Appendix 5.3) was circulated to participants at the Elementary and Junior High levels through the divisional courier. At the Senior High levels, teachers were personally approached at their relative department meetings by either the researcher or the department head to encourage participation in the study. Self-addressed envelopes were provided to increase the rate of return. In order to increase the likelihood that answers were reflective of participant's real beliefs and feelings, questionnaire returns were anonymous, however, envelopes were annotated by school in order to track response rates for individual schools. In all cases, one week subsequent to the distribution of the questionnaires, a follow-up letter was sent to encourage a second round of responses. Two weeks subsequent to the initial distribution, response rates by school were calculated and where response rates fell below 30%, which happened in only one of sixteen cases, a second follow-up letter along with a second copy of the questionnaire was mailed to participants. This mailing went to 7 teachers, only 1 of whom had previously completed and returned the questionnaire.

Response Rates

A total of 112 teachers received the questionnaire, 47 at the Elementary level, 28 at the Junior High level, and 37 at the Senior High level. Eighty-three questionnaires were returned, thus, an overall response rate of 74% was achieved. A further break-down of the response rates is shown in Table 1.

Table 1
Response Frequencies

Level/Sex	Female	Male	Total
Elementary	29/39 (74%)	6/8 (75%)	35/47 (74%)
Junior High	7/8 (88%)	11/20 (55%)	18/28 (64%)
Senior High	6/6 (100%)	24/31 (70%)	30/37 (81%)
Total	42/53 (79%)	41/59 (70%)	83/112 (74%)

The highest response rates were among female Junior and Senior High teachers whose combined response rate is 93%. Female teachers in mathematics, science, and computer literacy at these levels are typically outnumbered by the male colleagues at ratios from 2:1 to 8:1 in individual schools. The greater the tendency to be outnumbered by males, the higher the response rate for females. The lowest response rates were among male Junior High teachers. Overall, females response rates were slightly higher than males. Relative to levels, response rates were highest at the Senior High level where personal approaches were made via the departmentalized system.

Frequency Distributions

Collation of the questionnaire responses fell into three stages. First the responses were tabulated to display overall frequency distributions (See Appendix 5.4). Second, cross tabulations to obtain frequency comparisons between groups based on sex, age, teaching level, and teaching assignments (whether in high discrepancy enrolment areas or not) were obtained from the data. In the third stage fifteen questions were clustered in three groups of five to represent differing levels of awareness about gender bias: 1) General awareness and acceptance of sexism, 2) Seeking the inclusion of women and 3) Developing a woman centred/non-sexist view. Participants responses on these questions were numerically scored and tabulated to obtain overall scores for each of the three areas (See Appendix 5.5).

Strongly agree, agree, disagree, and strongly disagree responses were accorded numerical scores of 1, 2, 3, or 4. A score of one was assigned to a response which indicated a high level of understanding of gender bias. Responses of no opinion were assigned a numerical score of 2.5 so as not to skew the results in either direction. Therefore, the possible scoring band for each cluster of questions ranged from 5 to 20, 5 indicating a high degree of understanding of gender bias and 20 indicating a low degree. The results of the data analysis are discussed in subsequent sections.

Data Analysis

1. Do mathematics, science, and computer science teachers believe that they have a responsibility to create an educational environment free of gender bias?

All of the participants in the study agreed it was important for schools to provide an educational environment free of gender bias. In fact, when asked to respond to the statement "It is important for schools to provide an equal opportunity to all students regardless of gender, 93% of the respondents strongly agreed.

Table 2:
Teachers' Belief In Equality of Educational Opportunity

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total
It is important for schools to provide an equal opportunity regardless of gender.	77 (93%)	6 (7%)	0	0	0	83 (100%)

When asked more specifically to respond to different definitions of what equality of opportunity actually meant, almost three-quarters of the respondents defined it as "The same treatment for girls and boys". Only 18% of the respondents saw a need for special treatment for girls. These responses did not appear to be related to sex or to teaching level; males and females were equally unlikely to support special programs for girls. Of the fourteen respondents who agreed that equality would mean special treatment for girls, nine were in their forties, and only 1 was in her/his twenties [See Table 3]. While there may be a common perception that movement toward equality will become much more rapid as the next generation of teachers impacts upon the school system, there is no evidence to support such claims from these results.

Table 3:
Definitions of Equality By Age

Statement: Equality of opportunity related to gender is best described as:	Age 20 - 29	Age 30 - 39	Age 40 - 49	Age Over 50	Total
The same treatment for girls and boys	15 (83%)	21 (78%)	16 (59%)	9 (90%)	61 (74%)
Special treatment for girls in certain areas	1 (6%)	4 (15%)	9 (34%)	0 (0%)	14 (18%)
No Response	2 (12%)	2 (7%)	2 (7%)	1 (10%)	7 (8%)
Total	18 (101%) 1	27 (100%)	27 (100%)	10 (100%)	82 (100%) 2

The understanding and acceptance that discrimination against females has and still exists in

[1] As percentages are rounded off they do not always add to 100%.

[2] Although there were 83 respondents in this study, one respondent did not report by age.

education is central to the argument that "equality of opportunity" does not necessarily mean "sameness of treatment", and that gender-sensitive, not gender-neutral education is called for. Special treatment for girls is at times essential to the pursuit of equity and should not be construed as reverse discrimination and unfair to boys. The majority of teachers who responded to the survey did not, however, indicate an acceptance of this view and overall 56% responded that they believed special treatment for girls was unfair to boys. Consistent with the findings from Table 3, it was teachers in the 40 - 50 age group who were least likely to feel this way. Significantly, female respondents were slightly more likely than male respondents to consider special programs for girls unfair to boys.

When teachers in the study were asked how important they felt it was for girls and boys to participate equally in mathematics, science, and computer literacy, ninety-six percent of the respondents agreed or strongly agreed it was important.

Table 4:
Importance of Equal Participation by Age

Statement: It is important that males and females participate equally in mathematics, science, and computer literacy.

Age Group	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total
20 - 29	17 (94%)	1 (6%)	0 (0%)	0 (0%)	0 (0%)	18 (100%)
30 - 39	20 (74%)	6 (22%)	1 (3%)	0 (0%)	0 (0%)	27 (99%)
40 - 49	16 (59%)	11 (40%)	0 (0%)	0 (0%)	0 (0%)	27 (99%)
Over 50	6 (60%)	2 (20%)	1 (10%)	1 (10%)	0 (0%)	10 (100%)
Total	59 (72%)	20 (24%)	2 (2%)	1 (1%)	0 (0%)	82 (99%)

Here, younger teachers in the study indicated feeling more strongly than older teachers about the importance of equal participation in mathematics, science, and computer literacy. In fact, respondents in their 20's felt the most strongly of all the groups, 94% strongly agreeing with the statement, compared to 74% of respondents in their 30's, and 59-60% of respondents in their 40's and over 50. Similarly, Elementary respondents indicated feeling more strongly than Junior High respondents, who in turn felt more strongly than Senior High respondents (83%, 72% and 60% respectively). Women indicated feeling more strongly about equal participation in these subject areas than their male counterparts; 83% strongly agreed compared to 60%.

Table 5:
Importance of Equal Participation By Level and Sex

Statement: It is important that males and females participate equally in mathematics, science, and computer literacy.

LEVEL		Strongly Agree	Agree	Disagree	Strongly Disagree	Total (100%)
ELEMENTARY	F	25 (86%)	4 (14%)	0 (0%)	0 (0%)	29 (100%)
	M	4 (67%)	2 (33%)	0 (0%)	0 (0%)	6 (100%)
	T	29 (82%)	6 (17%)	0 (0%)	0 (0%)	35 (99%)
JUNIOR HIGH	F	6 (86%)	1 (14%)	0 (0%)	0 (0%)	7 (100%)
	M	7 (64%)	4 (36%)	0 (0%)	0 (0%)	11 (100%)
	T	13 (72%)	5 (28%)	0 (0%)	0 (0%)	18 (100%)
SENIOR HIGH	F	4 (67%)	1 (17%)	1 (17%)	0 (0%)	6 (101%)
	M	14 (58%)	8 (33%)	1 (4%)	1 (4%)	24 (99%)
	T	18 (60%)	9 (30%)	2 (7%)	1 (3%)	30 (100%)
TOTALS	F	35 (83%)	6 (14%)	1 (2%)	0 (0%)	42 (99%)
	M	25 (72%)	14(34%)	1 (2%)	1 (2%)	41 (99%)
	T	60 (72%)	20(24%)	2 (2%)	1 (1%)	83 (99%)

F=Female M=Male T=Total

When equity issues were made teacher specific and personalized, the vast majority of the participants, (84%), agreed or strongly agreed that they, as teachers, had a personal responsibility to work toward equal participation in mathematics, science, and computer literacy. Females indicated feeling slightly more strongly than males, 38% strongly agreeing compared to 24% of the male respondents.

Table 6:
Teachers' Feelings of Responsibility by Sex

Statement: I have a responsibility to work toward the equal participation of female and male students in mathematics, science, and computer literacy.

Sex	*Strongly Agree*	*Agree*	*Disagree*	*Strongly Disagree*	*No Opinion*	*Total*
Female	*16 (38%)*	*21 (50%)*	*1 (2%)*	*1 (2%)*	*3 (7%)*	*42 (99%)*
Male	*10 (24%)*	*23 (56%)*	*4 (10%)*	*0 (0%)*	*4 (10%)*	*41 (100%)*
Total	*26 (31%)*	*44 (53%)*	*5 (6%)*	*1 (1%)*	*7 (8%)*	*83 (99%)*

When the question of responsibility was extended to include a commitment to doing more as teachers, slightly more than half of the respondents supported the statement.

Table 7:
Teacher Commitment To Doing More by Sex and Level

Statement: Teachers should be doing more to promote equal participation in mathematics, science, and computer literacy.

LEVEL		*Strongly Agree*	*Agree*	*Disagree*	*Strongly Disagree*	*No Opinion*	*Total (100%)*
ELEMENTARY	*F*	*6 (21%)*	*14 (48%)*	*8 (28%)*	*1 (3%)*		*29*
	M	*0 (0%)*	*3 (50%)*	*1 (17%)*	*0 (0%)*	*2 (33%)*	*6*
	T	*6 (17%)*	*17 (49%)*	*9 (26%)*	*1 (3%)*	*2 (6%)*	*35*
JUNIOR HIGH	*F*	*1 (14%)*	*4 (57%)*	*1 (14%)*	*0 (0%)*	*1 (14%)*	*7*
	M	*0 (0%)*	*4 (36%)*	*4 (36%)*	*2 (18%)*	*1 (9%)*	*11*
	T	*1 (6%)*	*8 (44%)*	*5 (28%)*	*2 (11%)*	*2 (11%)*	*18*
SENIOR HIGH	*F*	*3 (50%)*	*3 (50%)*	*0 (0%)*	*0 (0%)*	*0 (0%)*	*6*
	M	*1 (4%)*	*14 (58%)*	*4 (17%)*	*1 (4%)*	*4 (17%)*	*24*
	T	*4 (13%)*	*17 (57%)*	*4 (13%)*	*1 (3%)*	*4 (13%)*	*30*
TOTALS	*F*	*10 (24%)*	*21 (50%)*	*9 (21%)*	*1 (2%)*	*1 (2%)*	*42*
	M	*1 (2%)*	*21 (51%)*	*9 (22%)*	*3 (7%)*	*7 (17%)*	*41*
	T	*11 (13%)*	*42 (51%)*	*18 (22%)*	*4 (5%)*	*8 (10%)*	*83*

Seventy-four percent of females agreed that teachers should be doing more compared to 53% of males. In analyzing groups by teaching level, 65% of Elementary respondents and 70% of Senior High respondents agreed that teachers should be doing more, however, only 48% of Junior High respondents felt this way. Eleven out of twelve female teachers at the Junior and Senior High levels felt teachers should be doing more. When compared by age, respondents in their 40's were the most likely to agree while respondents in their 20's and 30's saw less need for teachers to do more.

Table 8:
Teacher Commitment To Doing More by Age

Statement: Teachers should be doing more to promote equal participation in mathematics, science, and computer literacy.

Age Group	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total
20 - 29	3 (17%)	7 (39%)	5 (28%)	1 (6%)	2 (11%)	18 (101%)
30 - 39	2 (7%)	14 (52%)	7 (26%)	2 (7%)	2 (7%)	27 (99%)
40 - 49	6 (22%)	13 (48%)	5 (19%)	1 (4%)	2 (7%)	27 (100%)
Over 50	0 (0%)	7 (70%)	1 (10%)	0 (0%)	2 (20%)	10 (100%)
Total	11 (13%)	41 (50%)	18 (22%)	4 (5%)	8 (10%)	82 (100%)

Perhaps, most significantly, when asked whether this was an issue that they had given much thought to, nearly half of the respondents stated that they had not and, consistent with previous responses, younger teachers were the least likely to have given this issue much thought.

Table 9:
Teachers Responses To Having Thought About the Issue by Age

Statement: I really have not given gender equality in mathematics, science, and computer literacy a great deal of thought.

Age Group	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total
20 - 29	4 (22%)	5 (28%)	3 (17%)	6 (33%)	0 (0%)	18 (100%)
30 - 39	3 (11%)	13 (48%)	9 (33%)	2 (7%)	0 (0%)	27 (99%)
40 - 49	0 (0%)	11 (41%)	10 (37%)	4 (15%)	2 (7%)	27 (100%)
Over 50	0 (0%)	2 (20%)	4 (40%)	3 (30%)	1 (10%)	10 (100%)
Total	7 (9%)	31 (38%)	26 (32%)	15 (18%)	3 (4%)	82 (101%)

When compared by sex, fifty-four percent of males reported not having given much thought to gender equality in mathematics, science, and computer literacy compared to forty percent of females.

<u>Summary</u>

<u>Mathematics, science, and computer literacy teachers reported feeling equality of opportunity was important and equal participation of females in these subject areas was important, although a substantial majority did not support special treatment or special programs for girls</u>. Most teachers in the study agreed that they had a personal responsibility to promote equal participation and that more needed to be done in this area.

<u>Nonetheless, almost half of the respondents admitted to having not given gender equity in mathematics, science, and computer literacy a lot of</u>

thought, and teachers in their twenties and thirties were the most likely to make this admission. While younger teachers appeared to feel the most strongly about equal participation, they were the least likely age group to agree that more needed to be done. It appears that younger teachers are not, as might be commonly perceived, acting as advocates for change within the system and that change is not likely to take place simply as a matter of time.

Female respondents reported stronger feelings about equal participation in mathematics, science, and computer literacy, were more likely than males to feel that teachers needed to do more, and more likely to see it as their responsibility to promote equal participation. Thus, female respondents expressed a greater commitment to the issue of equality. Despite this, however, female respondents appeared to be slightly less comfortable than male respondents with the concept of special programs for girls.

2. Do mathematics, science, and computer science teachers believe the current system is gender biased?

Much of the research on gender bias in education supports a view that the majority of teachers are unaware of day to day practices which work to disadvantage females in our schools. When asked to respond to the statement, "Discrimination against girls is still a problem in education" about half of the respondents in this study (49%) either agreed or strongly agreed and about the same number (44%) either disagreed or strongly disagreed.

Table 10:
Teacher Beliefs About Discrimination in Education

Statement: Discrimination against female students is still a problem in education.

lEVEL		Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total (100%)
ELEMENTARY	F	9 (31%)	10 (34%)	2 (7%)	3 (10%)	5 (17%)	29
	M	0 (0%)	3 (50%)	3 (50%)	0 (0%)	0 (0%)	6
	T	9 (26%)	13 (37%)	5 (14%)	3 (9%)	5 (14%)	35
JUNIOR HIGH	F	1 (14%)	2 (29%)	3 (43%)	1 (14%)	0 (0%)	7
	M	0 (0%)	4 (36%)	5 (45%)	2 (18%)	0 (0%)	11
	T	1 (6%)	6 (33%)	8 (44%)	3 (17%)	0 (0%)	18
SENIOR HIGH	F	1 (17%)	3 (50%)	2 (33%)	0 (0%)	0 (0%)	6
	M	0 (0%)	8 (33%)	11 (46%)	5 (21%)	0 (0%)	24
	T	1 (3%)	11 (37%)	13 (43%)	8 (17%)	0 (0%)	30
TOTAL	F	11 (26%)	15 (36%)	7 (17%)	4 (10%)	5 (12%)	42
	M	0 (0%)	15 (37%)	19 (46%)	7 (17%)	0 (0%)	41
	T	11 (13%)	30 (36%)	26 (31%)	11 (13%)	5 (6%)	83

There are significant differences between the male and female responses to this statement. All eleven of the respondents who strongly agreed were female, and, overall, 62% of females favoured this statement compared to only 37% of males. A similar pattern is seen between levels; 63% of Elementary respondents, 39% of Junior High respondents, and 40% of Senior High respondents agreed or strongly agreed that discrimination is still a problem. Of the seven teachers of physics and computer science at the Senior High level where course enrolments can be proven to be discrepant, five did not support the idea that discrimination against females existed in education generally.

In sharp contrast to the responses regarding discrimination in education generally, 90% of respondents agreed or strongly agreed with the statement that boys and girls have equal opportunity in their school. In fact, 48% of all respondents strongly agreed with this statement.

Table 11:
Teacher Beliefs About Equal Opportunity In Their Workplace

Statement: In our school, boys and girls have equal opportunities.

Sex	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total
Female	25 (60%)	11 (26%)	3 (7%)	0 (0%)	3 (7%)	42 (100%)
Male	15 (37%)	24 (59%)	1 (2%)	0 (0%)	1 (2%)	41 (100%)
Total	40 (48%)	35 (42%)	4 (5%)	0 (0%)	4 (5%)	83 (100%)

The contrast between participants beliefs that discrimination in education still exists, but, that it does not exist in <u>their</u> school appears to indicate a significant amount of denial. Teachers were not able to, or were not willing to, recognize the day to day discrimination which forms part of the socialization and cultural production taking place in their own schools. Overall, more males than females favoured the statement, 95% compared to 86%, however, females accounted for the largest portion of the respondents who strongly agreed that equal opportunity existed in their school.

While 60% of the respondents in their 20's thought discrimination was still a problem in education, all of these respondents reported believing there was equal opportunity in their own particular workplace, once again supporting the data that younger teachers are not more aware of and knowledgeable about gender discrimination in education. Only four respondents disagreed that equal opportunity existed in their school; of these, all were high school teachers and three were female.

Table 12:
Teacher Beliefs About Equal Opportunity In Their Workplace By Age

Statement: In our school, girls and boys have equal opportunities.

Age Group	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion	Total
20 - 29	14 (78%)	4 (22%)	0 (0%)	0 (0%)	0 (0%)	18 (100%)
30 - 39	9 (33%)	16 (59%)	0 (0%)	0 (0%)	2 (7%)	27 (99%)
40 - 49	12 (44%)	10 (37%)	3 (11%)	0 (0%)	2 (7%)	27 (99%)
Over 50	5 (50%)	4 (40%)	1 (10%)	0 (0%)	0 (0%)	10 (100%)
Total	40 (49%)	34 (41%)	4 (5%)	0 (0%)	4 (5%)	82 (100%)

When asked if they thought boys and girls participated equally in mathematics, science, and computer literacy in their school, eighty percent of the respondents agreed or strongly agreed. There was a significant decline in these responses according to levels, 97% of Elementary respondents, 83% of Junior High respondents, and 56% of Senior High respondents felt that boys and girls participated equally. Given the fact that enrolments are discrepant at the Senior High levels (See Appendix 2.1), it is significant that even when there are quantitative differences, 56% of the respondents still deny such differences exist.

Research into classroom practice supports a view that teachers are often unaware of gender bias in classroom discussion and classroom resources. Results from this study supported these conclusions. Eighty-nine percent of respondents felt that girls and boys participated equally in classroom discussions in their school. In contrast, only 13% of the respondents reported having taped or having had observers evaluate their teaching to ensure they were responding equally to female and male students.

Table 13:
Teachers' Beliefs About Classroom Discussion

Statement	strongly agree	agree	disagree	strongly disagree	no opinion	Total
Boys and girls participate equally in classroom discussion in our school.	43 (52%)	31 (38%)	8 (10%)	0	1 (1%)	83 (101%)

Table 14:
Teacher Evaluation of Classroom Discussion

Statement	Yes	No	No Response	Total
I have taped or had observers evaluate my teaching to ensure I respond equally to male and female students	11 (13%)	71 (86%)	1 (1%)	83 (100%)

In response to the statement that textbooks and resources are male-biased, seventy-two percent of respondents disagreed or strongly disagreed. In contrast, only 35% of teachers reported having evaluated their textbooks and resources for bias. Overall, only nine of eighty-three respondents agreed or strongly agreed there was male-bias in textbooks and resources.

Table 15:
Teachers' Beliefs About Gender Bias In Textbooks and Resources

Statement	strongly agree	agree	disagree	strongly disagree	no opinion	Total
Mathematics, science, and computer literacy textbooks and resources in our school are male-biased.	2 (2%)	7 (8%)	41 (49%)	19 (23%)	14 (17%)	83 (99%)

Table 16:
Teacher Evaluation of Textbooks and Resources

Statement	Yes	No	No Response	Total
I have evaluated the textbooks and resources I use to be sure women and girls are included.	29 (35%)	53 (64%)	1 (1%)	83 (100%)

About half of Elementary respondents reported having evaluated their textbooks and resources compared to 28% of Junior High respondents and 20% of Senior High respondents. Females were twice as likely as males to have done this activity. While 78% of male respondents reported textbooks and resources were not male-biased, only 22% reported having evaluated their materials for gender bias.

Summary

Even though more than half of the respondents in the study felt discrimination against girls was still a problem in education generally, only a handful of participants were aware of gender bias in their own schools. The overwhelming nature of responses suggesting equal participation in activities and discussion, as well as equal representation in textbooks stands in direct contrast to the relatively few teachers who had, in fact, evaluated their practices for gender bias by investigating their responses to students or by examining their resources. There is strong evidence that even when teachers voice concern about gender bias, they are not aware of the day to day sexist practices which pervade schools and teaching activities. These responses present a strong argument that denial is pervasive and works to maintain the status quo even where teachers voice a commitment to, and a concern for, equal opportunity regardless of gender.

3. **Are teachers of mathematics, science, and technology in this division responding to sexism and if so, how are they responding?**

Despite not perceiving gender bias in their own schools, participants in this study did report responding to sexism in a variety of ways. Forty-eight percent of respondents reported having discussed sex-role stereotyping with their classes at some time during the previous year. Female teachers were slightly more likely than male teachers to have done so. A more significant pattern emerged when comparing grade levels, 66% of Elementary respondents reported this activity compared to 39% of Junior High respondents and 33% of High School respondents. Teachers in their thirties and forties were the most likely to have included sex-role stereotyping discussions in their classes.

Table 17:
Teacher Activity: Sex-Role Stereotyping

Statement: In the past year I have included discussions about sex-role stereotyping in my classes to challenge myths about gender roles.

RESPONSES		Yes	No	Total
SEX:	Female	22 (52%)	20 (44%)	42 (100%)
	Male	18 (44%)	23 (56%)	41 (100%)
LEVEL:	Elementary	23 (66%)	12 (34%)	35 (100%)
	Jr. High	7 (39%)	11 (61%)	18 (100%)
	Sr. High	10 (33%)	20 (67%)	30 (100%)
AGE:	20 - 29	7 (39%)	11 (61%)	18 (100%)
	30 - 39	16 (59%)	11 (41%)	27 (100%)
	40 - 49	14 (52%)	13 (48%)	27 (100%)
	Over 50	2 (20%)	8 (80%)	10 (100%)
TOTAL		40 (48%)	43 (52%)	83 (100%)

When asked about student reactions to such discussions, the most frequent comments were that students listened politely, were open, and agreed gender was not a problem. Other comments from teachers included:

"the boys quickly put down the girls";

> "even at the primary level there seem to be ingrained gender roles which are difficult to address";
> "boys responded nervously when speaking of ballet being an activity for boys as well as girls";

and one teacher stated:

> "boys see their accomplishments as more important. They respond that they are stronger, faster, smarter, etc."

When asked to identify practices within the school which promoted or reinforced sex-role stereotyping 25% of respondents chose not to comment, and 42% of respondents specifically stated they could not think of any. Thus, although 48% of teachers reported having discussed sex-role stereotyping with students only 33% identified school practices which contribute to sex-role stereotyping. Those teachers who did identify practices commented on the following:

> "I, for one, always ask the girls to clean up after any type of hands-on work."
> "asking boys to carry objects"
> "girls and boys lines"
> "girls against boys activities"
> "grouping by gender"
> "male caretakers/female secretaries"
> "male administrators; male department heads"
> "play and phys-ed activities - intramural choices"
> "films in science usually have male demonstrators and always have male narration"
> "male-biased textbooks"
> "picking boys to start groups in phys-ed"

In response to other questions regarding teacher activities, twenty-eight percent of respondents reported having supplemented their curriculum in order to address gender equality. Elementary respondents and respondents in their thirties were again the most likely to have supplemented the curriculum.

Table 18:
Teacher Activity: Supplementing Curriculum

Statement: In the past year I have supplemented the curriculum in order to address gender equality.

RESPONSES		Yes	No	No Response	Total
SEX:	Female	12 (29%)	29 (69%)	1 (2%)	42 (100%)
	Male	12 (29%)	29 (71%)	0 (0%)	41 (100%)
LEVEL:	Elementary	12 (34%)	22 (63%)	1 (3%)	35 (100%)
	Jr. High	4 (22%)	14 (78%)	0 (0%)	18 (100%)
	Sr. High	8 (27%)	22 (73%)	0 (0%)	30 (100%)
AGE:	20 - 29	5 (28%)	13 (72%)	0 (0%)	18 (100%)
	30 - 39	10 (37%)	16 (59%)	1 (4%)	27 (100%)
	40 - 49	7 (26%)	20 (74%)	0 (0%)	27 (100%)
	Over 50	1 (10%)	9 (90%)	0 (0%)	10 (100%)
TOTAL:		24 (29%)	58 (70%)	1 (1%)	83 (100%)

When asked if they had worked actively to encourage girls' participation in mathematics, science, and computer literacy, 57% of teachers reported they had. Thirteen of the eighty-three respondents, all of whom were Elementary teachers, made a point of commenting that girls are given the same opportunity as boys and that both genders are treated equally. Seven of the respondents, all of whom were Senior High teachers reported having verbally encouraged girls, apparently on an individual basis. Other respondents related changing assignments and notes to be more gender-neutral, choosing examples of female scientists, inviting speakers to talk about opportunities for girls in science, acting as role models, and encouraging parents to give positive support to their daughters.

The role of professional development in transformation is a powerful and important one. Teachers need to become more aware and knowledgeable about gender bias, however, the results of this study show that teachers have almost no formal training in recognizing and programming for gender equality. When asked to indicate their professional background, only nine of eighty-three respondents reported having taken course work or workshops on gender equality. Of these, the majority were Elementary teachers and all were female. Of the respondents in their twenties who were the most recent graduates from Education, only two reported having had course work or workshops on gender issues, thus, it appears that little or no programming has been developed and implemented for university students completing teaching degrees.

Summary

It appears that some mathematics, science, and computer literacy teachers are attempting to respond to sexism by introducing additional curricula and discussing sex-role stereotyping in their classrooms. Despite these activities, it does not appear that teachers have the knowledge or the awareness to recognize practices which contribute to sex-role stereotyping, many of which have been traditionally accepted in schools. <u>Very few teachers report having had professional development or educational opportunities related to developing strategies to successfully work through gender issues with students</u>. In order to transform schools and develop gender-sensitive educational practice, it is imperative that teachers develop a high degree of understanding and consciousness. On-going opportunities for professional growth and reflection upon the influence of gender in education are vital to this process, yet, teachers reported little exposure to these experiences.

4. <u>What levels of awareness or feminist consciousness are indicated by the responses of mathematics, science, and computer literacy teachers?</u>

Three groups of questions were clustered to correlate to the following levels of feminist consciousness: 1) General awareness and acceptance of sexism, 2) Seeking the inclusion of women, and 3) Developing a woman-centred/non-sexist view (See Table 19).

Table 19:
Levels of Feminist Consciousness

Levels of Consciousness:	*Statements*
General Awareness:	*Discrimination against females is still a problem in education.*
	In our school, girls and boys have equal opportunities.
	Boys and girls do participate equally in mathematics, science, and computer literacy activities in our school.
	In our school, girls and boys participate equally in classroom discussions.
	In general, girls have less background experience with mathematics, science, and computers than boys.
Including Women:	*Mathematics, science, and computer literacy textbooks and resources are male-biased.*
	The mathematics, science, and computer literacy curriculum exclude women's accomplishments in these fields.
	We should have programs targeted specifically for girls in order to increase their confidence in mathematics, science, and computer literacy.
	The generic use of "he" and "his" in our textbooks and resources includes women and does not need to be changed.
	We should be actively looking for more women mathematics, science, and computer science teachers at the secondary level in order to provide role models for female students.
Woman-centred/ Non-sexist view	*Well-controlled scientific experiments are virtually free of bias.*
	One of the good things about mathematics, science, and computer literacy is that content is free of gender bias.
	The major goal of scientific and technological applications should be to predict and control outcomes.
	A feminist view of mathematics, science, and computer literacy needs to be developed and included in the curriculum.
	Science and technology today would be different if women had participated in decision-making in these fields in the past.

The scoring band for each cluster of questions, ranging from 5 to 20 was divided roughly into three sections: 1) scores between 5 and 9 which indicated a high level of knowledge and understanding of gender issues within that cluster, 2) scores between 10 and 14 which fell in the mid-range and 3) scores between 15 and 20 which indicated a low level of knowledge and understanding of gender issues within that cluster.

In the first cluster related to general awareness, 60 of 83 respondents had total scores between 15 and 20 indicating about 70% of the participants selected answers considered to reflect a low level of understanding of gender bias and suggestive of Eichler's "business as usual response". The remaining 23 respondents had total scores which fell in the middle range. There were no respondents with a total score in the range considered to reflect a high level of general awareness, thus, it appears the majority of teachers do not recognize sexism in schools or consider sexism an issue of marginal importance.

In the second cluster related to the inclusion of women in a male view, 25 respondents had total scores reflecting little understanding of the need to include women, 55 had total scores in the middle range and 3 respondents selected answers reflecting a belief in the need to incorporate women into the existing framework of science and technology. The earlier responses of these three teachers did not indicate a high level of general awareness, thus, it appears that even where teachers consider inclusion of women important, they may still deny sexism exists in their school.

In the third cluster related to developing a woman-centred/non-sexist view of mathematics, science, and technology, 23 respondents had total scores indicating little or no understanding, 58 respondents had total scores in the mid-range and 2 respondents had total scores which indicated they saw a need to develop and incorporate a woman-centred view of science and technology into educational curriculum. Of these two respondents, only one selected answers which indicated an understanding of the need to include women.

It appears that the majority of the teachers who participated in this study do not recognize gender bias in schools, including the differences in conversational patterns, interests, and backgrounds of girls and boys. Only a handful of teachers selected responses which indicate they feel it is important to include women through language, textbook references, role models, and programs aimed at developing girls' confidence in mathematics, science, and computer literacy. Only two respondents indicated an acceptance or understanding of a woman-centred/non-sexist view of science and technology. Further, respondents who supported including women did not, in most cases, recognize and accept discrimination in their schools. These contradictions do not support a hierarchial model of developmental stages in the emergence of a feminist consciousness and serve to underscore the need for more qualitative research to develop an understanding of the complexities involved in responding to sexism.

5. <u>What are the factors mathematics, science, and computer literacy teachers felt are important in the underrepresentation of females in mathematics, science, and technology?</u>

In response to the open-ended question asking teachers to comment on the important factors preventing girls from participating equally with boys in mathematics, science, and computer literacy, teachers identified eight general areas: 1)societal roles, 2)parental and home environment influences, 3)girls' interests and attitudes, 4)peer relations, 5)role models, 6)career planning, 7)natural differences, and 8)teacher attitudes and practice. Of the eighty-three respondents, thirty-one offered no comment or responded that there were no factors. Of the other fifty-two respondents, fifteen commented about the societal influences which condition girls away from science. One respondent commented:

> "Young females learn they get ahead faster by looking good - Society puts more emphasis on how women look rather than on what they think."

Twenty-two of the respondents made comments citing parental influences, home environments and play experiences as significant factors. As one (male) teacher explained:

> "Everyday experiences with everyday things - tools, lab equipment, etc."

Eleven respondents noted that girls' own attitudes and interests determined their choices.

Teachers also commented about peer pressure in the classroom, particularly in the older grades.

> "Boys are more aggressive and don't give girls a chance."
> "Girls have a tendency to go to the washroom and swap stories about how difficult science is."
> "Girls are ashamed and don't try."

Several teachers commented on the lack of role models for girls in mathematics, science, and computer literacy, particularly at the Junior and Senior High levels. Others commented on the tentative career aspirations of girls, the lack of knowledge of girls about careers in science and technology and the fact that there were no workshops for girls. One respondent felt career information at the Junior and Senior High levels needed attention.

One respondent cited "natural" differences as a significant factor:

> "Undiscovered physiological reasons for differences in brain functions - ie. emotions, needs, drives, attitudes."

In fact six respondents agreed or strongly agreed with a statement that boys showed more natural ability in mathematical and scientific thinking than girls. While these respondents were from all levels, five of six were male.

Some of the respondents identified teacher attitudes and practices as important factors in the unequal participation of girls and boys. One respondent commented:

> "Not enough emphasis is placed on equality",

Another stated:

> "The subtle influences of the hidden curriculum - language, etc."

In some case teachers blamed other teachers:

> "The bias of male teachers"
> "Lack of science programs in the Elementary schools"
> "Lack of science background of Elementary teachers"

One respondent noted teaching strategies as an important factor:

> "[no] exposure to a learning style which suits their [girls] needs"

In responding to the open-ended questions asking teachers to comment on the barriers which prevented them from addressing this issue successfully, respondents identified a number of areas. Most prominent among their responses were comments regarding teacher attitudes and awareness of gender equality. While forty-one respondents either did not comment or did not see barriers, sixteen respondents commented on teachers themselves in identifying these barriers:

> "Teacher attitudes that gender equality is not a problem - not making changes"
> "Teachers are not interested in this issue"
> "Teachers' personal philosophies on gender/roles"

The lack of workshops to address gender equality along with the lack of opportunity for teachers to reflect on these issues were also mentioned as important barriers.

Five respondents stated there was not enough time to cover the curriculum as it was without adding new curriculum to address this issue. Other respondents felt the most important barrier was that teachers were at odds with/competing with prevailing influences from the media, the home, and society in general.

Other teachers identified resources, textbooks, the need for activity-based programs, male dominated administration and department heads, and the lack of role models in secondary schools as important barriers to equal participation of females in mathematics, science, and technology.

One teacher commented that women who specifically targeted equality issues were seen as sexist. In fact, 22% of respondents agreed or strongly agreed that they risked being ridiculed by their colleagues if they presented gender bias as a serious problem. A further 25% chose not to respond to the statement. Interestingly, the greatest agreement occurred at the Senior High level, where 33% of the respondents favoured this statement and 30% chose not to respond.

When asked to identify practices which might work to intimidate girls in mathematics, science, and computer science, teachers had the following comments:

> "predominately male enrolment"
> "Boys spend more time on these activities"
> "Science clubs are all boys"
> "aggressive behaviour and attitudes of male classmates"
> "view of science as hard"
> "computer programs often show male figures in graphics"
> "tendency to phrase questions in the masculine "he" rather than use "the experimenter" or "she""

One female science teacher suggested that this was a question we should explore with the girls themselves.

DISCUSSION

The underrepresentation of females in mathematics, scientific, and technological fields of work is not likely to change without serious consideration of how schools work to reinforce and maintain sex segregated activity. Educators at all levels must make a strong commitment to equality and be prepared to critique traditional practice on a daily basis if significant change is to occur. The results of this study point out a very real and very discouraging lack of awareness about gender issues on the part of teachers. In contrast to transforming schools, it appears teachers are largely engaged in "business as usual".

It is not, yet, clearly understood how gender and level are interwoven to create differences in professional climate, beliefs and responses to sexism, but, that gender and level are related is evident by the overwhelming number of female teachers employed at the Elementary level and the equally overwhelming lack of female teachers at the Senior High level, particularly in the disciplines of mathematics, science, and technology. The evidence of slightly different age profiles at different levels also underscores the complexities involved in attempting to understand teachers' views on gender equality.

Despite the complicated nature of the issues surrounding teacher awareness of gender equality, there are certain patterns which appear to emerge from the data analysis. While teachers in this study voiced a concern for, and a strong belief in, gender equality there appears to be a significant lack of knowledge about how gender issues are played out in the classroom.

The majority of teachers in the study defined equal opportunity as the same treatment of boys and girls. Thus, it appears most of these teachers were attempting to employ a gender-blind or gender-neutral approach to education. In so doing, they are ignoring that gender bias still exists in our society and in our schools. In a sexist society gender is always operative; girls routinely clean-up after labs and record results while boys do the hands-on work; girls routinely worry about getting high marks and having the right answer, while boys take risks and rely less on grades as a source of self-esteem. To say gender is not operative here, is to deny the female reality and to minimize girls' experiences. A gender-neutral approach does not address issues of equal participation or equal results, and it serves to ignore and conceal the processes by which sexism is perpetuated in schools.

It is also evident that the "same treatment" means girls are subjected to an unchallenged and uncritiqued "male" education. Curriculum, particularly in mathematics, science, and computer literacy, continues to be designed and directed by males, for males. It clearly advantages males and disadvantages females in its content, yet, teachers appeared largely unaware of this bias.

The majority of teachers did not support special programs for girls and considered such programs unfair to boys. Such programs are significant, not only in helping to build girls' skills in mathematics, science, and computer literacy, but, also, in providing a support system to discuss and understand gender inequities. These programs offer an opportunity for females to develop a common language, to locate their personal experience within gender, and to develop an understanding of the impact of gender on their lives. The emergence of a feminist voice in mathematics, science, and technology is crucial to the emergence of a woman-centred and, perhaps, ultimately, of a non-sexist view of mathematical and scientific learning. Without the opportunity to locate a voice, the common threads of female experiences will remain invisible and, therefore, unchangeable.

Some teachers of mathematics, science, and computer literacy in this study appeared to be actively engaged in activities to challenge the status quo, however, the nature and depth of these activities has to be challenged. Teachers reported discussing stereotyping, supplementing curriculum, analyzing textbooks, and engaging in various other activities to address gender issues, however, it appears that they were attempting to do so without being able to recognize gender bias. While many teachers voiced a strong commitment and a belief in their responsibility to promote equality, they largely denied the existence of sexism in their own schools. Without a recognition of the processes which work to make education and schools sexist, it cannot be possible to effectively challenge gender bias.

Developing this recognition is a process of raising consciousness - bringing to the conscious those actions which contribute to inequity - and developing an understanding of how gender bias is perpetuated in schools. <u>On-going and substantive professional development activities for teachers on gender bias are vital to ensure teachers are knowledgeable and educated to critique traditional practices and address these concerns with students in a real and meaningful way.</u> Very few teachers in this study reported having ever participated in workshops or coursework on gender equity. Among the school related barriers to change cited by respondents in the study, teacher attitudes, interests, and awareness were the most frequently mentioned.

While female teachers appeared to express greater concern about the issues related to equality, they were not, as a group, more likely to recognize gender inequalities in the practice of teaching. According to their responses, they were more likely to feel strongly about equality and to feel a professional responsibility to address the issue. They reported checking textbooks, introducing discussion into the classroom and attending professional development on gender bias more often than males, however, they were not more likely to identify bias in textbooks, conversational patterns or classroom participation in mathematics, science, and computer literacy. If females are not more likely than males to recognize sexist practice, then hiring more female teachers in mathematics, science, and computer literacy, although providing female role models, is not likely to dramatically change either girls' participation or the curriculum being taught. There is a clearly a need to seek out and to hire feminist teachers who will work to critique and transform the status quo.

In order to provide the atmosphere for transformation, strong leadership and support of feminist practice is critical. This study indicates that ridicule is operative among teaching colleagues when gender bias is presented as an issue, and that school cultures work to diminish those teachers concerned with gender inequity. This marginalization means that discussion and exploration of feminist issues is unlikely to take place in schools. In Senior High Schools one third of teachers felt they were open to ridicule if they presented gender bias as an issue. A supportive climate which fosters critique and actively works to deter the marginalization of colleagues is the only climate in which gender-sensitive education can truly take place. <u>Administrators have an important role, not only in developing their own consciousness about gender issues, but, also in building a school climate which visibly encourages and validates the work of feminist teachers</u>.

Since female mathematics, science, and computer science teachers begin to disappear in Junior High when peer influences and sex-role identity are increasingly played out in schools, the lack of role models at Secondary levels has implications for girls. <u>As support for "non-traditional" behaviour becomes increasingly necessary, girls are increasingly faced</u>

with male teachers who are less likely to be interested in gender issues and less likely to feel a professional responsibility to encourage equal participation.

Many teachers reported feeling that equal participation will be a result of time; as the system renews itself with younger teachers, equality of opportunity will become a reality. Younger teachers did express a strong belief in the principle of equality and more specifically in the equal participation of females in mathematics, science, and computer literacy. However, in comparison to teachers in their thirties and forties, they were less likely to see the need to do more, less likely to have included discussions on sex-role stereotyping in their classes, and less likely to have supplemented their curriculum. All of the respondents in their twenties perceived there was equal opportunity for girls in their schools. Despite their more recent emergence from University programs, half of the respondents in their twenties admitted to not having given much thought to this issue and only two reported having had coursework or workshops on gender equality. It appears that we cannot rely on younger teachers to be the transformation agents in our schools because they are more likely to be unknowingly working in the interests of preserving the status quo.

The development of gender-sensitive education depends upon a feminist perspective of education. It appears there are very few teachers in the survey group who have an understanding of the pervasive nature of gender bias. Only three of the eighty-three teachers in the study responded in a manner which suggests an understanding of the need to include women in mathematics, science, and computer literacy, and of these, only one indicated a need for a feminist view of Science. However unconsciously, almost all of the respondents in this study continue to allow the perpetuation of a patriarchal system which supports sex segregated activity and streams girls away from careers in mathematics, science, and technology. These findings are consistent with other research which has found that teachers are generally unaware of the ways in which schools are male-biased.

Transforming schools to be gender sensitive will be, in itself, a difficult task. Without the assistance of highly conscious teachers actively working to challenge the societal forces which draw girls away from mathematics, science, and technology, and the establishment of a systemic practice of feminist critique, it will be an impossible one. It is of paramount importance that teachers recognize the need to seek the knowledge and skills of a feminist consciousness and that all educators make a meaningful commitment to gender-sensitive education as a priority in education.

CHAPTER SIX

SUMMARY

Over the past two decades, a significant body of research has developed in education to underscore that gender is a problematic issue in schools. As a reflection of our society, our schools work to disadvantage girls. Most educators consider the goal of education to be one of encouraging and challenging all students to reach their potential. Gender bias continues to marginalize and discourage females from this endeavour. If we, as educators, are truly committed to equality then we must struggle with the tough issues of gender inequity and develop strategies to transform schools.

When children enter kindergarten, they have already formed sex-role stereotypes and they already engage in sex-typed activity (Kelly, 1987; Whyte, 1986; Harvey, 1980; Guttantag, 1976). The fact that boys arrive at school, more comfortable and more skilled at mathematical, scientific, and technical concepts is not accounted for within the educational system.

Throughout their elementary and secondary years, boys continue to receive social experiences with mechanical and technological principles as part of their developing masculinity, while girls are taught that such activities are unsafe and unfeminine. At the same time, parents appear less likely to view mathematics and science as important for girls and are less likely to identify and support girls' strengths in these areas. As a result, boys bring more skills and an attitude that mathematics, science, and computer literacy are male activities to our classrooms while girls have less self-confidence and are taught that the sciences are "hard" (Canadian Teachers' Federation, 1988).

Despite the fact that research and teachers' experiences document this situation, neither special programs aimed at overcoming the social disadvantage of girls in these areas, nor programs aimed at educating parents on the importance of experiences with these concepts are currently available in schools.

Schools which teach science using a textbook or demonstration approach further disadvantage girls by once again denying them the opportunity to engage in scientific activity. Science needs to be hands-on from Kindergarten to Grade 12 and girls need to be encouraged to take risks and enjoy the results. Nonetheless, even in activity-based science lessons, gender continues to be operative; girls are likely to clean, help and record while boys do the hands-on work and direct the activity of the lab groups (Fabricant, Svitak, and Kenschaft, 1990). Without a high level of awareness of gender issues, teachers often overlook these subtle differences in participation.

In schools, where girls and boys study the same information, girls do as well or better than boys when school grades are compared (Linn and Hyde, 1989). However, girls' interest and confidence have been shown to be lower even where they are enroled equally and receive equally high marks (May, Boone and Hopkins, 1988). In contrast, boys are likely to view science and mathematics as activities for which they are suited.

The climate of the classroom appears to have significant effects on girls' participation. Where ridicule and sarcasm are used girls feel more uncomfortable, whereas boys like to establish "the pecking order" and are less susceptible to intimidation. Girls tend to participate more equally when teachers include more conferencing and less lecture activity, and where teachers direct questions in large groups rather than relying on volunteer answers (Eccles and Blumenfeld, 1985). From a very early age, girls develop an ethic of care, while boys develop an ethic of rights and justice, thus, girls tend to view the feelings of others and the harmony of the group as important while boys often argue their points and put down their opponents as a matter of course (Gilligan, 1982).

Typical classroom conversational patterns reflect these differences; males dominate discussion and often interrupt or ignore female contributions (Sadker and Sadker, 1986; Spender, 1982). Teachers, who tend to view students as gender-neutral, are largely unaware of these differences and even argue that equal participation in discussion exists where they are documented to be favouring boys (Spender, 1982).

The peer culture of a school or classroom can also have significant influence on girls' participation, interest, and confidence. Along with being "put down" in class, girls who excel in what are considered "male pursuits" are publicly ridiculed and labelled as part of peer sanctions. Talented girls are often forced to choose between social isolation or self-deprecation (Batcher, 1987; Mahoney, 1983). Teachers play into the hands of peer cultures by sex stereotyping girls and boys, for example, in asking girls to clean and boys to carry, and in grouping by sex, for example in dividing students to play girls against the boys games, thereby visually and psychologically reinforcing that gender differences are significant. Schools still model sex stereotyped behaviour and as students move into adolescence and adulthood these stereotypes become increasingly evident in schools. For example in most Junior High and High School settings, we still see male caretakers, female secretarial staff, male administrators and department heads, male coaches, and male teachers in mathematics, science, and computer literacy. Far from providing role models to challenge the stereotypes, schools continue to accept and even celebrate sex-stereotyped activity. When asked to identify stereotyped activity in schools, many teachers could not even think of one example.

The curriculum, too, plays a part in gender-biased education. Mathematics, science, and computer literacy textbooks and resources reflect that these subject areas are male domains; they picture males more frequently, use biased language, and exclude women scientists (Rosser, 1990). The curriculum content, textbooks, and resources reflect male-related interests such as space or mechanics rather than female-related interests such as the environment. It is important that the topic areas through which concepts are studied, made relevant, and tested, include areas which appeal to females.

On an even more subtle level, the view of science which we teach can be considered male-biased. The dominant view of science is one which makes use of the scientific method and divorces applications from context as men have traditionally been divorced from the day to day context of home management and family life. As care-givers, women experience life as unpredictable and inter-related with others. Scientific study, like the dominant male experience, often assumes laboratory applications will be replicated in the real world and that rational planning is all that is necessary for successful implementation. This type of abstraction is an over-simplification of complex and changing contexts. A more feminine view of science is one which takes context into account using qualitative methodologies and one which understands the unpredictable nature of the world (Franklin, 1990). Qualitative methodologies, which focus on the importance of context in determining outcomes, continue to be absent from our traditional science curriculum.

In keeping with the development of an ethic of care and the use of this ethic in decision-making, the ethical and social implications of scientific and technological applications are typically of more importance to females than males (Overfield, 1981). Again, these important dimensions of scientific and technological education which should be integral and explicit in a non-sexist curriculum, are absent from our content driven curriculum and are often not even mentioned by teachers.

Career education in secondary schools continues to be founded on helping students select a career based on their interests and aptitudes. On the basis of role models, interests, self-confidence, and role conflict, girls continue to choose stereotyped occupations (Ellis and Sayer, 1986; Baker, 1985; Glaze and Ellis, 1980). Their expectations of a future continue to involve the dilemma of coping with the major parenting and household management role as well as a full-time career (Canadian Teachers' Federation, 1990). Programs where young women can discuss these role conflicts and the part that gender inequities in our society play in creating these conflicts do not exist. Teachers who ignore that gender is operative in career planning and who are not sensitive to the experience of being female in our society only work to further diminish young women who see the barriers and are provided with no assistance in negotiating the path.

Gender is operative in our schools and in our society. Our students come to school identified and treated differently according to gender since birth and will continue to be treated differently throughout their lives. The unequal representation of young women in mathematics, scientific, and technology-related careers is part of a patriarchal order. A gender-sensitive education is the first step in beginning the transformation process in schools. Our greatest need is to develop gender-sensitive teachers to meet this challenge.

CHAPTER SEVEN

QUESTIONING GENDER BIAS IN MATHEMATICS, SCIENCE, AND COMPUTER LITERACY: AN ACTIVITY FOR TEACHERS

Teachers must begin a practice of critical examination of their classrooms and their schools in building their awareness of gender bias. The following questions are guidelines for teachers in mathematics, science, and computer literacy to use in exploring their practice and their classrooms.

1. Are girls participating in manipulating equipment? Are girls' hands on science activities? Have they seen the inside of a computer? Can they remove/replace cards? Have they seen a microchip? Do they have some idea of how a computer functions? Do they know how to trouble shoot if something goes wrong? Do you show girls how machines and equipment work and ask them to assist you in doing so?

2. Do girls go to mathematics, science, and computer centres in their free time? Do they express interests in scientific or computer related topics? Are their science fair projects activity based?

3. Are parents encouraged to interest their daughters in mathematical, scientific, and computer related activities? Are parents encouraged to ensure their daughters learn basic home maintenance skills and become comfortable with tools and equipment?

4. Do you use a variety of teaching methodologies including conferencing and small group work? Is cooperative learning an equal part of classroom practice? Are students encouraged to work together on solving problems in mathematics, science, and computer literacy?

5. What is the peer culture of the classroom like for girls? Are any of the girls labelled by boys? If so, why are they being labelled and what can you do about it? Do boys assume helping roles with other students? Are all students caring and supportive of one another? What can you do to make the classroom more supportive?

6. Are gender groupings evident? Do girls sit with girls and boys with boys? If so, why? Do these groups serve a purpose or are they unnecessary reinforcers of gender differences? Are misbehaving boys made to sit with girls?

7. Is sex-role stereotyping evident - Do girls clean-up, take helping roles, and act as secretaries while boys carry and direct activity? Do all students act in all roles? Do you recognize sex stereotypes on a regular basis? Do you point out examples of sex stereotyping to your students when they occur?

8. Do you reflect on the way you respond to girls and boys in your classroom? How could you determine if you respond differently? Do you offer the same kind of assistance to boys and girls? If not, why? Do you offer the same amount of assistance to boys and girls? If not, why? What can you do to make it more equitable <u>and</u> meet the needs of students?

9. Do you reflect on conversational patterns in the classroom? How could you determine if male students talk more, ask, and/or answer more questions than female students? Do male students get more "air time" in your classroom? Do male students interrupt female students or discourage female students from sharing their knowledge?

10. Do posters, textbooks, resources, etc. picture women engaged in mathematical, scientific, or computer-related activity? Do resources use gender inclusive language? Do you use biased materials to stimulate discussion with students on stereotyping and gender inequity?

11. Do you supplement the curriculum to include women? Are women scientists highlighted? Are quantitative and qualitative approaches to science included? Are girls interests reflected as well as boys? Is science and computer technology applied in ways girls can relate to and are interested in? Are ethics discussed in class as new applications are introduced? Are social implications of scientific and technological development discussed?

12. Do career education programs address the realities of young women's lives? Do girls have an opportunity to meet female mathematicians, scientists, and computer specialists who can act as role models and who can talk about the conflicts of maintaining a scientific career and a family as part of a career plan? Do girls and boys have an opportunity to discuss and explore gender inequity in our society?

CHAPTER EIGHT

RECOMMENDATIONS

It is apparent from this study that there is a need for a conscious commitment to gender equality within this school division. The level of awareness of the participants in the study strongly suggests that ongoing support and leadership aimed at developing a feminist consciousness amongst teachers is a necessary pre-requisite to gender-sensitive education. Administrators need to be sensitized to the day to day practices in schools which work to reinforce and maintain sex-roles and to develop programs which challenge and educate teachers and students about gender issues. On-going professional development activity to develop reflective and feminist teaching practice is crucial.

Career awareness programs which focus on role conflict and challenging traditional gender-related choices as well as parent information programs which focus on the need to encourage girls to acquire the mathematical, scientific, and technological literacy skills necessary for informed participation in our society need to be developed and implemented. There is a need for direct confrontation with sexism in schools so that women and girls can develop strategies to deal constructively with male ridicule and aggressiveness and men and boys can reflect on the meaning of masculinity and the effects of their behaviour on others.

Curriculum change is an important aspect of provision for equality in mathematics, science, and computer literacy. The Department of Education has a responsibility to re-evaluate curriculum, to assure equal female representation on curriculum committees in these traditionally male areas and to develop a core curriculum which includes feminist perspectives. School divisions must provide the resources and training for hands-on mathematics, science, and computer science programs at all levels.

It is apparent that Faculties of Education are neither delivering gender-sensitive education, nor teaching students to be gender-sensitive. There is a need to develop mandatory undergraduate coursework which focuses on equality issues and ensures those teachers entering the profession have the expertise to deliver gender-sensitive education. There is a need for professors within the faculties to demonstrate awareness of gender issues by evaluating their own curriculum. Student teacher advisors should be made conscious of gender issues and gender equity evaluated as an integral part of student teaching experiences.

New teachers need to develop the skills to critique traditional practices which are inequitable.

Qualitative research which addresses the underlying issues of sexism at a deeper level needs to be carried out with teachers and students. Interview and observational research which focuses on the day to day experience of females in education needs to be conducted in an effort to illuminate sexist behaviour and patterns in order that these may become the site of struggle in an effort to transform our schools.

A system of tracking girls within the school system, and assessments of their confidence, their interests, and their course enrolments need to be developed in order to evaluate how well educators are doing. Research needs to focus on qualitative information from girls themselves, as well as provide statistical documentation on post-secondary choices and success rates.

At all levels, including policy development, systemic feminist critique must become part of the process of developing and implementing educational programs. Educators must begin to ask themselves daily as they go about their work, <u>Is gender operative here?</u> and <u>If so, what needs to be done to promote and ensure gender equality?</u>.

Armstrong, J. M., & Price, R. A. (1982). Correlates and predictors of women's mathematics participation. Journal for Research in Mathematics Education, 13(2), 99-109.

Badger, M. E. (1981). Why aren't girls better at math? A review of the research. Educational Research, 24(1), 11-23.

Baker, M. (1985, March). What will tomorrow bring? A study of the aspirations of adolescent women. Ottawa: The Canadian Advisory Council on the Status of Women.

Batcher, E. (1987). Building the barriers: Adolescent girls delimit the future. In Greta Nemiroff (Ed.), Women and Men: Interdisciplinary readings on gender (pp. 150-164). Montreal: Fitzhenry & Whiteside.

Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). Women's ways of knowing. New York: Basic Books.

Benbow, C. & Stanley, J. (1982). Consequences in high school and college of sex differences in mathematical reasoning ability. American Educational Research Journal, 19(4), 598-622.

Benston, M. (1988). Women's voices/men's voices: Technology as language. In C. Kramarae (Ed.), Technology and women's voices: Keeping in touch (pp. 15-28). London: Routledge & Kegan Paul Ltd.

Benston, M. (1984). The myth of computer literacy. Canadian Woman Studies, 5(4), 20-22.

Briskin, L. (1990). Feminist pedagogy: Teaching and learning liberation. Feminist Perspectives(No.19). Ottawa: Canadian Research Institute for the Advancement of Women.

Best, J., & Kahn, J. (1989). Research in Education (6th ed.). Englewood Cliffs, N.J.: Prentice Hall.

Bleier, R. (1984). Science and gender: A critique of biology and its theories on women. New York: Pergamon Press.

Brophy, J. (1985). Interactions of male and female students with male and female teachers. In L. Wilkinson & C. Marrett (Eds.), Gender influences in classroom interactions (pp. 115-142). Orlando: Academic Press.

Canadian Teachers Federation. (1990). ACAPPELLA: A report on the realities, concerns, expectations and barriers experienced by adolescent women in Canada.

Canadian Teachers' Federation. (1988). Women and education: A resource book for improving the participation and success of female students in science and technology. Toronto: Canadian Teachers' Federation.

Carroll, B. & Cherry, F. (1988). Some advice for overcoming barriers to women's achievement in non-traditional occupations. Feminist Perspectives (No. 13). Ottawa: Canadian Research Institute for the Advancement of Women.

Collis, B. (1987). Adolescent females and computers: Real and perceived barriers. In J. Gaskell & A. McLaren (Eds.), Women and education: A Canadian perspective (pp. 117-131). Calgary: Detselig Ent.

Connell, R. W. (1987). Gender and power. Stanford: Stanford University Press.

Crossman, K. (1987). Teachers' interactions with girls and boys in science lessons. In A. Kelly (Ed.), Science for girls (pp. 58-65). Philadelphia: Open University Press.

Decore, A. (1984). Vive la difference: A comparison of male/female academic performance. The Canadian Journal of Higher Education, 14(3), 35-38.

Deem, R. (Ed.). (1980). Schooling for women's work. London: Routledge & Kegan Paul Ltd.

Dweck, C. & Elliot, E. (1983). Achievement motivation. In P. Mussen (Ed.), Handbook of child psychology: Vol. 4. Socialization, personality and social development (pp. 643-692). New York: John Wiley & Sons.

Eccles, J. & Blumenfeld, P. (1985). Classroom experiences and student gender: Are there differences and do they matter? In L. Wilkinson & C. Marrett (Eds.), Gender influences in classroom interactions (pp. 79-114). Orlando: Academic Press.

Eichler, M. (1987). The relationship between sexist, non-sexist, woman-centred and feminist research in the social sciences. In Greta Nemiroff (Ed.), Women and men: Interdisciplinary readings on gender (pp. 21-53). Montreal: Fitzhenry & Whiteside.

Eichler, M. & Lapointe, J. (1985). On the treatment of the sexes in research. Ottawa: Research Council of Canada.

Ellis, D. (Ed.). (1988). Math 4 girls. Toronto: Ontario Educational Research Council.

Ellis, D., & Sayer, L. (1986). When I grow up: Career expectations and aspirations of Canadian schoolchildren. Ottawa: Labour Canada.

Ernest, J. (1976). Mathematics and sex. Santa Barbara: University of California.

Fabricant, M., Svitak, S., & Kenschaft, P. (1990, February). Why women succeed in mathematics. Mathematics Teacher, pp. 150-154.

Fausto-Sterling, A. (1985). Myths of gender. New York: Basic Books.

Fennema, E. (1984). Girls in mathematics. In H. Neely Cheek (Ed.), Equity activities in mathematics education (pp. 68-78). Reston, Virginia: National Council of Teachers of Mathematics.

Fennema E. & Peterson J. (1985). Autonomous learning behaviour: A possible explanation of gender related differences in mathematics. In L. Wilkinson & C. Marrett (Eds.), Gender influences in classroom interaction (pp. 17-35). Orlando: Academic Press.

Fennema E. & Sherman, J. (1978, May). Sex related differences in mathematics achievement and related factors. Journal of Mathematics Education, 189-203.

Ferguson, J. (1983, February). Science education for the 1980's. Proceedings of the First National Conference for Women in Science and Technology (pp. 54-61). Vancouver, B.C.

Forg, T. & Wubbels, T. (1987). Physics a problem for girls or girls a problem for physics? International Journal of Science Education, 9(3), 197-207.

Frank, M. (1990, January). What myths about mathematics are held and conveyed by teachers? Arithmetic Teacher, pp. 10-12.

Franklin, U. (1990). The real world of technology (C.B.C. Massey Lectures). Toronto: C.B.C. Enterprises.

Franklin, U. (1984). Will technology change women or will women change technology? Knowledge reconsidered: A feminist overview (pp. 81-90). Ottawa: Canadian Research Institute for the Advancement of Women.

French, M. (1985). Beyond power: On women, men and morals. New York: Ballantine Books.

Friedman, L. (1989). Mathematics and the gender gap. Review of Educational Research, 19(2), 185-213.

Gaskell, J., & McLaren, A. (Eds.). (1987). Women and education: A Canadian perspective. Calgary: Detselig Enterprises.

Gaskell, J., McLaren, A., & Novogfodsky, M. (Eds.). (1989, November). Claiming an education. Our Schools: Ourselves.

Gay, L. R. (1981). Educational research (2nd ed.). Columbus: Charles E. Merrill.

Geller, G. (1984). Aspirations of female high school students. Resources For Feminist Research, 13(1), 17-19.

Ghosh, R., & Ray, D. (1987). Social change and education in Canada. Toronto: Harcourt, Bruce, Jovanovich.

Gilligan, C. (1982). In a different voice. Cambridge: Harvard University Press.

Glaze, A., & Ellis, D. (1980). Ontario girls aspirations and expectations. Orbit, 11(3), 19-22.

Grady, K. (1981). Sex bias in research design. Psychology of women quarterly, 5(4), 628-636.

Guttentag, M., & Bray, H. (1976). Undoing sex stereotypes. New York: McGraw-Hill.

Haggerty, S. (1987). Gender and science achievement: A case study. International Journal of Science Education, 9(3), 271-179.

Hall, R., & Sandler, B. (1982). The classroom climate: A chilly one for women. Washington: Association of American Colleges, 1818 R Street, NW, Washington, DC 20009.

Hammond, G., & Oleson, C. (1989, January). Participation of girls and women in math, science and technology. A paper presented at the Joint Education and Status of Women Ministers' Conference, Ottawa, Canada.

Harding, S. (1986). The science question in feminism. Cornell: Cornell University Press.

Harvey, T. J. & Edwards, P. (1980). Children's expectations and realisations of science. British Journal of Educational Psychology, 50, pp. 74-76.

Hornig, L. (1986, October). Women: Their underrepresentation and career differentials in science and engineering. Proceedings of The National Science Foundation Workshop (pp. 103-122), Washington, DC.

Houston, B. (1987). Should public education be gender free? In Greta Nemiroff (Ed.), Women and men: Interdisciplinary readings on gender (pp. 134-149). Montreal: Fitzhenry & Whiteside.

Institutional Statistics. (1990, October). I S book (6th ed.). University of Manitoba: Office of Institutional Analysis.

Kahle, J. & Matyas, M. (1986, October). Equitable science and math education: A discrepancy model. Proceedings of the National Science Foundation Workshop (pp. 5-41), Washington, D.C.

Keller, E. (1985). Reflections on science and gender. Yale: Yale University Press.

Keller, E. (1983, May). Is science male? Proceedings of the First National Conference for Women in Science and Technology (pp. 21-33), Vancouver, B.C.

Keller, H. (1983). A feeling for the organism: The life and work of Barbara McClintock. New York: W. H. Freeman & Co.

Kelly, A. (1987). Science for girls. Philadelphia: Open University Press.

Kelly, A. (1981). Is there a problem? The missing half: Girls and science education. Manchester: Manchester University Press.

Kirby, S., & McKenna, K. (1989). Experience, research, social change: Methods from the margins. Toronto: Garamond Press.

Koblitz, A. (1987). A historian looks at gender and science. International Journal of Science Education, 9(3), 399-407.

LaFrance, M. (1986). The school of hard knocks: Nonverbal sexism in the classroom. Theory Into Practice, 24(1), 41-44.

Lapointe, A., Mead, N., & Phillips, G. (1988). A world of differences: An international assessment of mathematics and science. Princeton: Educational Testing Service.

LeBold, W. (1986, October). Women in engineering and science. Proceedings of The National Science Foundation Workshop (pp. 49-98), Washington, DC.

Lewis, M. (1990). Interrupting Patriarchy: Politics, resistance and transformation in the feminist classroom. Harvard Educational Review, 60(4), 467-488.

Linn, M., & Hyde, J. (1989, November). Gender, mathematics and science. Educational Researcher, pp. 17-27.

Long, J. S. (1986, October). Problems and prospects for research on sex differences in the scientific career. Proceedings of The National Science Foundation Workshop (pp. 157-169), Washington, DC.

Maccomby, E., & Jacklin, C. (1974). The psychology of sex differences. Stanford: Stanford University Press.

Mahoney, P. (1983, September). How Alice's chin really came to be pressed against her foot: Sexist processes of interaction in mixed sex classrooms. Women's Studies International Forum, 6(1), 107-115.

May, S., Boone, W., & Hopkins, B. (1988). Sex related differences in mathematics: Participation, achievement and attitudes in the Newfoundland and Labrador setting (Report No. 0-920769-66-7). Department of Education, Government of Newfoundland and Labrador, Canada.

McBride, M. (1989). A Foucaldian analysis of mathematical discourse. For The Learning of Mathematics, 9(1), 40-46.

McKim, G. (1989, September). Career exposures for the 90's. Education Manitoba, pp. 26-28.

McLaren, J. (1989). Women's ways of knowing: Significant new research on women's cognitive development. Women's Education, 7(2), 10-13.

McLaren, P. (1989). Life in school: An introduction to critical pedagogy in the foundations of education. Toronto: Irwin Publishing.

McLoed, L. (1988). Progress as paradox: A profile of women teachers. Toronto: Canadian Teachers' Federation.

Menzies, H. (1982). Computers on the job. Toronto: James Lorimer & Co.

Menzies, H. (1981). Women and the chip. Montreal: Canadian Institute for Research on Public Policy.

Mishler, E. (1979). Meaning in context: Is there any other kind? Harvard Educational Review, 49(1), 1-19.

Morse, L. & Handley, H. (1985). Listening to adolescents: Gender differences in science classroom interaction. In L. Wilkinson & C. Marrett (Eds.), Gender influences in classroom interactions (pp. 37-56). Orlando: Academic Press.

Mura, R., Kimball, M., & Cloutier, R. (1987). Girls and science programs: Two steps forward, one step back. In J. Gaskell & A. McLaren (Eds.), Women and education. (pp. 133-149). Calgary: Detselig Ent.

Nevitte, N., Gibbins, R., & Codding, P. (1988). The career goals of female science students in Canada. The Canadian Journal of Higher Education, 18(1), 31-48.

O'Brien, M. (1983). Feminism and education: A critical review essay. Resources For Feminist Research, 12(3), 13-16.

Oleson, T. (1990, May 5). Unravelling the brain's mysteries. [Review of Brain sex: The real difference between men and women]. Winnipeg Free Press, p. 24.

Organisation For Economic Cooperation and Development. (1986). Girls and women in education. Paris: O.E.C.D.

Outram, D. (1987). The most difficult career: Women's history in science. International Journal of Science Education, 9(3), 409-416.

Overfield, K. (1981). Dirty fingers, grime and slag heaps: Purity and the scientific ethic. In D. Spender (Ed.), Men's studies modified: The impact of feminism on the academic disciplines (pp. 231-248). Oxford: Pergamon Press.

Parker, L. & Offer, J. (1987). School science achievement: Conditions for equality. International Journal of Science Education, 9(3), 263-269.

Parlee, M. (1985). Psychology of women in the 80's: Promising problems. International Journal of Women's Studies, 8(2), 193-204.

Pedersen, K., Bleyer, D., & Elmore, P. (1985, March). Attitudes and interests of junior high mathematics students. Arithmetic Teacher, pp. 45-48.

Poverty profile 1988. (1988). Ottawa: National Council of Canada, Ministry of Supply and Services.

Report of the Royal Commission on the Status of Women. (1970). Ottawa: Information Canada.

Rainbird, G. (1990, August). Education and information technology. Paper presented at the National Institute Awards, Halifax, N.S.

Reynolds, C. (1988, June). Denial, distancing and self-disclosure: Toward a feminist pedagogy. A paper presented at the annual meeting of C.A.C.S., University of Windsor.

Robertson, H. (1989, February). Teacher development and sex equity. A paper presented at the International Conference on Teacher Development, OISE, Toronto, Canada.

Rosser, S. (1990). Female-friendly science. New York: Pergamon Press.

Rosser, S. (1984). A call for feminist science. International Journal of Women's Studies, 7(1), 3-9.

Rybczynski, W. (1983). Taming the tiger: The struggle to control technology. New York: Viking Press.

Sadker, M., Sadker, D., & Steindam, S. (1989). Gender equity and educational reform. Educational Leadership, 46(6), 44-47.

Sadker, M., & Sadker, D. (1986, March). Sexism in the classroom: From grade school to graduate school. Phi Delta Kappan, pp. 512-515.

Science Council of Canada. (1982). Who turns the wheel? Ottawa: Ministry of Supply and Services.

Science Council of Canada. (1984). Science for every student: Educating Canadians for tomorrow's world. Ottawa: Ministry of Supply and Services.

Sexton, P. (1976). Women in education. Bloomington: Phi Delta Kappan.

Shakeshaft, C. (1986, March). A gender at risk. Phi Delta Kappan, pp. 499-503.

Sherman, J. (1980). Mathematics, spacial visualization and related factors: Changes in girls and boys, grades 8-11. Journal of Educational Psychology, 72(4), 476-482.

Spear, M. (1987). Science teachers' perceptions of the appeal of science subjects to boys and girls. International Journal of Science Education, 9(3), 287-296.

Spear, M. (1987). The biasing influence of pupil sex in a science marking exercise. In A. Kelly (Ed.), Science for girls (pp. 46-51). Philadelphia: Open University Press.

Spender, D. (1982). Invisible women: The schooling scandal. London: Writers and Readers Publishing.

Spender, D. (Ed.). (1981). Men's studies modified: The impact of feminism on the academic disciplines. Oxford: Pergamon Press.

Sprung, B. (Ed.). (1978). Perspectives on non-sexist early childhood education. New York: Teachers College Press.

Stanworth, M. (1983). Gender and schooling. London: Hutchinson and Co.

Stanley, L., & Wise, S. (Eds.). (1983). Breaking out: Feminist consciousness and feminist research. London: Kegan Paul.

Statistics Canada. (1985). Characteristics of women in the labour force. Ottawa: Statistics Canada.

Tetrault, M. K. (1985). Feminist Phase Theory. Journal of higher education, 56(4), 363-384.

Tite, R. (1986). Sex-role learning and the woman teacher. Feminist Perspectives (No. 7). Ottawa: Canadian Research Institute for the Advancement of Women.

Tobias, S. (1982, January). Sexist equations. Psychology Today, pp. 14-17.

Toronto Board of Education. (1985). Mathematics: The invisible filter. Toronto: Author.

Unger, R. (1983). Through the looking glass: No wonderland yet. Psychology of Women Quarterly, 8(1), 9-32.

Verne, G. (1987). Women's challenge to computer science and technology. International Journal of Science Education, 9(3), 361-366.

Walkerdine, V. (1987). Some issues in the historical construction of the scientific truth about girls. In A. Kelly (Ed.), Science for girls (pp. 37-44). Philadelphia: Open University Press.

Wallston, B., & Grady K. (1985). Integrating the feminist critique and the crisis in social psychology. In V. O'Leary, R. Unger, & B. Wallston (Eds.), Women, gender and social psychology (pp. 7-33). Hillsdale, N.J.: Lawrence Erlbaum Assoc.

Watt, W. (1990). Gender issues in mathematics and science. Education Manitoba, 17(7), 17-18.

Weiler, K. (1988). Women teaching for change: Gender, class and power. South Hadley: Bergin & Garvey.

Wienekamp, H., Jansen, W., Fickenfrerichs, H., & Peper, R. (1987). Does conscious behaviour of teachers cause chemistry lessons to be unpopular with girls? International Journal of Science Education, 9(3), 281-286.

Wilkinson, L., & Marrett, C. (Eds.). (1985). Gender influences in classroom interaction. Orlando: Academic Press.

Whyte, J. (1986). Girls into Science and Technology. London: Routledge and Kegan Paul.

Whyte, J., Deem, R., Kant, L., & Cruickshank, M. (Eds.). (1985). Girl friendly schooling. London: Methuen & Co.

Women in the labour force. (1983). Ottawa: Labour Canada, Ministry of Supply and Services.

Zalnieriunas, V. (1989, April). Science and math for girls. The Reporter, pp. 29-32.

APPENDIX 1.1

<u>COURSE ENROLMENTS 1989/90</u>

COURSE	FEMALE	MALE	%FEMALES	%MALES
ADV MA100	27	20	10%	7%
MA100	166	164	60%	54%
MA101	29	40	10%	13%
ADV MA200	36	36	14%	13%
MA255	24	24	9%	9%
MA200	124	117	47%	43%
MA201	39	42	15%	15%
MA300AP	8	12	2%	4%
MA305/355CAL	21	34	6%	11%
MA305	3	8	1%	3%
MA300	152	122	47%	40%
MA301	42	41	13%	13%
AVD SC100	14	13	5%	4%
SC100	167	178	60%	59%
SC101	33	43	12%	14%
ADV CHEM200	4	11	2%	4%
ADV PHY200	5	11	2%	4%
CH200	124	115	47%	42%
PHY200	78	109	29%	40%
BIO	225.5	133	38%	23%
SC201	16	34	6%	12%
CH300	99	98	30%	32%
ADV PHY300	0	5	0%	2%
PHY300	63	97	19%	32%
SC301	9	23	3%	8%
CS105	17	26		
CS205	16	70		
CS305	1	18		
CSTOTAL	34	114	4%	13%
DP202	25	44		
DP302	4	11		
DPTOTAL	29	55	5%	18%

APPENDIX 1.2

SCHOOL - ENROLMENT AND ACHIEVEMENT RESULTS

COURSE	FEMALE	MALE	%FEMALES	%MALES	MARK F	MARK M
MA200AP	14	11	13%	9%	86	88
MA255	2	4	2%	3%	97	70
MA255/CAL355AP	22	20	20%	16%	75	69
MA300AP	8	12	6%	9%	82	77
MA355/ADVCAL355	11	24	8%	18%	71	77
MA100	81	99	71%	67%	76	71
MA200	64	69	59%	54%	67	65
MA300	76	74	57%	54%	70	70
MA101	14	22	12%	15%	69	67
MA201	22	23	20%	18%	73	70
MA301	24	26	18%	19%	66	62
PHY200AP	5	11	5%	9%	80	74
PHY300AP	0	5	0%	4%		86
SC100	88	102	77%	69%	70	67
CH200	71	73	65%	57%	71	67
CH300	54	64	41%	47%	72	73
PHY200	40	51	37%	40%	77	63
PHY300	26	52	20%	38%	66	69
BIO200/300	149	104	62%	40%	N/A	N/A
SC101	12	25	11%	17%	68	53
SC201	7	15	6%	12%	59	67
SC301	7	19	5%	14%	58	59
CS205	13	48				
CS305	0	9				
CSTOTAL	13	57	4%	14%	69	75
DATAPRO202	18	42				
DATAPRO302	3	11				
DATAPROTOTAL	21	53	6%	13%	N/A	N/A

COURSE	FEMALE	MALE	% FEMALES	% MALES	MARK F	MARK M
MAAF100/200	10	3	6%	2%	88	87
MAAF200/300	9	10	6%	7%	86	84
MA100/200H	17	17	10%	11%	78	83
MA200/300H	13	15	8%	10%	83	75
MA305CAL	10	10	5%	6%	85	67
MA305TOPICS	3	8	2%	5%	93	89
MAF100	16	6	10%	4%	67	69
MA100	69	65	42%	42%	69	68
MA200	60	48	38%	33%	69	69
MA300	76	48	40%	29%	72	71
MA101	15	18	9%	12%	68	57
MA201	17	19	11%	13%	68	66
MA301	18	15	9%	9%	64	68
SC100/CH200H	14	13	9%	8%	72	77
CH200/300H	4	11	3%	7%	85	79
SC100	79	76	48%	49%	66	62
CH200	53	42	34%	29%	74	68
CH300	45	34	23%	20%	73	71
PHY200	38	58	24%	39%	75	71
PHY300	37	45	19%	27%	76	73
BIO205	76.5	29	22%	9%	N/A	N/A
SC101	21	18	13%	12%	69	63
SC201	9	19	6%	13%	58	63
SC301	2	4	1%	2%	66	62
CS105	17	26			81	77
CS205	3	22			75	76
CS305	1	9			71	76
CSTOTAL	21	57	4%	12%	N/A	N/A
DP202	5	2				
DP302	1	0				
DPTOTAL	6	2	2%	1%	N/A	N/A

APPENDIX 5.1

QUESTIONNAIRE

Circle the most appropriate answer.

	strongly agree	agree	disagree	strongly disagree	no opinion
1. It is important for schools to provide an equal opportunity to all students regardless of gender.	1	2	3	4	5

2. Equal opportunity related to gender is best described as:

    1. The same treatment for girls and boys
    2. Special treatment for girls in certain areas to address the effects of socialization and discrimination
    3. Other (Please specify)____

	strongly agree	agree	disagree	strongly disagree	no opinion
3. The concept of special programs for girls is unfair to boys.	1	2	3	4	5
4. Discrimination against female students is still a problem in education.	1	2	3	4	5
5. In our school, boys and girls have equal opportunities.	1	2	3	4	5
6. In our school, girls and boys participate equally in classroom discussions.	1	2	3	4	5
7. It is important that males and females participate equally in mathematics, science and computer literacy in schools.	1	2	3	4	5
8. Girls and boys do participate equally in mathematics, science and computer literacy activities in our school.	1	2	3	4	5
9. I really have not given gender equality in mathematics, science and computer literacy a great deal of thought.	1	2	3	4	5
10. Mathematics, science and computer literacy textbooks and resources in our school are male-biased.	1	2	3	4	5
11. In general, girls have less background experience with mathematics, science and computers than boys.	1	2	3	4	5
12. Teachers should be doing more to promote equal participation in mathematics, science and computer literacy.	1	2	3	4	5
13. With all of the other demands of teaching, gender equality in mathematics, science and computer literacy is not a priority.	1	2	3	4	5

	strongly agree	agree	disagree	strongly disagree	no opinion
14. Change is slow; it's just a matter of time before males and females participate equally in mathematics, science and computer literacy.	1	2	3	4	5
15. I have a responsibility to work toward the equal participation of female and male students in mathematics, science and computer literacy.	1	2	3	4	5
16. I think boys show more natural ability to learn mathematical and scientific concepts.	1	2	3	4	5
17. Well-controlled scientific experiments are virtually free of bias.	1	2	3	4	5
18. Girls are free to choose according to their interests; there is not much teachers can do if girls do not participate equally in mathematics, science and computer literacy.	1	2	3	4	5
19. One of the good things about mathematics, science and computer literacy is that the content is free of gender bias.	1	2	3	4	5
20. More resources and curriculum support materials are necessary to address gender equality in mathematics, science and computer literacy.	1	2	3	4	5
21. If I presented gender bias as a serious problem in our school, I would risk being ridiculed by my colleagues.	1	2	3	4	5
22. Our school system supports and encourages teacher concern with gender equality.	1	2	3	4	5
23. The mathematics, science and computer literacy curriculum exclude women's accomplishments in these fields.	1	2	3	4	5
24. The major goal of scientific and technological applications should be to predict and control outcomes.	1	2	3	4	5
25. We should have programs targeted specifically for girls in order to increase their confidence in mathematics, science and computer literacy.	1	2	3	4	5

	strongly agree	agree	disagree	strongly disagree	no opinion
26. We should be actively looking for more women mathematics, science and computer science teachers at secondary levels in order to provide role models for female students.	1	2	3	4	5
27. The generic use of "he" and "his" in our textbooks and resources includes women and does not need to be changed.	1	2	3	4	5
28. A feminist view of mathematics, science and computer literacy needs to be developed and included in our curriculum.	1	2	3	4	5
29. Science and technology today would be different if women had participated in decision-making in these fields in the past.	1	2	3	4	5

TEACHER ACTIVITIES:

30. I have evaluated the textbooks and resources I use to be sure women and girls are included. 1) Yes 2) No

31. I have taped or had observers evaluate my teaching to ensure I respond equally to male and female students. 1) Yes 2) No

32. In the past year, I have supplemented the curriculum in order to address gender equality. 1) Yes 2) No

33. In the past year, I have included discussions about sex-role stereotyping in my classes to challenge myths about gender roles. 1) Yes 2) No

If so, what were the students' reactions?

____

____

34. I have worked actively to encourage girls' participation in mathematics, science and/or computer literacy. 1) Yes 2) No

If so, explain.

____

____

35. I have participated in workshops or courses on gender equality. 1) Yes 2) No

COMMENTS: (Use back of page if desired)

36. What do you see as the important factors which prevent girls from participating equally with boys in mathematics, science and computer literacy?

____

____

37. What do you see as the important barriers preventing teachers from successfully addressing gender equality in mathematics, science and computer literacy?

____

____

38. What practices are you aware of in your school which may work to promote or reinforce sex-role stereotyping?

____

____

____

39. What practices are you aware of in your school which may work to intimidate girls in mathematics, science and computer literacy?

____

____

____

40. What practices are you aware of in your school which are being used to encourage equal participation in mathematics, science and computer literacy?

____

____

____

BIOGRAPHICAL INFORMATION: Circle all that apply.

41. Current teaching responsibilities:

1) Science (general)
2) Mathematics
3) Computer Literacy/Computer Science
4) Biology
5) Chemistry
6) Physics

42. Current teaching level:
1) Elementary
2) Junior High
3) Senior High

43. Sex: 1) Female 2) Male

44. Age: 1) 20-29 2) 30-39 3) 40-49 4) over 49

THANK-YOU!!!

APPENDIX 5.2

INTERVIEW DISCUSSION

Maybe, we could begin by talking about your own experiences and interests in the areas of math and science. When did you first become interested in math and science activities?

What is your view of math and science? What makes math and science important? What should be the goals of math and science education?

As you are aware, I am interested in the differential participation and achievement of male and female students in these areas. Do you see differences between the two? Could you elaborate on how you see these demonstrated in the classroom/school?

What factors do you think contribute to these differences?

In your experiences and work with teachers in this division, do you see practices in schools which you feel may be contributing to the problem? Could you elaborate/give examples?

In your experience in this division, have you or other teachers you know been actively trying to combat the problem? What kinds of things have you/they been doing?

Do you think anti-sexist practices have been supported by others? How? By whom? Do you think there is subtle or overt resistance to these practices? Can you give some examples?

What do you think needs to be done to resolve this problem? How would you like to see it approached? What role should teachers play?

APPENDIX 5.3

November 4, 1990

Dear Colleague,

As you may be aware, the Science Council of Canada has identified the participation of female students in mathematics, science, and technology as an issue of national concern in education. I have chosen to study this topic at a divisional level as a thesis research project for my Master's program in Education. The attached questionnaire has been developed in an effort to obtain information regarding this issue from teachers with experience in the areas of mathematics, science, and/or computer literacy.

I estimate the questionnaire will take about 15 minutes to complete and you are free to discontinue participation at any time without penalty. Your responses are extremely valuable in gaining insight into our local situation and I invite you to comment freely.

Any information reported will ensure anonymity and data will be reported in aggregate form. Any comments quoted will ensure the identity of participants is protected. I would appreciate it if you would return the completed questionnaire to me in the attached envelope before November 23, 1990.

A summary of this study will be available to any interested participants or schools upon completion. If you wish to obtain additional information, please contact Dr. Jon Young at the Faculty of Education, University of Manitoba.

Sincerely,

Wendy Fidkalo

APPENDIX 5.4

RESPONSE FREQUENCIES TO QUESTIONNAIRE

	strongly agree	agree	disagree	strongly disagree	no opinion
1. It is important for schools to provide an equal opportunity to all students regardless of gender.	92.8%	7.2%	0%	0%	0%

2. Equal opportunity related to gender is best described as:

The same treatment for girls and boys - 73.5%
Special treatment for girls in certain areas to address the effects of socialization and discrimination - 18.1%

	strongly agree	agree	disagree	strongly disagree	no opinion
3. The concept of special programs for girls is unfair to boys.	19.3%	37.3%	30.1%	4.8%	7.2%
4. Discrimination against female students is still a problem in education.	13.3%	36.1%	31.3%	13.3%	4.8%
5. In our school, boys and girls have equal opportunities.	48.2%	42.2%	4.8%	0%	4.8%
6. In our school, girls and boys participate equally in classroom discussions.	51.8%	37.3%	9.6%	0%	1.2%
7. It is important that males and females participate equally in mathematics, science and computer literacy in schools.	72.3%	24.1%	2.4%	1.2%	0%
8. Girls and boys do participate equally in mathematics, science and computer literacy activities in our school.	37.3%	42.2%	14.5%	4.8%	1.2%
9. I really have not given gender equality in mathematics, science and computer literacy a great deal of thought.	8.4%	38.6%	31.3%	18.1%	3.6%
10. Mathematics, science and computer literacy textbooks and resources in our school are male-biased.	2.4%	8.4%	49.4%	22.9%	15.7%
11. In general, girls have less background experience with mathematics, science and computers than boys.	2.4%	30.1%	37.3%	22.9%	7.2%
12. Teachers should be doing more to promote equal participation in mathematics, science and computer literacy.	13.3%	50.6%	21.7%	4.8%	9.6%

	strongly agree	agree	disagree	strongly disagree	no opinion
13. With all of the other demands of teaching, gender equality in mathematics, science and computer literacy is not a priority.	7.2%	30.1%	41.0%	10.8%	10.8%
14. Change is slow; it's just a matter of time before males and females participate equally in mathematics, science and computer literacy.	2.4%	41.0%	31.3%	8.4%	15.7%
15. I have a responsibility to work toward the equal participation of female and male students in mathematics, science and computer literacy.	31.3%	53.0%	6.0%	1.2%	8.4%
16. I think boys show more natural ability to learn mathematical and scientific concepts.	1.2%	6.0%	54.2%	32.5%	6.0%
17. Well-controlled scientific experiments are virtually free of bias.	21.7%	37.3%	21.7%	3.6%	15.7%
18. Girls are free to choose according to their interests; there is not much teachers can do if girls do not participate equally in mathematics, science and computer literacy.	6.0%	27.7%	48.2%	12.0%	4.8%
19. One of the good things about mathematics, science and computer literacy is that the content is free of gender bias.	9.6%	50.6%	15.7%	8.4%	14.5%
20. More resources and curriculum support materials are necessary to address gender equality in mathematics, science and computer literacy.	8.4%	34.9%	31.3%	4.8%	20.5%
21. If I presented gender bias as a serious problem in our school, I would risk being ridiculed by my colleagues.	4.8%	16.9%	38.6%	14.5%	24.1%
22. Our school system supports and encourages teacher concern with gender equality.	2.4%	54.2%	13.3%	1.2%	27.7%
23. The mathematics, science and computer literacy curriculum exclude women's accomplishments in these fields.	2.4%	14.5%	42.2%	16.9%	21.7%

	strongly agree	agree	disagree	strongly disagree	no opinion
24. The major goal of scientific and technological applications should be to predict and control outcomes.	4.8%	26.5%	30.1%	4.8%	30.1%
25. We should have programs targeted specifically for girls in order to increase their confidence in mathematics, science and computer literacy.	2.4%	21.7%	48.2%	20.5%	7.2%
26. We should be actively looking for more women mathematics, science and computer science teachers at secondary levels in order to provide role models for female students.	18.1%	48.2%	24.1%	6.0%	3.6%
27. The generic use of "he" and "his" in our textbooks and resources includes women and does not need to be changed.	10.8%	27.7%	32.5%	12.0%	14.5%
28. A feminist view of mathematics, science and computer literacy needs to be developed and included in our curriculum.	3.6%	18.1%	43.4%	19.3%	15.7%
29. Science and technology today would be different if women had participated in decision-making in these fields in the past.	8.4%	33.7%	19.3%	8.4%	30.1%

TEACHER ACTIVITIES:

30. I have evaluated the textbooks and resources I use to be sure women and girls are included.	Yes -34.9%	No -63.9%
31. I have taped or had observers evaluate my teaching to ensure I respond equally to male and female students.	Yes -13.3%	No -85.5%
32. In the past year, I have supplemented the curriculum in order to address gender equality.	Yes -28.9%	No -69.9%
33. In the past year, I have included discussions about sex-role stereotyping in my classes to challenge myths about gender roles.	Yes -48.2%	No -51.8%
34. I have worked actively to encourage girls' participation in mathematics, science and/or computer literacy.	Yes -56.6%	No -41.0%
35. I have participated in workshops or courses on gender equality.	Yes -10.8%	No -89.2%

BIOGRAPHICAL INFORMATION:

41. Current teaching responsibilities:

    67.5% - Science (general)
    73.5% - Mathematics
    37.3% - Computer Literacy/Computer Science
    6.0% - Biology
    9.6% - Chemistry
    4.8% - Physics

42. Current teaching level:
    42.2% - Elementary
    21.7% - Junior High
    36.1% - Senior High

43. Sex:
    50.6% - Female
    49.4% - Male

44. Age:
    21.7% - 20-29 yrs.
    32.5% - 30-39 yrs.
    32.5% - 40-49 yrs.
    12.0% - over 49
    1.2% - no response

APPENDIX 5.5

OBS	AWARE	INCLUDE	FEMINIST
1	15.0	15.0	12.5
2	10.0	12.0	13.0
3	15.0	16.0	15.0
4	20.0	18.5	15.5
5	11.0	14.0	15.0
6	17.0	12.0	14.0
7	16.5	18.0	14.0
8	20.0	17.5	18.5
9	13.0	15.5	11.5
10	15.0	13.0	13.0
11	18.0	14.0	16.0
12	12.0	14.0	12.0
13	13.5	13.0	11.5
14	10.0	10.5	9.5
15	16.0	15.0	15.0
16	15.0	16.0	17.5
17	16.0	15.5	15.5
18	16.0	18.0	17.0
19	14.0	12.0	13.5
20	15.0	13.5	7.0
21	18.0	11.5	16.5
22	12.0	9.5	11.0
23	13.0	13.0	14.0
24	18.0	14.0	15.0
25	17.5	16.0	14.5
26	14.0	12.5	12.5
27	18.0	13.5	13.0
28	17.0	9.5	15.5
29	13.5	12.5	10.0
30	19.0	18.0	15.0
31	13.0	13.5	11.5
32	15.0	13.5	12.5
33	17.0	13.0	13.0
34	14.0	13.0	10.0
35	16.0	13.0	11.5
36	19.0	14.0	14.0
37	15.0	9.0	10.0
38	17.0	16.5	12.5
39	16.0	17.0	15.5
40	17.0	14.5	13.5
41	16.5	12.5	12.5
42	13.0	13.0	13.0
43	11.0	11.0	13.0
44	19.0	15.5	16.0
45	14.5	10.0	11.0
46	16.0	16.0	15.5
47	14.0	20.0	15.5
48	16.0	16.5	14.5
49	14.5	12.0	12.0
50	17.0	13.0	14.5
51	14.0	14.0	11.0
52	20.0	15.0	14.5
53	14.0	12.0	12.0
54	17.0	12.0	14.0
55	10.0	10.0	10.5

OBS	AWARE	INCLUDE	FEMINIST
56	20.0	15.0	13.0
57	16.5	12.5	13.0
58	14.0	12.0	12.0
59	14.0	13.5	14.0
60	13.0	11.0	16.0
61	16.5	10.5	13.5
62	18.0	15.0	17.0
63	17.0	6.0	11.0
64	14.0	12.0	13.0
65	16.0	13.0	11.0
66	10.5	13.5	14.5
67	10.5	8.0	9.0
68	15.0	15.0	16.0
69	19.0	15.5	15.5
70	14.0	13.0	15.0
71	14.0	13.5	13.0
72	16.0	11.0	12.0
73	15.0	14.5	13.0
74	14.0	13.0	11.0
75	16.0	11.0	14.0
76	18.0	13.5	13.0
77	14.0	11.0	13.0
78	12.0	11.5	12.0
79	19.0	17.5	14.0
80	11.5	6.5	6.0
81	15.0	15.0	14.5
82	13.5	12.0	14.0
83	18.0	14.5	15.0