FEMALE STUDENT PERCEPTIONS OF SINGLE-SEX PHYSICS INSTRUCTION

by

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ABSTRACT

Many students, and a particularly high proportion of females, do not study physics in high schools. Research indicates that segregation by sex may help encourage increased enrolment of females in subject areas that have been traditionally male dominated. The main objective of this study was to explore and document female student perceptions of a single-sex physics class in a coeducational public high school. Data were drawn from a questionnaire and a personal interview. All 20 students participated in the questionnaire presented during class time and 17 of the students volunteered to be interviewed. Appendices include the student questionnaire and interview questions.

Significant findings of the study include:

1. Class participation did increase due to the relaxed atmosphere of the class.
2. There was little interest in single-sex instruction for other subjects.
3. Prior to the course, students anticipated the content to be difficult.
4. Once in the course, the perception of difficulty was reduced.
5. Student lack of involvement in the decision-making process leads to student misunderstandings about the purposes of the intervention.

6. There was frustration with the knowledge of the other grade 12 physics class ahead in the curriculum.
7. The sex of the teacher was not perceived as crucial for providing a role model.
8. Single-sex instruction as an isolated strategy may trivialize gender equity.

The findings of this study suggest that for the majority of the students, the intervention has made no difference in their lives as females or as students of physics. All but one of the students had previously decided to study physics regardless of the school's program. Parental influence, rather than the program, was a major factor in the decision to study physics.

If increased female enrolment is a purpose of single-sex physics instruction, then schools need to reach potential physics students prior to high school, and before high-school course decisions are made.

There are a number of factors involved in the low participation rates of women in scientific and technological professions. The best strategies are those designed in consideration of, and collaboration with, the many factors that are involved in the lives of girls and science.

Perhaps the most significant finding of the study is that interventions that are designed and implemented must also be monitored and evaluated as professional evidence of responsible accountability to society, parents, and students.

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Chapter One

Introduction

We all have a story to tell. Our stories come alive and are shared in countless ways from simple writing to a complex video presentation. In some way or another we all strive to share what our lives, with all its imperfections, discrepancies, and limitations, mean to us. In essence, we are all storytellers and all we need is an audience, even if only ourselves. To share our story is to invite a glimpse into the psyche that commands every word, belief, and action. Sharing our story with others contributes to a broader understanding of human experience as well as contributing to a sense of self-understanding. With enough glimpses, patterns can often be recognized and connected to a larger picture. A principle resplendent in Plato's writings is that we cannot adequately define humankind by attempting to explore individual experiences unless we also view the individuals within the larger political and social contexts.

This thesis is a story -- a story of a group of female high school students and the sense they make of a unique public school organizational practice of single-sex physics instruction. More generally, it is a story of individual understandings of a school intervention that seeks to alter the traditional school experience. Finally, it is a story that explores the tendency to offer a simple

solution to a complex problem. This thesis offers no grandiose solutions; it offers an insight into the personal realities of those who may be literally held hostage by the whims of the times.

To an outsider, long since removed from the high school experience, a student's world may look like an exciting, carefree, and vivacious existence replete with dreams, promises, and opportunities at every corner. It is often a world one wishes to return to for that second chance to rework ambitions and "do it right." What is often forgotten is the tenuous, exhaustive, and frightening plight of existing in a vacuum, teetering precariously between childhood and adulthood. Carol Gilligan (1990) succinctly expresses the female adolescent, in particular, as in danger of drowning or disappearing as she struggles to connect with the world, with others in her life, and yet remain connected to herself.

Upon closer examination, the female high school student appears to be caught in a web of external pressures, expectations, and challenges from teachers, guidance counsellors, parents, peers, the school, the Ministry of Education, post-secondary institutions, the media, feminist groups, and society as a whole. Is one voice able to hear itself, let alone be heard above the din and hype of current philosophies? This thesis offers the voices of female high school students on the brink of adulthood.

It seems that public education has been a battlefield of opinion and preference since its inception, from class struggles and racial conflicts, to the

more recent gender debates. It has been criticized as the instigator and perpetrator of most of society's ills with few periods of acclamation. One underlying principle of most of the battles has been the desire for particular groups to fully participate in the opportunities education is believed to offer. The view and subsequent promise of public education is one of equal access for all citizens, providing equal opportunity, and thus, fair to all. Though the concept of fairness is basically a universal one, the definitions vary according to culture.

The recent quest for gender justice in education began as a result of the broader women's movement of the 1960s and 1970s. The unequal participation of women in economic, political, and social life became defined as social issues rather than individual circumstances. Women lacked power and opportunity and the schools were examined as one of the players in their subordination. Feminist researchers began documenting the hidden obstacles that denied women access to the opportunities men had. As a result, feminists have attempted to stimulate change to allow women fuller participation in all facets of life.

As a result, the issue of gender equity has become a legitimate topic of discussion in education today. National and provincial government educational authorities and institutions have taken steps to attempt a response to the outcry

in many countries of gender inequalities. Is it possible to change the schools to reflect this new knowledge? Taylor (1985) tells us that schools, as organizations, are constructed to resist change. Given the generally conservative attitude of the facilitators of education, Taylor's idea may well seem descriptive of reality. Though traditionally, public school was viewed as a politically neutral enterprise, promising to correct social inequalities, reproduction theorists have made the accusation that schools actually reproduce the inequalities present in the larger society (Kelly & Nihlen, 1982). Florence Howe (1984) states that the school does reflect society and that "schools function to reinforce the sex-role stereotypes that children have been taught by their parents, friends, and the mass culture we live in" (p. 67). The perceived gender differences of yesterday are intricately involved in the streaming practices and biases where girls and boys generally pursue different goals. Looked at through the larger societal lens, we see the origin of the female ghettos lacking economic, social, and political impact.

Turner (as cited in Grant, 1989) offers four conditions to the concept of equality that need to work in concert to achieve true equality, with the ultimate measurement of such being equal outcomes or results:

1. ontological equality: fundamental equality of persons
2. equality of opportunity to achieve desirable ends
3. equality of conditions where there is an attempt to make the conditions of life equal
4. equality of outcome or result. (p. 91)

With the recent re-emergence of women's rights to educational opportunities, researchers have diligently examined these four tenets and have found a myriad of historical and current conceptions that have consistently denied equality between the sexes. Earlier feminist movements resulted in achieving rights to ontological equality and the equality of opportunity that the present schooling system now embraces without debate. Equality of conditions and outcome arguments have been seriously challenged by feminists and the accusations have revealed a deeper level of injustice.

Fennema and Meyer (1989), for example, point out that there is an underlying assumption of equality in the public school system: the sexes are not separated; teachers tend to teach whole groups; and, teachers, for the most part, do not consciously or willfully treat girls and boys differently to the point of unfairness. However, upon completion of junior high school, two very significant factors come into play -- streaming and option courses. Because these option exist, it has been assumed that students are not prevented or discouraged from taking certain subjects and thereby equal opportunity is achieved. It is, therefore, reasonable to expect that if equal opportunity is operating, then equal representation or equal outcomes would occur.

Numerous investigations into school practices uncovered possible explanations for the diverse career paths females and males were selecting.

The very subject areas culturally deemed prerequisites for economic, political, and social advancement were charged to be biased against female participation, thereby providing unequal conditions of education. Females are not participating in the maths and physical sciences at the same rate as males which results in the discrepancy in equal outcomes. In today's job market, the maths and sciences appear to be one of the springboards to participation in society's power structures and women number few players.

Extensive research studies have shown clearly that equal conditions, or treatment, do not exist in most schools and classrooms from kindergarten to university (Byrne 1978; Fennema & Meyer, 1982; Skolnick, Langbort & Day, 1982; Lockheed, 1984; Mahoney 1985; Spear, 1987; Spender 1983; Stanworth 1983). Boys are given preferential treatment in teacher-student interactions, with and in curricular resources, classroom space, and playground access. Guidance practices have consistently aligned advice to stereotypical beliefs. Looking at science, and physics in particular, the research studies indicate a bias favoring males that has entrenched in its history a masculine image. It is noted that teachers and schools, as part of the larger society, have been unwitting agents of the perpetuation of this image.

Why are there differences in the conditions of equality between the sexes? Are these differences affecting the equality of outcomes? Some

scholars have suggested that schools simply mirror the ideals and beliefs of a society and therefore reproduce society's injustices, while other scholars see tremendous potential in the institution of school to correct social inequalities. As a result of the latter view, many educational programs have been designed over the years to provide a more equitable education for a number of diverse groups. Underlying all such designs are assumptions that serve to direct the purposes of the interventions.

Once the problem of gender inequalities has been established, solutions can be sought to bring about gender equity in the public school system. Bennison, Wilkinson, Fennema, Masemann, and Peterson (1984) propose four philosophical models for achieving educational equity that may be used to design educational programs. The first model, most prevalent in public school, is the assimilation model which assumes gender is not a characteristic of the capacity to learn. The basic premise is that the outcomes of education will be the same for both sexes because equal access to programs of study is presented to all. One serious contradiction in the practice of this model occurs when girls and boys are not treated equally, and boys are treated more favorably in terms of accessing opportunities.

The second model is a deficient approach which focuses on compensating for undeveloped characteristics deemed necessary by the

dominant culture and it is generally accepted that the disadvantages are a result of socialization practices. Intervention strategies designed to develop girls' spatial abilities in order to increase their participation in senior math courses is one example.

The third model is a pluralist model that assumes different groups have different needs which subsequently result in diverse outcomes. This model validates varying perspectives that are not threatening to the dominant perspective. The first schools for girls were eventually accepted with the persuasive arguments of female students becoming better wives and mothers. More prevalently, the practice of streaming in high schools is based on this model. More recent proponents of this model are usually interested in the cultural perpetuation of specific groups, bilingual programs being an example. Gender equity within this model assumes women are sharing the same culture as the male dominant culture and an increase in female participation would result in equal outcomes.

The fourth and most controversial model is the justice model that accepts differences among groups when relevant and ignores them when irrelevant to the educational process. It subsumes characteristics of the other three models. The underlying premise of the justice model is that all people in a society have the right to certain social goods and each new claim is judged against this

standard. Though a near universal principle of fairness exists, what constitutes it is often hotly debated. Affirmative action is one program based on this model.

These four approaches to the issues of equality and equity illustrate underlying assumptions that are often not articulated nor recognized by those trying to deal with the problems (Bennison, et al. 1984). It seems that until one defines the fundamental beliefs of human equality, it is questionable whether gender equality can be understood fully.

Interventions to address the inequitable conditions of science have been plentiful and have been directed at raising teacher and student awareness about the value and worth of scientific endeavors. Many of the initial interventions focused on providing girls with experiences to develop favorable skills and attitudes that boys had traditionally gained through childhood experiences and expectations. Interventions of this sort strive to challenge stereotypes and alter girls' misconceptions of sciences as a masculine activity. There is, however, the shadow of blaming the victim which is an undesirable message for many (Kelly, 1987a).

Other interventions have focused on less of a compensatory model. Bentley and Watts (1987) describe an intervention approach that seeks to change the science classroom to accommodate and thus validate student interest, which includes the context of social and ethical concerns. This more

holistic approach attempts to unite social concerns with the dominant yet isolated concerns in scientific investigations. Another component of this type of approach is less emphasis placed on competitiveness while encouraging more collaborative approaches to problem-solving.

A different perspective on the issue of girls and science has been gaining ground recently. It proposes that science itself is partly to blame in its reluctance to accommodate the interests and needs of underrepresented groups, women included. This possibility has led some researchers to explore the historical construction of science that subsequently leads to questioning the definitions of what constitutes science. This exploration questions the rigidity of the subjects, methods, and subsequent interpretations of traditional science.

The purpose of this thesis is to examine one high school's strategy of single-sex physics instruction to bring about some gender equity. Though the exact process by which the school arrived at the decision to offer the program is unknown to me, there seems to be a general fit to a gender-equity model suggested by Millman (1989). Emphasizing the importance of each school examining itself prior to any decision-making, Millman suggests three steps in the process of school self-examination:

1. the collection and analysis of their own school data
2. a diagnosis of the problems and needs found
3. possible solutions.

It appears a discrepancy in enrolment figures was identified in the school data, which led to a diagnosis as to the reasons, and subsequently, the solution of single-sex physics instruction was chosen. The school's objectives were to increase the female enrolment rate in first- and second-level physics and decrease the attrition rate in the second-level physics classes.

The intervention program began with an all-female Physics 30 class in the fall of 1989. Physics 10 is the first-level physics course but it is most often combined with Physics 20 and taught in one semester as Physics 10/20 to grade 10 and 11 students. Physics 30 is the final high school level physics course. There has only been the one teacher involved in the special physics program.

At the time of this study, the program was nearing the end of its third year. The school had not kept, nor has since produced, any formal analysis of the enrolment figures over the years prior to and since the program's inception though an increase in female enrolment was one of the program's objectives. This may seem somewhat lax on the part of the school, but the principal explained that the school is not interested in producing statistics, but rather, interested only in their students. The school did not have an end date in mind but the principal thought the program may run for another year or two.

The school, for whatever reasons, did not present the collection and analysis of their data nor the research, to the female population they were attempting to encourage, to see whether the students themselves perceived a need for change in school policy and their own educational choices. Millman (1989) questions what chance there is for a breakthrough if students do not see a need for change? This, in part, is one reason why I chose to examine what this experiment has meant to one class of grade 12 female physics students who came to the school as grade 10 students in the program's first year.

There are limitations in the study which need to be mentioned. One limitation is the brief encounter the students had with the researcher whom they did not know. Although I believe the students felt comfortable with me, the discourse could still be affected by this context. Another limitation is that the meanings gleaned from the students were based on the completion of a questionnaire and a 20- minute interview. As well, there are only 20 students represented in the questionnaire items and 16 in the interviews, which severely limits the generalizability of the study. Finally, though six informal observations were conducted, formal classroom observations with were not part of the study because of my own unfamiliarity with the teaching and learning of grade 12 physics. Formal classroom observations, with detailed field notes, would likely have enriched the study by adding another facet of the whole intervention.

My interest in the meanings the students themselves make of the intervention is subsequent to the realization that the student voices are often not heard amidst the flurry of educators attempting to make the world a better one. Students become adults soon enough and what is presented to them as children and adolescents will have a significant effect on their own conceptions of a better world. It is my belief that students will provide us a mirror with which to measure our best intentions, if we are brave enough to look.

This thesis will also show that the mere implementation of an isolated strategy to affect change in enrolment rates is unrealistic. The gender equity issue extends far beyond the science or physics, classroom. To keep it there trivializes the complexity of the women and science issue. It is recommended that a team of significant players supporting multiple strategies that are regularly monitored and evaluated is what makes for change.

As with any story, there is structure to this thesis. The research question guiding the entire study was the need to know what sense the students made of the school's intervention strategy. Chapter Two presents the literature reviewed to gain an understanding of the larger picture of the women and science issue. The third chapter explores the various programs that have been attempted to increase female enrolment and highlights a number of factors that have shown themselves to be possible resources in the design of school strategies to bridge girls and science. Chapter Four describes the research

methodology concerning the recovery of the students' sense of the intervention. The fifth chapter consists of the interpretation of the data; and finally, Chapter Six presents the study's conclusions.

Chapter Two

Girls and Science

This chapter will address society's need for scientists, science's emergence into the public school curriculum, and the underrepresentation of women in science. Reasons for this lack of female participation in the sciences will be reviewed in the research using three foci: biologically determined differences; the perpetuation of a masculine image; and, the construction of science that sanctions specific characteristics of, and approaches to, investigation procedures.

It is generally accepted that the lifestyle afforded by industrial nations depends on an adequate number of able scientists, technologists and skilled workers in the scientific community. A report on Canada's future needs claims that a shortage of highly qualified scientists and engineers is anticipated if we are expected to continue in world competition (Hennebury, 1989). The U.S. Office of Technology Assessment (1986) has predicted an increased need for scientists in the 1990s. They suggest more women need to be encouraged to enter the professions and support the removal of the barriers that have served to prevent female participation. It is clear that the underrepresentation of girls in science is a factor in reducing their job and career opportunities. Even without using the high school sciences as prerequisites to a variety of jobs, girls

	Doctoral		Master's		Bachelor of Arts	
Field of Study	%	(n)	%	(n)	%	(n)
Education	46	(127)	63	(1,973)	70	(11,824)
Humanities	42	(127)	58	(1,226)	63	(7,995)
Social Sciences	42	(215)	42	(2,678)	55	(21,753)
Agricultural/ Biological Sc.	28	(85)	46	(375)	57	(4,115)
- Biology	26	(25)	43	(131)	54	(2,090)
Engineering/ Applied Sciences	7	(19)	14	(196)	14	(1,064)
Math/Physical Sciences	16	(79)	22	(247)	29	(1,894)
- Chemistry	25	(45)	29	(52)	37	(363)
- Mathematics	16	(12)	24	(60)	39	(807)
- Physics	6	(7)	14	(25)	14	(102)

Statistics Canada, 1989

are losing out on the fundamental principles of a general and broad education especially given the technological direction of today's society.

Since the resurgence of the women's movement in the 1960s, one area particularly stimulated by the issue has been the domain of science. Science has been traditionally characterized as powerful, authoritarian and masculine. Twenty three years ago, Astin (1969) looked at the female doctorates in America and concluded that women were undisputedly underrepresented in the professional scientific community. Statistics Canada (1989) reports the number of post-secondary degrees awarded to women and men which shows a continued discrepancy in the natural sciences as Table 1 illustrates. The specific area of studies that correspond to high school sciences are indented under the broader field of study. Math is included in the same way because of its traditional relationship with the physical sciences.

Table 1

Post-Secondary Degrees Awarded to Women

Clearly, women are engaged in post-secondary pursuits but they are not participating in great numbers in what have been described as the hard sciences, namely applied and physical. Women remain undisputedly underrepresented in the professional, scientific community.

Using the UNESCO Statistical Yearbooks, Kelly (1978) computed percentages in science at the tertiary level across 80 countries. Noting considerable variances from country to country, her conclusions were that "only in African and western countries were women underrepresented in science relative to other subjects" (p. 6). It is interesting to note that in East European countries 49.1% of the students in natural sciences were women compared to Western countries where only 25% were women.

Looking at Britain's statistics at various educational levels, Kelly (1978) reports that women were overrepresented in biology, underrepresented in chemistry, and even more underrepresented in physics with the ratio increasing at each level of education with the major loss at age 16, when subject choices are generally made.

Not only is female participation significantly lower than male participation, those females enrolled in science courses have generally demonstrated lower achievement. Lower achievement may contribute to less confidence and interest in participation when females are presented with a choice. In 1975, the American National Assessment of Education Progress, confirming a

previous national U.S. survey, reported boys' performance as better than girls' in science with the gap widening with age. Physical science saw larger sex differences than biological science in both surveys (cited in Kelly 1978). In Eastern Europe, at the same time, similar sex differences were found. Interestingly, the same patterns were not revealed in Poland where little performance difference was found between girls and boys. However, in countries where research of this nature was being done, marked sex differences were reported with the gap increasing with each educational level. In an international study of 14 countries, females consistently performed below males. In only one country, Japan, did the girls achieve at a comparable level to that of all boys (Kelly 1981). The differences in achievement are greatest for physics and least, if at all, for biology. Many researchers have strongly correlated this to student preferences and interests which will be discussed later in this chapter.

In a study conducted by the International Association for the Evaluation of Educational Achievement (1988), a comparison of science achievement in 17 countries found boys generally outperforming girls at all grade and age levels. Almost all the countries show this disparity increasing with grade level. Girls as underachievers in the sciences appears to be an undisputed, international fact.

Since the science debate and subsequent advent of science content in the public school curriculum, it has been assumed that all students have had

access to sciences courses in the secondary school. Much of the research into why girls do not elect to take sciences, especially the physical sciences, focuses on a deficit model implying that if girls could simply "catch-up" with males, or if girls could just gain "more confidence" they would be able to participate more fully. However, it was not that long ago, in 1930, when the science community was wondering why so few students were electing to take high school chemistry and physics. In 1930, a US survey of educators and administrators asked why student enrolments in chemistry and physics were declining and girls' lack of interest was noted as one of the many reasons (DeBoer, 1991). Shortly thereafter, a curriculum reform followed wherein content, materials and activities were adapted to better suit the science needs of the students. Though not an aim of the reform specifically, it was expected that enrolment in the science courses would increase. It did not.

In the mid 1950s, scientists became involved in an attempt to bring science into the intellectual arena as part of a liberal education for all students. Shortly after that the U.S. government joined the crusade, after the 1957 launching of the U.S.S.R.'s space explorer, Sputnik. Science education had become a national security concern. In 1964, physics educators were so concerned about persistent low enrolment that a number of national studies were conducted to discover the reasons for it. As DeBoer (1991) states (using V. Young's survey conclusions), "the results, again, overwhelmingly supported

the belief that high school physics courses were too difficult" (p. 170). DeBoer tells us that a new focus in science education emerged in the late 1960s -- that of scientific literacy with a relationship between science and society as part of every student's educational experience.

Prior to the resurfacing interest in women's experience of the last two decades, educators undoubtedly were aware of the diverse paths girls and boys generally took, but it was not perceived as a problem. The question of why there is an underrepresentation of women in science has recently been asked by many feminists with an eye particularly at the high school level where career choices are generally made. In the last twenty years there has been an extensive amount of research in this area where researchers have attempted to explain the phenomena of little female participation in the scientific professions.

Once the option of course selection is offered, significant differences are seen in subjects taken while prior to secondary school, girls and boys are engaged in the learning of the same subjects. In fact, Skolnick, Langbort and Day (1982) report that in elementary school girls and boys start off equal in math and science performance, and, as far as we know, in interest. Zerega, Haertel, Tsai and Walberg's (1986) study show no significant differences in science achievement at the early adolescent level. Yet, later adolescent years showed differences as significant. Countless studies have been undertaken in an attempt to explain the reasons for this discrepancy between boys and girls

choosing the sciences and maths as a career path. Undoubtedly, taking high school science and math courses creates greater opportunities in post-secondary options. Still, many girls continue to choose traditional female jobs while economically the key areas are in the sciences and technologies.

A review of the research studies shows three explanations to account for the differences between female and male participation rates in the natural sciences. The traditional explanation was that biological differences determined intellectual differences with males physiologically, and thus inherently, better equipped to master the knowledge and skills of scientific inquiry. Another explanation proposes that a masculine image of science has been perpetuated and suggests a change in this image to reflect a balanced one as the solution. A more recent explanation considers the social construction of science as inherently masculine and therefore questionable as gender neutral. These three explanations will be reviewed.

Biological Explanation

Nevitte, Gibbins, and Codding (1990) claim the hypothesis of biological differences was the common explanation for so few women in the scientific professions during the 1970s. There was an acceptance of the perceived scientific skills of quantitative ability, visual-spatial ability, and field articulation as being biologically determined. Hyde (as cited in Steinkamp & Maehr, 1984)

found "small yet persistent differences between males and females" (p. 45) within these three specific areas. The differences accounted for no more than one to five percent of the population variance. Steinkamp and Maehr conclude that the differences are not substantial enough as an explanation for achievement differences. The biological explanation has been challenged vigorously due to weak correlations and variance factors, let alone the controversies over data interpretations. Further, this line of reasoning does not account for the evidence indicating that the women who do pursue science achieve levels comparable to males and sometimes outperform them.

Findings from the International Association for the Evaluation of Education study of 14 developed countries found that Hungarian and Japanese female students achieved higher mean scores than boys in all countries in chemistry, with Japanese girls achieving physics mean scores comparable to those of boys in other countries (Kelly, 1981). A recent Thailand study found that girls outperformed boys in high school chemistry and physics. In Thailand, the science stream is a prestigious one and attracts the more able students, an attraction that has been balanced between the sexes. It is interesting to note that students who select the science stream must take all three sciences in grades 10, 11, and 12 (Klainin, Fensham & West, 1989).

Kimball (1981) states that the biological explanation appears to persist to some degree in that many assume girls do not do well in science "because of

biologically determined inferiority in mathematical and spatial abilities, and that efforts to improve their participation are futile and misdirected" (p. 48). Birke (1986) protests that the ability to solve a few spatial problems is hardly indicative of success in a science career. The challenges to the deterministic view have somewhat altered common perceptions of inherent capabilities.

In an analysis of 15 years of research, Friedler and Tamir (1990) report wide acceptance of no sex differences in intellectual capacity between girls and boys. However, they specifically found in three IQ subscales that: 1) girls have an advantage verbally, and, 2) boys are advantaged numerically and spatially. Equally so, an earlier U.K. study argued that the differences in spatial abilities are not a significant predictor (Kelly, 1987b; Rosenthal & Rubin, 1982). They support their conclusions by addressing the fact that nearly 40% of engineers in the USSR are women. Kelly (1987b) suggests that the differences in spatial ability are far more likely to be a symptom of the problem as boys likely develop spatial ability through the toys and tools they play with and the activities traditionally engaged in as children. Kimball (1981) refutes any illusions about biological differences in motivation by stating that the variance is too small to account for the differences in representation of the two sexes.

Compounding many of the studies on achievement in science is the difference in the number of science courses that each sex has previously had which may skew the outcomes. Frequently boys have had more science

courses than girls at the time of a study but this factor has not always been recognized as a variable in the research data (Zerega, et al., 1986; Kimball, 1981; Mura, Kimball, & Cloutier, 1987). It also should be noted that researchers, as a rule, tend to focus more on the differences between girls and boys while the data indicates a greater variance within each group (Kelly, 1987).

It is fitting to conclude this section on biological differences between girls and boys with a quote from Florence Howe (1984), an esteemed American educator:

> John Stuart Mill was the first man (since Plato) to affirm that we could know nothing about innate sexual differences, since we have never known of a society in which either men or women lived wholly separately. Therefore, he reasoned, we can't 'know' what the pure 'nature' of either sex might be. What we see as female behavior, he maintained, is the result of what he called the education of 'willing slaves' (p. 67).

Acceptance of the biological explanation appears to be acceptance without a structural basis, as Mill so aptly describes. However, it seems biological differences do persist as a popular explanation to account for individual preferences and/or talents. Neurological research on brain lateralization has, in piecemeal, become titillating news for everyday conversation. What is clear, however, is that women and men are equipped with the same organs and senses that function to perceive and interpret information and the environment. What may be different is what individuals do

with the information they receive and that seems more a matter of preference or perspective than physiology. It is more reasonable that the problem is not that girls do not perform as well in the sciences, but that they opt out of the opportunity to study them. With the biological differences debate reasonably refuted, educational researchers began to explore cultural and social influences that were serving to steer girls from the sciences, and physics in particular.

Masculine Image

A second explanation for gender differences in science concerns the masculinity of traditional science that has been perpetuated. Kelly (1987a) states there are three distinct features that allude to the image of masculinity of the science domain that systematically socialize girls away from it:

1) individuals predominant in science
2) packaging of science
3) classroom interactions that promote the image

These characteristics will be examined more closely. Given the emergence of science in the public school arena at a time when society had explicitly defined masculine and feminine roles, it is not surprising that men were the scientists. Also given the rigor of groups of scientists who appeared to have the control of life at their fingertips, i.e. the atomic bomb, weaponry and

space exploration, countries had become pitted against one another in an attempt to safeguard their interests. In this cloud of mystery, behind secretive laboratory doors and reticent personalities, the common person in society almost revered scientists in some magical way.

In 1953 an American psychologist, Anne Roe, wrote The Making of a Scientist based upon her sociological survey of 64 white male scientists. Throughout the text her reverence for these accomplished men is evident. Roe's character sketches of the scientists have been described by Vivian Gornick (1990) as "private, civilized, cheerfully lonely men" (p. 35). Roe's book appears to have confirmed and further illuminated the institution of science as a male domain. It is hardly surprising, then, that recently in a grade six classroom in Western Canada, when the teacher asked students to draw a picture of a scientist, all but one girl drew a male. This student's mother was a scientist at the local university. As a result of this biased revelation, the teacher invited the scientist to visit. The woman came in a dress and high heels and was told by the students that she did not look like a scientist. However, upon the woman donning a lab coat, sporting spectacles, and mussing her hair, the students were able to identify the scientist (Kaye, 1991).

The media has simply reflected the male model of scientist in such film productions as "Frankenstein," "The Fly," "Back to the Future," "Dr. Jekyll and Mr. Hyde," as well male hosts of CBC Television's "The Nature of Things," and

CBC Radio's "Quirks and Quarks." When the media has generated images of female scientists, the message has been negative. Lynda Erickson (1981) reports that:

> Books, movies and television programs frequently portray women in science as serious, dowdy, rather unsociable unfeminine people. These images are not attractive to teenage girls, and they reinforce the notion that science is an area for masculine people (p. 91).

Zerega et al. (1986) state that:

> A negative perception of women in science may lead to lower achievement and motivation for 17 year old females, and thus arbitrarily deny opportunities to girls, and a source of human intellectual capital or resources to the nation (p. 460).

Another generally accepted endorsement of masculine scientific prowess is the packaging of science in resource materials. Textbook authors and book publishers have persistently illustrated males in far greater number and on the rare occasion when a female was shown, it was clearly in a position of subordination. Research has shown that the science textbook plays an undeniable role in determining classroom events (Barr, 1988; Cole & Griffin, 1987). With over 90% of all science teachers using a textbook 95% of the time, (Harmes & Yager, 1981) it is evident that this vital resource requires constant policing. Recently, textbook publishers have attempted to respond to the lobbyists by revamping their lucrative commodity to reflect a less biased position. Kahle (1985) studied the reformed textbooks and reported that

progress had been made, however limited. While more equal representation of the sexes in the illustrations was presented, female contributions were not part of the written text.

Children learn about many male scientific contributions such as those of Newton, Einstein, Banting, Galileo, and Fleming, to name but a few, but whoever learns that Einstein's first wife was a physicist whom some people believe should have shared his 1921 Nobel Prize? What child learns the contribution of Canadian nuclear physicist, Harriet Brooks, who identified radon gas at the turn of the century or Britain's Dorothy Hodgin's 1964 Nobel Prize for her work with the structure of the B12 vitamin? Girls and boys view science as it is presented and that is clearly a male defined image. As Kelly (1987c) succinctly summarizes:

> The word 'image' is closely linked to 'imaginary' and... suggest[s] that the masculinity of science is only an illusion, not an intrinsic part of its nature (p. 75).

Children's images of science appear to depend upon impressions and information they gain from parents, teachers, peers, and society as a whole.

Recently watching a 16 mm film on lasers with a grade twelve class of girls, I was entranced by the opening five minute segment of a scantily clad young woman gyrating to music as her fingertips orchestrated a spectacular show of the color spectrum. The male teacher interjected and apologized for

the sexism displayed, just before going off into a corner of the lab to do some work. Later in the film, the all-male cast was conducting a laser transmission using a newspaper advertisement of women's undergarments. Not a word was said in the room; not a hint of physical reaction was observed as I quickly monitored for reactions from the students. As I had almost missed the subtlety of the event, I wondered if I was the only one to realize consciously what had just been presented.

As shown in extensive research, parental expectations and encouragement of perceived appropriate sex behaviours, toys, and activities, children often come to the kindergarten classroom with well defined sex stereotypes. As two kindergarten teachers told me, boys resist the kitchen centre; girls resist the building centre. Research has consistently demonstrated that teachers also treat girls and boys differently, which may have significance for female motivation and interest in the physical sciences. The school has allegedly served to perpetuate the sex stereotypes started earlier, with teachers spending more time with boys all around and gearing topics to the interest of boys. England's Girls into Science and Technology (GIST) project researchers spent many hours in science classrooms specifically looking for inequalities in teaching-student exchanges and for clues as to what it is about science that causes girls to lose interest. Whyte (1985) states:

> We found that boys acted in a way which made science seem more masculine than it really is; the teachers also helped to create the impression that science is a very macho business (p. 81).

Margaret Crossman's (1987) study investigated biology and physics classrooms and found that, overall, teachers (equally male and female) interacted with boys one and a half times more than with girls. The female teachers had a greater number of interactions favoring males at one and three quarters times more than the girls. The physics teachers' interactions favored boys more than the biology teachers'. Looking specifically at teacher and pupil, once again, the balance favored the boys. Statistically significant results favoring the males were shown in teacher acceptance of ideas, teacher criticism, and teacher selection of boys to answer questions. It is pertinent to mention here, in light of low female enrolment figures, that the sample consisted of 65 girls and 70 boys. At the conclusion of the study, informal interviews were held with the staff and the teachers were told of the researcher's purpose. Crossman's description of the response of female teachers who favored males, warrants reproduction here.

> One female teacher claimed that she made no distinction between boys and girls, while the other two female teachers, said that they made a special effort to include and encourage the girls. These decisions are not reflected in the results obtained (p. 64).

Monitoring one's own behavior while involved in the complexity of instruction is not so easily or accurately done.

It is suggested that student motivation is intricately woven with teacher expectations, attitudes, and beliefs. Kearns (1989) looked at teacher responses and found that "the achievements of girls tend to be seen in the context of their social expertise, those of boys in terms of getting the task done" (p. 61). Old habits die hard. It is paramount to consider that as active members of society, teachers and parents, as well as students, are affected by this masculine aura in the sciences.

Some researchers have proposed that it is easier to challenge the male image of science in an all-girls school where the staff is more likely to be women and the senior students of science are girls (Kelly 1987b). They claim that girls' interests can be addressed and capitalized upon without interference with and subsequent adherence to, the interests of the boys.

Citing Pratt et al.'s postal survey of subject preference, Whyte (1986) states that 37% of girls in single-sex schools elect to take physics while only 16% do so in coeducational schools. However, without a more complete explanation of just what the postal survey entailed, these figures may be a little dubious, though the findings did confirm Ormerod's (1975) national study of secondary schools that showed the division between male and female subjects as more marked in coeducational schools. Vockell and Lobona (1981) and Lee

and Bryk (1986) found that girls in single-sex schools are far less likely to view science careers as exclusively male. It appears that girls in single-sex schools are less affected by the masculine or feminine image of a subject.

There is a growing body of evidence that consistently documents girls' higher achievement and enrolment in, and more positive attitudes towards, the maths and sciences in single-sex schools (Bryne, 1978; Hamilton, 1985, Harris, 1986; Lee & Bryk, 1986; Rowe, 1988; Riordan, 1990; Young & Fraser 1990). Confounding all studies, to some degree, however, is that single-sex schools tend to be private and generally serve a middle- to upper-class clientele. Recent studies, however, controlled for the variance in socio-economic status (SES), found statistically significant differences in science education for girls favoring single-sex schools (Lee & Bryk, 1986; Young & Fraser, 1990). Some studies used Catholic single- and mixed-sex schools in order to control further variables. Lee and Bryk (1986) and Riordan's (1985) U.S. studies controlled for race, SES, sex, and geographic region and found sufficient evidence that single-sex schools may well be more advantageous for female students. Comparing single-sex schools and coeducational schools, Harvey and Stables (1986) suggest there may well be advantages for girls to be taught the physical sciences in an all-female environment.

An argument for coeducational settings is that girls are presented with a broader range of non-traditional courses and thereby presented with an equal

opportunity. As statistics indicate, some girls have taken advantage of the opportunity to explore and study the sciences beyond secondary school despite the masculine portrait presented. They have become scientists with many of them also incorporating other priorities such as raising children and maintaining a home. It is clear that women like and enjoy scientific activity as much as men, but it is evident that their contributions and endeavors have not always been widely accepted into the discipline as valid or acceptable. Most girls are not taking advantage of the situation as indicated by enrolment figures from secondary school up through post-secondary. These figures have led some researchers to ask why. Why are girls not enroling in the science courses at the same rate as boys? What are female students thinking? Are traditional sex roles still operating? Is there something more entrenched in the nature of science?

Construction of Science

A third line of inquiry recently explored in the research to explain marked differences in male and female participation in the sciences has been that the construction of science itself fails to appeal to the interests and needs of many females. Some researchers have found that boys are more science motivated (Harvey & Stables, 1986) and that they rate the social environment of their science classroom more positively than girls (Zerega et al., 1986). Extensive

evidence, from a number of countries, suggests that classroom climate predicts cognitive and affective achievement gains (Walberg, 1983). Recent findings (Milner, Ben Zui, & Hofstein, 1986) have clearly shown that enrolment figures in science are highly dependent on students' personal feelings -- how interesting they find their science studies and how confident they feel about learning science.

Though science advocates have long touted science's impersonal, separate, and objective tenets as the criteria of pure investigation, this has been challenged recently by many voices to be mechanistic, artificial, and dehumanizing. Lynda Birke (1986) elaborates:

> Too much of modern science is highly mechanistic and reductionistic.... It is a way of looking at the world that many people, but particularly women, find difficult to understand and often find abhorrent. It has also been successful, enabling humanity to exploit the environment and to use human creativity to produce innovative forms of technology, yet it is precisely this sense of science as enabling exploitation which many find objectionable (pp. 195-196).

Sandra Harding (1991) states that "almost all natural science research is driven by technology" (p. 60). The need for bigger, better, faster, stronger products to keep up profits has overriden the potential for science and technology to improve conditions of life for all people. Though she qualifies that individual scientists may not be motivated by the same appeal, the research funders certainly seem to have visions of control and profit. Science is undoubtedly

dependent upon financial support and given that much of scientific research is supported by private business and military interests of governments, motivation behind scientific support becomes highly questionable.

The conventional view of science has its roots in the desire to understand, control and dominate nature's mysteries. Weinreich-Haste (1986) tells us that the prescribed father of modern philosophy, Rene Descartes, reaffirmed Plato's separation of reason and emotion by exalting scientific activity as "rational, untouched by emotion, analytical, objective" (p. 117). She goes on to say that across most cultures women have been consistently viewed in opposition as "more emotional, less rational, more intuitive, childlike and passive" (p. 117) and that these characteristics have become regarded as feminine characteristics and consequently less valued. Evelyn Fox Keller (1986) states that modern science "is constituted around a set of exclusionary oppositions, in which that which is named feminine is excluded, and that which is excluded - be it feeling, subjectivity, or nature - is named female" (p. 173). Prominent feminists have suggested that women may well approach the sciences quite differently than men, not so much in opposition to men, but certainly with a different perspective (Harding, 1986; Keller, 1987; Rosser, 1990, Walton, 1986).

This view that women may approach the sciences with a different but equally valid perspective is building momentum. It has been suggested that the

young girl's gender identification with the mother leads to the female developing a greater sense of connectedness and relationship between the self and others (Birke, 1986). Carol Gilligan's (1982) work with morality indicates that the female is generally more committed to the condition of context and relationship where impartial judgement is unacceptable. This insight leads us to consider that the social context cannot be ignored in any human endeavor, including scientific inquiry. Scientist Anne Walton (1986) conducted a study of female scientists in various fields and found that all their work had "strong humanitarian connotations" (p. 10). Sue Rosser's (1990) study of women scientists found that while none of the women violated the basic scientific method of inquiry, the women demonstrated differences in observation strategies, methods of data collection, and the conclusions and theories drawn from the data that have not always been readily or immediately accepted. To illustrate further, the work of Jane Goodall Lawick and Barbara McClintock was not in line with the scientific norms and expectations of their times. Both of them challenged the traditional scientific method of impersonal objectivity, defined in the isolation of researcher from the subject investigated, as they strove to enhance their understanding of science and nature. Their scientific contributions were relational and in conflict with scientific rules and boundaries though they have since been reexamined and consequently accepted as valid (Harding, 1985; Keller, 1986).

Though many feminists retreat from the notion of a solely female

perspective unknown to males, it is clear that Goodall and McClintock bring to us a "lesson in diversity" (Keller, 1986, p. 175). It has been suggested that a feminine perspective, or perhaps more precisely, a holistic view of nature and its mysteries, would also serve to attract and appeal to many more males as well. Given the rise of groups concerned with science's potential for destruction of many of the earth's resources, a more holistic view seems most appropriate for the conservation of our world.

In her survey of school age children through to undergraduate students, Helen Weinreich-Haste (1986) concludes that the scientific myth persists -- scientific subjects are seen as "hard, complex, based on thought rather than feeling, abstract and masculine" (p. 115). Harding and Sutoris (1987) report that girls are more inclined to view science in terms of relationships and its relevance to human needs while boys are more inclined to view science in abstract terms. If science and technology are presented and perceived as masculine and irrelevant to human needs, then it is hardly surprising that most girls are simply not interested. Lynda Birke (1986) states that "science's masculinity comes into direct conflict with their self-concept of femininity and women's roles." She elaborates:

> However ill founded it may be, our culture shares a common image of science that it is somehow remote, abstract, and requires a degree of separation of the human observer from the natural world - the true pursuit of objectivity. If girls do tend to see themselves as more

> embedded in relationships with both other people and with nature, then they are not going to find this image of science either convincing or appealing (p. 190).

Harding (1986) suggests that many more female students would be motivated to explore the sciences if the social context was an integral component and the potential of serving human needs was made explicit.

Clearly there are gender problems that need solutions in the scientific arena. How does a society go about solving them when there remains uncertainty and little agreement as to the boundaries and responsibilities of the dispute? Debating and discussing the issue in books, journals, and newspapers is not sufficient. One thing that is most evident in these discussions, however, is the discrepancy in the participation rates of men and women in the sciences. Some people have gone beyond the discussion to attempt a plan of action to address the discrepancy.

Advocates of the masculine image of science explanation appear to believe that increasing the number of women in science will change the image to one less gender specific. This philosophy has stimulated a number of intervention strategies aimed at eliminating the gender bias in scientific and technological professions. A myriad of collective efforts have been directed at specific programs to encourage girls to enter traditionally male disciplines. The justification for these intervention strategies is that the biological hypothesis of

gender discrepancy in interest and career aspirations is fallacious. The main thrust is an attempt to make equality of outcomes the result of equality of opportunity.

Some researchers have explored the idea that the move to encourage girls into the sciences may serve to undermine and devalue the traditional areas where females have excelled (Elliott & Powell, 1987; Whyte, Deem, Kant & Cruickshank, 1985). This push into the science fields may surreptitiously give them more status and value. Whyte, et al. (1985) however, recognize that it has been educationally expedient for girls to focus on these traditionally feminine subjects. It is important, then, to ensure interventions are not constructed on a female deficit model but rather, on a model of scientific inquiry that accommodates female interests and concerns. Rosser (1990) explains that women approach scientific inquiry differently from the traditional male approach in the way observations are carried out and in the method of data collection. There are many instances where women's contributions have revolutionized a particular area of science.

Conclusion

This chapter has briefly examined the introduction of science into the school curriculum as part of the education for all students. As a result of the discipline permeating every facet of human life with the promise to make life

safer, healthier, and more prosperous, science has become a prized, powerful, and apparently coveted activity. Along with the interest in technological progress, a myriad of new job opportunities have resulted, while displacing a number of conventional careers.

The recent resurgence of the women's movement resulted in the study of various human activities to pinpoint those that were, in some way, abetting the oppression of half the population. The discipline of science was revealed to be a powerful area where few women participated and the challenge of this staggering discrepancy fuelled a debate in the subsequent attempt to explain the reasons.

Though the numbers of females electing to pursue science courses were few, it appears to have been viewed as evidence that males were intellectually more capable. Given the traditional socialization of gender roles, this view sustained for many generations. Women who persisted, and were judged successful, were seen as the exception and more like men than women. Studies suggested that females were biologically not able to sustain the rigor required in science as they demonstrated poorer achievement and aptitude scores.

Many advocates of the women's movement revisited the research studies and called into question other variables that may have been operating to skew the results in a more fundamental way. Thus began the task of looking

beyond the statistical data and exploring the socialization factors that were presenting obstacles to women's participation in the science community. The charge of science perpetuating a masculine image became diligently examined and revealed a systematic socialization that served to steer females away from science. Through feminist efforts, it was shown that science indeed had a masculine image from the predominant presence of men, the packaging in school materials, to classroom interactions that favored the male students, thereby systematically perpetuating the myth that science is a masculine activity.

Another explanation has recently emerged that challenges the social construction of science as inherently disassociating the female. The roots of scientific inquiry were alleged to be developed in order to control and dominate nature's mysteries, including the mysteries of women's procreation capability, with the earliest advocates professing the purity of scientific activity as rational, analytical, objective, and unaffected by emotion. These characteristics have since become identified as masculine with the complementary characteristics of irrational, intuitive, subjective, and emotional regarded as feminine and consequently as less valued. Many feminists believe that the problem of women in science is far greater than simply a problem of numbers. Prominent feminists have studied women scientists, past and present, and have found a difference in style, or perspective, in women's approach to the scientific

process. Women scientists have demonstrated differences in observation strategies, methods of data gathering, and ways of interpreting data that show an acknowledgement of interdependence or connectedness between science, living things, and society. It is suggested that a validation of style or perspective would contribute to the growth of scientific knowledge by the exploration of the world in a more realistic and constructive way.

Chapter Three

Factors to Consider in Designing Intervention Strategies

Knowledge is not understanding. Change does not occur in a vacuum. Life is lived in constant interaction, and often conflict, with the convictions of yesterday, the ideals of the present, and the visions of tomorrow. The institution of public school functions amidst the power of such forces. The role of the educational system is to help ensure that all children are encouraged to reach their potential. Though there can be no single, simple solution to the complex problem of the participation of girls in science, specific considerations have been explored and programs attempted to address the issue. We may learn more about the value of intervention by exploring the factors that may have significance in the design of intervention strategies.

The Role of Parents

By the sheer number of years spent with children, parents can positively influence their children's interest in and interaction with scientific elements of the physical world by providing stimulating experiences almost from birth. Kahle (1985) discusses parental attitudes as affecting girls' choices of science classes, confidence in their science ability, and perception of science as masculine. Parental knowledge of careers information and the perscribed high

school prerequisites may help and encourage females to broaden their career possibilities.

Various programs have included parents in their intervention designs. A major aim has been to heighten awareness of the many career options in the scientific and technological fields that have opened up in the last decade and to encourage the participation of women in them.

The Role of Teachers

Whyte (1985) informs us of the crucial and paradoxical role the teacher plays in the evolution of change by stating that "teachers are both a major obstacle to change and yet the means by which change might be achieved" (p. 75). Teachers play a significant part in the construction and delivery of meaning in their classrooms. Much of what occurs in any classroom is determined by the teacher's values and beliefs. Are teachers aware of the part they play in the development of patterned responses in their students? Reflecting on my own years of teaching and countless discussions with colleagues, I have observed that many teachers are not fully cognizant of the impact their values and beliefs may have on students. It seems crucial that a significant intervention would be teacher in-service programs that provide encouragement and skills for teachers to research their own schools and classrooms as to possible reasons for girls' underachievement in, and less

positive attitudes toward, the sciences.

If gender equity in the classroom can be achieved, at least partly, through the values and beliefs of teachers, then it is important to examine teachers' understanding of gender equity (Clark & Petersen, 1986) through the provision of teacher education programs that encourage and support teachers to explore their own beliefs and potential impact on student attitudes, decisions, and career aspirations. These teacher education programs, however, may be resisted by teachers who, in their classroom isolation, feel defensive about challenges to their teaching practices. Beliefs and values generate practices that are not readily altered by mere suggestion or accusation. Teachers require a base of information which gives them a context in which to examine society's gender socialization practices and their own beliefs and practices.

A tremendous amount of literature, media coverage, and workshop based meetings and programs for teachers are striving to promote a consciousness of personal biases and an understanding of the gender socialization that appears to promote gender inequity. Though many institutions have responded by implementing a variety of measures aimed at promoting equity, without a commitment from individual teachers and school staffs to work as a team, any implementation of policies would be near futile in changing existing teaching beliefs and practices.

As Crossman's (1987) study revealed, even teachers who believed they

were not biased in their treatment of girls and boys, and believed they were making special efforts to encourage girls, favored male students in their behaviors and interactions. It is difficult for teachers to monitor their own student interactions while simultaneously teaching. One strategy aimed at promoting equal opportunities in schools found that even teachers who were committed to equal opportunities were hesitant to alter classroom organization and curriculum content in ways that might not be accepted by colleagues, students, and parents (Millman, 1989). It appears that for significant change to occur, support networks and the assurance of collaborative efforts are crucial.

Guidance Counselling

Another area related to teachers is the function of career counselling in secondary schools. Erickson (1981) discusses the importance of school counsellors in encouraging girls to take science and increasing student awareness of science-related careers. Many of the teacher interventions are directed at those teachers in school counsellor roles. Having a counsellor simply tell girls they can be whatever they want is not enough when girls may be up against rigid stereotypes amongst peers, family and society in general. Jane Roland Martin (1981) discusses the raising of consciousness of our female students so that they know what has been happening to women in science and may well be happening to them. Guidance programs have

tremendous potential in expanding the knowledge base that career decisions are made from. Enlightening students about women's social and economic roles and the persistent struggle for women's rights may have tremendous impact on female aspirations and confidence at a time when career choices are being seriously explored.

Course Options

One guidance manoeuvre to defer student choice of subjects has shown some success. Delaying the freedom to opt out of the sciences may prevent girls from being disadvantaged later on when career decisions are more clearly formulated. The lack of science and technological courses may interfere with prerequisites needed for career opportunities at a later date (Berryman, 1983; Burchell & Millman, 1989; Harding, 1983). Kelly (1987b) reports one school district that adopted a common curriculum to age 16 and the increased female participation in physics option courses rose from 10% to 40% following the compulsory curriculum. Many of the girls had reported that they would have dropped physics the year before had it been an option. The province of Alberta is preparing to implement a required Science course for all grade ten students which will delay student selection of the specific sciences by one year. Under the new program, every student will receive instruction in chemistry, biology, and physics. It is expected that a more informed choice will then be

made upon completion of grade ten. This may help tremendously in dispelling the perception that physics, in particular, is too difficult to pursue.

Outreach

In many instances, support from post-secondary institutions has helped dispel the images and cultural bias prevalent in traditional careers. York University in Toronto invites a group of female students from grades seven and ten to participate in an apprenticeship where the girls spend a summer month immersed in laboratory and self-development workshops. The University of Alberta, in Edmonton, currently runs a summer research program for grade 11 students. The girls spend time with research teams in the faculties of Science and Engineering. An additional component of this particular program is the opportunity for grade 11 boys to have comparable experiences in the faculties of Nursing and Home Economics. Interventions that involve outreach from agencies outside of the school speak to the relationship between high school and the adult society that its students come to participate in. It seems especially significant that the gender problem today is not just a societal one but an institutional problem too. It seems reasonable that as more people and groups work together to address gender equity, at all levels, the more effective they will be.

Single-sex Classes

A number of experiments have been carried out in which single-sex classes have been created for female students in subject areas that have been masculine-typed (Carpenter & Hayden, 1987; Hamilton, 1985; Harvey & Stables, 1986; Kelly, 1987c; Whyte, 1986). The rationale for these classes has been the belief that female students may be inhibited as learners of a traditional male subject. Without boys in the class, girls become less reluctant to become more fully involved in class participation. An all-girls class can also provide a support system among the female students that may help to dispel the suspicion that females are inferior in the maths and sciences. Lockheed and Klein (1985) claim that there is evidence that short-term single-sex instruction may have positive effects though they do caution that long-term intervention may well serve to perpetuate sex stereotypes.

A slight alteration of the single-sex classroom concept is being used to target the female population in a northeastern Mississippi high school. A female physics teacher introduced a program of all-girl science field trips with positive results. The teacher reported increased interest and participation from the girls without the physical and verbal presence of the boys (CBC Radio 1992a). Having a female physics teacher, obviously committed to generating female interest, most likely influences the students' participation as well.

Role Models

A number of studies have recommended female role models in the scientific and technological professions. Stage, Kreinberg, Eccles and Becker (1985) conclude that role models of women in math and science fields are extremely motivational for students. Erickson (1981) discusses a media program produced by the Massachusetts Institute of Technology on women in engineering, but notes that the lack of personal interaction which would address particular student concerns and questions is a problem.

On the other hand, Fischer (1981) suggests that role models may not be as significant as some people think. Fischer studied 163 female engineering students at an Ontario university and found that only two had ever met a female engineer, though she notes that more than half of the girls had a female relative or family friend who was successfully working in a traditionally masculine field. Louise Lafortune (1990), a successful Canadian mathematician and professor, stresses the importance of female role models while presenting the bias she encountered during her career advancement. In a radio interview (CBC Radio, 1992b) chemical engineering student, Alaina Madanski, was perplexed at the need for a Canadian Committee on Women in Engineering. She claims she has never experienced sexual discrimination of any kind in her chosen field. In the course of the interview, however, it was revealed that she had been raised in the U.S.S.R. where it is not unusual for women to pursue engineering as a

career choice. Madanski suggested that upon her arrival in Canada, she may have been oblivious to the problems associated with women and engineering in North America because of her early exposure to engineering as a normal and acceptable profession for a woman.

With few women working in the sciences, it is difficult for them to reach out to a large number of students, to serve as role models. It would be beneficial if employers supported the need for outreach to young women through presentations to aspiring professionals. Appropriate models can also be effectively presented in the media and literature.

A Pilot Program

Of course, this is not to say that one school cannot make any difference, but only that with a concentrated effort to alter women's position in general, a school is one of many significant players. One school that attempted to address low science enrolment figures with specific plans is reviewed here. Mary Doherty (1987), a Science Head at a girls school in Croydon, Surrey, was hired with a specific mandate to increase student interest in the physical sciences. Reflecting on her years as an educator, and examining the research literature, she concluded that there were two problems to overcome: the lack of confidence girls demonstrated in their science ability, and their perception of science as a masculine activity. She describes the school's efforts through a

cohort of students through three years which will be briefly discussed here. The department's initial goal was to emphasize the relevance and social nature of science to the girls in the school year prior to the year when the sciences become option courses. This began with the implementation and use of materials that would capitalize on student interest and experience. An example on the concept of waves, was having the students explore waves using musical instruments, the toy slinky, and hospital x-rays. The equipment used on the topic of electricity and electronics was the wiring of a doll's house and specifically, the mechanism of the front and back door bell. Doherty tells of the obvious pleasure and involvement of first year students. As part of this first year experience, the girls contemplated and discussed statistics of women's employment, women's role in society, and the pay scales of men and women. The emotion Doherty describes their response as is anger.

Other specific project actions consisted of presenting to parents the importance of the sciences in widening career opportunities, inviting male and female scientists and engineers to the school, careers advice and peer-counselling with older students who were taking physics and chemistry as options. It should be noted that Doherty's vision was not to ensure all students elected option science courses the next year, but rather to ensure that their choice to take science or not was an informed one.

Prior to the second year Doherty spent time with the Maths Head

developing a liaison between the two curricula to ensure synchronization of topics and compatible terminology where possible. The staff was informed of the reasons and were asked for their support. During the second year, project actions continued with visiting scientists and engineers with the addition of female engineering students, and individual counselling to pin-point individual difficulties. Two additional components were the offering of after school tutorials for students needing additional help or reassurance and the implementation of peer tutoring with older students.

In the last year, the students became the tutors for the younger girls and were involved with designing presentations with practical displays for incoming students. Project actions continued with the addition of "taster weeks" at an engineering institute and more responsibility for the lab equipment.

The school achieved success as is evident in option physics and chemistry course enrolment figures with Physics enrolment in 1983 going from 5% of the student population to 50% just three years later. Chemistry figures increased from 13% prior to the intervention to 55% three years later. At the beginning of the new program, 30% of the students were not taking any option science courses and that number totally disappeared by year three of the project. Doherty goes on to explain the generation of interest as being the easy part. Though some of the girls began to consider careers in the sciences, their confidence level remained extrinsically tied to teacher encouragement. Did

they need further encouragement or was it physics itself that simply disinterested them?

The Image of Science

Most of the interventions designed to date have operated on the need to change the image of science to one more balanced between the sexes in order to address the discrepancy in participation rates. The attempt to make science more girl-friendly has increased participation rates in high school option science courses and has increased girls' confidence in their intellectual abilities. Though these interventions are definitely forging in the right direction, they seem to imply an acceptance of scientific method and style at face value.

A Final Consideration

Interventions that serve to challenge and change the very nature of scientific inquiry are not as easily designed. However, it is widely believed that in order for real change to occur, in anything, it must come from within an organism not from without. Women need to be players in scientific activity. They will need the skills and knowledge to partake, earn some credibility, and then encourage more diverse perspectives, and a feminist one in particular (Rosser, 1986). The concern of and desire to alter the nature of science inquiry, has a much wider ramification than simply promoting increased female

participation. A redefined science is believed to benefit all life.

Conclusion

A number of interventions have and are being explored as a way of addressing the discrepancy of numbers of male and female scientists with the educational system as a focal point. The research presents a myriad of studies concluding that schools, as products of society, have perpetuated the male and female stereotypes thereby contributing to traditional career aspirations. Teachers, in particular, have been shown to favor male students. Increasing teacher awareness of possible bias in classroom activity has been the intent of many educators. Many schools have since participated in collaborative efforts with outside agencies to further encourage female students. Other school districts have delayed science course options to dispel the beliefs of science being very difficult.

The extent of teacher bias has led some researchers to examine possible advantages of single-sex schooling for girls in dispelling the male image of science. The assumption that without the physical and verbal presence of male students, female students would be more inclined to develop the skills and confidence needed for scientific inquiry. The many variables operative, in single-sex schools, however, have confounded the studies. The single-sex environment within the coeducation school is based on the premise

that there is an advantage to single-sex schooling. This is being explored by specific science classes and activities within the schools and summer workshops, to encourage increased female participation.

Some researchers have suggested that role models are highly motivational in encouraging young women to consider a career in science. Many schools have attempted to present role models by hiring female science teachers or having classroom visitations by women in the scientific and technological professions.

The reforms necessary to encourage girls in science are components of the larger reforms intent on changing women's position in society. Altering centuries of tradition does not occur without resistance on all fronts. The issue of girls and science will likely continue to generate research endeavors until equality of opportunity progresses to equality of outcomes, when women and men participate equally and freely in not only scientific professions, but in life.

Chapter Four

Methodology

The Research Question

The question guiding the purpose of the study was: What sense have the students made of the school's intervention strategy?

The Design of the Study

This research study is an examination of student perceptions about single-sex instruction in a coeducational high school. The methodology is both quantitative and qualitative in that it employs a questionnaire and interviews. The task of understanding the sense students make of any particular part of their school life can be difficult since one must attempt to enter into the psychological world of the student. Interviews can be most useful in the recovery of meaning, as Hargreaves (1971) has noted "when a person speaks the richest sources of potential information become available" (p. 21). The principal and teacher, both male, were interviewed to obtain background information.

The School

The city high school, where the survey took place, is situated in the

vicinity of the city's university and is considered an upper-middle-class community. The school has a strong reputation as being an academic school. It is one of only three city schools to offer high school French immersion which results in students being bussed in from a large area of the city.

In 1989 the school's Science Department Head considered the idea of experimenting with an all-girls physics class as a way to increase the female enrolment figures and decrease the female attrition rates in high school physics. She presented her case to the principal and the program began to take shape. The school sought, but was unable to recruit, a female physics teacher. A male teacher was approached and accepted the position enthusiastically. The teacher, as he describes himself, is one to try anything with possibilities. He has a passionate and infectious interest in physics and had a very successful teaching track record demonstrating an interest in innovative ideas and projects.

The All-Girls Class

The first physics class of all girls was in the fall of 1989. In the fall of 1990, a local newspaper article was published which portrayed the intervention as a positive experience that the students were enjoying, as quoted comments from the girls indicated. A short feature was also published in Woman's Day magazine. In the fall of 1991, after hearing a national radio coverage of the grade 11 class, the researcher enquired as to the possibility of a study. At the

time, the teacher was instructing an all-girls Physics 10/20 class of grade ten and eleven students. The brief radio interview had focused on these particular students' comments which were positive ones referring to the aspects of a relaxed atmosphere and the lack of intimidation by male students.

By the time the actual study took place, in March 1992, a new semester had begun and the class was Physics 30 with grade 12 students. Only one student in this new class had been in the fall Physics 10/20 class. All but two of the students were expecting to graduate in June.

The Students

The 20 students were all in grade 12 and most were 17 years old though the range was from 17 to 19 years of age. The students were very academically inclined with almost all of them having taken all 3 sciences, Biology, Chemistry and Physics.

A short presentation was made to the whole class by the researcher as to the nature of the study and the use of the data. Consent letters were sent home which requested parent and student signatures for approval. As well as being informed as to the specific acts required of them, the students knew that they would be given pseudonyms and could withdraw from the study at any time.

All the students chose to complete the questionnaire, but three were not

interviewed (one was ill on the last day when her interview was scheduled; the other two did not make an appointment). This study was the first time that they were asked how they felt and what they thought about the special program they were involved in.

Questionnaires were also mailed out to the previous year's grade 12 students who had participated in the program and had since graduated.

The Questionnaire

All the students returned the signed consent forms and the questionnaire was filled out during class time. The questionnaire consisted of 16 closed questions and 14 open questions (see Appendix A). A question arose from one of the students whether or not they could select more than one answer. As some questions may have needed more than one answer (i.e., "What other Sciences are you taking?"), I answered yes. Although there were items that I had specifically wanted one answer selected (i.e., "When you do very well on an assignment or test, what do you usually attribute it to?"), it was my error to not clearly define them as such on the questionnaire. Also, as I was expecting the first-level physics class (the semester had ended and a new one begun) the semantics of some of the items were not correct although the items were easily understood and transposed by the students (i.e., "Why are you taking Physics 10/20?"). The questionnaires mailed out to the previous year's students were

essentially identical outside of verb tense and a written postscript that invited additional comments. The school office accepted the prepared envelopes and mailed them out, thereby ensuring anonymity.

The Interviews

The students in the study were requested to participate in one interview. They selected an interview time block of 30 minutes during their spare periods or lunch hours. The interviews were intended to allow the students to discuss and to clarify their understanding of the school's program. While the interviews were structured in that questions had been prepared in advance (see Appendix B), there seemed an openness and flexibility in the interviews that allowed the students to voice their perceptions with ease. Seventeen interviews were taped and transcripts were made. One interview was not recorded due to recording difficulties.

Observations

The observation of six classes was included because of the researcher's desire to encourage a sense of familiarity with the students prior to the interviews, and to informally observe the class. As a result, formal observation notes were not recorded but general impressions of the class were noted after each class.

The Interpretive Process

The transcripts and questionnaires provided specific pieces of information about the sense the students made of single-sex instruction. To make meaning of the information, a researcher needs to categorize, analyze, and interpret the data. Erickson (1986) has outlined a process. To start, all the data is reviewed to generate through induction what has been called descriptive statements. The data is then reviewed repeatedly to test the validity of the assertions. Themes and patterns are looked for so that more general assertions and hypotheses can be extracted until the researcher is relatively satisfied that valid meanings have been uncovered.

Essentially, this time consuming endeavour was the process I followed in deriving sense from the data. Part of the difficulty experienced was undoubtedly due to my relative unfamiliarity with the researcher role and the unavailability of a pilot group to field test. A process requiring an intensive search for deep connections and meanings is a complex task. Intentionally or not, a researcher comes to a project with perceptions, assumptions and purposes already formulated to some degree which are likely to complicate the interpretive process. Separating the researcher from the researched would seem near impossible. Researchers have recognized this and have acknowledged the centrality of the researchers and their values and purposes in research projects (Clark & Peterson, 1986).

The data gathering was completed in two weeks. Due to the distance between the research site and the researcher base, I did not share with the participants the descriptions and generalizations that I had worked out. The students, teacher, and principal did not receive a copy of the interview transcripts to give them an opportunity to clarify their intended perceptions and hence, the interpretive stage was done on my own making me totally responsible for the interpretations and implications of the data. Close reading and repeated rereading of the questionnaires and transcripts eventually came to serve to develop an understanding.

Chapter Five

The Results

The analysis of the student responses to the questionnaire (Appendix A) and the interview questions (Appendix B) are presented to describe how the students' perceive the intervention of a single-sex physics class and its implications. The results reveal two conflicting themes of student resistance and acceptance of the program. These two themes will be examined within the context of three areas: the school program, the subject of physics, and gender issues specifically. Lastly, a brief summary of the previous student questionnaire analysis will be presented.

Profile of the Girls

As previously mentioned, the majority of the 20 students were 17 years old. Most of them were expected to graduate from high school in three months with a high percentage of them armed with all three academic sciences. Eighty percent had taken Biology 30 and 90% had taken Chemistry 30. Of the 16 girls interviewed, eight had taken the first level prerequisite in the single-sex class, seven in a mixed class and one student did half in the all-girls and the other half in the mixed. The students appeared to be highly motivated students with all of them planning post-secondary education at the university level.

A questionnaire item revealed more definite ideas about ideal and expected occupations. Eight of the girls had definite ideas as to their future careers with no discrepancy reported between their ideal and expected occupation. Of this eight, three plan to enter traditional male professions of law, engineering, and pharmacy. Six other students cited traditional male professions as the ideal career with only two of the six responding to expected occupation and interestingly, they selected traditional female occupations of veterinary assistant and nurse. The remaining four students were uncertain as to the expected occupation. Two students listed many possibilities under ideal, but responded with "none of the above" for expected occupation. Another two students responded with comments describing their uncertainty of either ideal or expected occupation. One student had visions of becoming an actor with the expectation of practising law and another student's response was too vague to define. One might summarize their ideal occupational leanings as favoring traditional male careers while the expected occupational leanings, outside of uncertainty, as favoring traditional female careers.

From the interview data, nine of the students were taking Physics 30 in order to keep their options open for later consideration of career choice. Six students were taking it as a definite prerequisite to post-secondary studies and only one was taking it without future need for it. From the high percentage of girls opting for all three sciences, it is evident that these students were not

prepared to be in a disadvantaged academic position after graduation especially with more than half of them indicating uncertainty as to expected career.

In an effort to uncover where this view to the future originated, a questionnaire item asked if there was someone who had encouraged them to pursue the sciences as a possible career avenue. Out of the 15 students who replied yes, 11 responded with parents and 7 cited teachers as those who had encouraged them specifically. Nine students listed friends and 3 referred to guidance counsellors. Parents played a significant role in the career considerations of this particular group of students. Though initial interpretation may draw negative impressions of the school counselling services, it is noted that counsellors may well have reiterated parental guidance and were, therefore, not viewed as a particularly influential force. Two of the 3 students who cited guidance counsellors, however, also listed their parents. No doubt, encouragement by adults has played a role in the career decisions of these students.

In the interviews, some of the girls referred to the guidance they had received as a negative experience. One student reported that the guidance office turns students away from physics unless they have very strong math marks while another quoted guidance personnel as raising students' self-doubt by asking, "Are you sure you want to take that?" After grade 10 math marks were reported, another student was asked if she would like to reconsider her

decision to continue with the next level of physics. Others were familiar with negative experiences of friends and acquaintances. One of the students had recently written a letter to the guidance office with respect to her observations that the guidance personnel did not demonstrate concern for students. At the time of the interview, two weeks had passed without a response which served to confirm for the student a lack of caring. These comments from the students show that the attitudes of guidance personnel have an impact and can reinforce a student's doubts about her ability.

Enrolment in Physics

The girls entered into the program without understanding its objectives. This appears rather odd as it was the principal's assertion that one of the program's goals was to encourage female enrolment. It is noted, however, that encouragement is more than a one-shot endeavor. Considering the program's second goal of decreasing the female drop-out rate in physics, the single-sex class may have served to encourage the high achievers to continue on to the advanced course.

Formal school statistics were not available to verify a decrease in drop-out rates. School statistics were also not available for enrolment figures, though I was given teacher record books for the last seven years to do a manual count. Fortunately, previous teachers were still on staff to aid the sex

identification of those names that did not clearly indicate such. The following chart illustrates female and male enrolment in the school's physics classes from 1985-1992:

Table 2

High School Physics Enrolment for Girls and Boys, 1985-1992

Year	Girls (%)	Boys (%)	Total Students
1985-86	44 (32.6)	91 (67.4)	135
1986-87	33 (29.2)	80 (70.8)	113
1987-88	77 (32.8)	158 (67.2)	235
1988-89	74 (37.2)	125 (62.8)	199
1989-90*	90 (37.8)	148 (62.2)	238
1990-91*	112 (44.3)	141 (55.7)	253
1991-92*	98 (45.4)	118 (54.6)	216

Note.

* Years of single-sex instruction program included among co-ed classes.

Female enrolment has certainly increased over the years though a gradual rise is evident prior to the school's intervention program. With the general rise in the number of women entering non-traditional fields over the last decade, it is not conclusive that the enrolment increase is due to the intervention alone. Considering that all but one of the students in the study had designed a program that included physics, regardless of the make-up of the class, the program's role in the enrolment increase is difficult to conclude. Interest in physics is on the rise, leaving the question of whether single-sex classes provide better support for this aspect of girls' educational choices.

Upon first hearing of the special class, prior to the formal teacher presentation on the first day of classes, half of the girls were appalled at the idea describing their responses as, "I hope I don't get in; was not going to be fun; silly to do; weird idea; stupid; dumb; didn't appeal of me; no point to it." The other half were divided equally between thinking it a good idea and ambivalence. The positive expectations included not feeling intimidated by boys to ask questions; feeling more comfortable; and, an interesting way to learn. Once in the course, however, the number of students who viewed the class positively increased to 11 from the original 4. Only 1 student held the same ambivalent view while 2 students who had seen the class as initially promising later saw it as an intimidating experience due to the above average ability of the class. It seems that prior to the experience, the idea of a single-sex class

appeared abnormal in light of their many years in a coeducational environment. Once involved in the course, however, the idea did not seem so preposterous.

Two of the 20 students had chosen specifically the single-sex Physics 30 class and 2 students would have transferred in had it not been designated on their schedules. One student, coming from another school, transferred in from the mixed physics class after hearing about it. The 2 students who would have transferred in had both taken the prerequisite physics in a mixed class and referred to the boys in that first class as "immature and dominating." With only 3 students of the current class choosing the single-sex course, it would appear that most of the students did not find the special program intended for them as particularly attractive. However, the girls had heard from previous years that they would not be allowed a choice anyway which could account for them not specifically requesting it.

From the interviews, it was learned that many of the girls had the impression they were blocked into the class and could not get out without disrupting their entire year of study. Three of the girls had approached the guidance office to rearrange their schedules and were told that they were blocked into the physics class and could not get out except by dropping the course. One of the girls, feeling ambivalent about the all-girls class, had wanted to rearrange the academic load on her schedule and was informed she could not get out of the physics class. It is expected that the school would

lose the experiment if the students were given the option of transferring out this was probable, particularly at the start of the program, given that half of the students did not anticipate a positive experience. However, one of the three students, at the time of the study, had finally secured guidance approval to transfer to the mixed class and had only to obtain the present teacher's permission. She was reluctant to discuss the matter with him because she did not want to offend him personally. Her major concern was the pace at which the course content was being covered as the mixed class was two units ahead. This student was very outspoken and articulate and it was evident to me she would not settle for an answer that did not serve her academic needs.

At a time in their lives when a sense of control is increasing, not having a choice of this particular class may serve to undermine the students' independence, though the choice does remain whether or not to take physics itself. At the same time, it seems important that the school act in the students' best interests, yet, it would be impractical to have three or four students in a single-sex class. The principal viewed the situation simply as, "The girls rear up and complain but at the end of the program they say, I'm really glad; I've really done well." Given the increase in a positive perception of the program initially, the school administration appears to have learned to weather the initial objections in anticipation of more favorable attitudes at a later date. If the school is anticipating a "storm" then perhaps a consideration of presenting the

reason for the intervention would alleviate initial discomfort of the students and anticipation of conflict of the administration.

The Curriculum

The majority of the girls, in fact, had serious complaints about the lack of structure and subsequent slow pace of course instruction. Their concern was the looming diploma exam that all Physics 30 students in the province write at the end of the term. When asked if they had brought their concerns to the teacher's attention they felt that he knew about them through their casual comments in class but they had not spoken directly to him as a group. The concern of not meeting curriculum requirements to allow sufficient knowledge and confidence on the provincial exam may also be related to a sense of second class treatment as many of the students were aware that the predominant male Physics 30 class was two units ahead of them.

Concerns about the diploma exam and the advancement of the other class aside, almost all of the students found that the lack of constant attention to the provincial curriculum boundaries allowed the class to delve into the applications of physics. This was enhanced by the teacher's enthusiasm and passion for the subject. Almost all the students commented on the teacher's vast knowledge of physics and their admiration for him was clearly evident. The teacher's love of physics was evident from the fact that he had built his

own environmentally efficient house and his own airplane. As one of the students put it, "He knows everything about physics." Compared to the earlier nuances of second class treatment, this was reassuring.

The concern about content coverage came up again when the students were asked what they thought the males thought of the all-girls class. Most of the students did not know exactly, but had suspicions due to casual comments made by their male friends and peers. A recurring comment was that the boys probably believed the all-girls class was offered because the girls needed extra help and attention because they could not keep up with them. One of the students emphatically expressed that she did not want that message to be given out. This research was not intended to analyze specific teaching styles or preferences, but the evident student apprehension about completing core curriculum may have ramifications on the perceptions of the entire study body that may contribute to the notion that girls are inferior academically.

Class Participation

Half of the students reported increased participation as compared to other classes, but this may be due to the teacher's knowledge and enthusiasm. The teacher's resistance to the more formal classroom structure encouraged the girls to ask questions and speak out without adhering to the usual expectation of putting up one's hand and waiting to be acknowledged. The

students' total freedom from hesitation to speak for fear of reprimand was predominant. The teacher also made references to the girls helping one another out during instruction which he reported did not happen with the boys. As he put it, "Once the boys have got something to hang onto, they feel powerful with, they'll keep it. The girls will share right away." For a number of possible reasons, the all-girls class appeared to establish an environment of ease and comfort. One student stated that she did talk more in this class but it was not always subject related. Four of the 16 students viewed their participation as no different in this class than other classes and said that when they have a question, they simply ask it no matter which class it is. One student thought her participation might be a little more in the single-sex class. The only student who purposely avoided asking questions in this class, compared to her other classes, cited the reason as not wanting to encourage further diversion from the topic at hand.

Although only the comments of a few students, it still seems worth noting that the students who had taken first level physics in the predominant male class indicated that their previous preference was to ask questions after class. One student reported that she had not spoken aloud in the mixed class throughout the entire term. This student wished she had been able to take the first level all-girls physics course so as to not have been afraid and embarrassed to ask questions in class. She reported being particularly at ease

in this second level physics class and stated that even if she believes her question to be a stupid one, she knows it will be received well by everyone. Another student elaborated that the boys were often frustrated with the girls' questions. She commented that girls in this class are more "forgiving" about questions that seem inappropriate or redundant and do not respond negatively. Though most of the students in the mixed first level physics class reported little difference with respect to comfort in asking questions, it seems evident that the single-sex environment of the present physics class served to encourage greater interaction for some students.

The Intimidation Factor

Feeling intimidated by boys was not personally experienced by most of the girls. Half of those interviewed believed they were not intimidated by their male peers in any way. Of the five students who had experienced or witnessed intimidating behaviour by their male peers, all of them reported increased participation in the present class. One student recalled a time when a female classmate was asking a question and a male student, under his breath but loud enough for many to hear, chanted, "Looooser, looooser." It is not surprising that this was the student who had not spoken once in the first physics class where this incident was witnessed. From the students' and teacher's experience, it seemed a common occurrence for males to put-down anyone,

not females specifically. The teacher commented extensively on this particular behaviour during our interview and lumped it under the phrase "false bravado." It appears evident and reasonable that some people are reluctant to voice questions or comments in the face of possible negative response from others.

When asked the open-ended questionnaire item as to why they thought a school would offer all-girls physics instruction, half of the students responded using the word "intimidation" by boys with others referring to the discomfort level in a class with boys. Eight of the students made comments possibly related to the male intimidation factor using words to describe the all-girls class as "comfortable, friendly, conducive to learning, and non-threatening." I found the repetition of the word intimidation particularly intriguing as the word did not come up in the interview and discussions with the principal and the physics teacher. In the interview, however, the classroom teacher frequently referred to the male high school student's intimidating behaviour as "the nature of the beast," with an apparent total acceptance of it being quite natural. The use of this specific phrase was also noted in the teacher's informal classroom dialogue with the students more than once.

Looking more closely at the intimidation by boys factor as one of the school's possible reasons for having a single-sex class, two different responses emerged. One response reflected the girls' own beliefs that girls are intimated by boys, and the other reflected the view that the school perceives girls' feeling

of being intimidated by boys. To illustrate this more clearly, the following written comments are presented in Table 3. The questionnaire item was, "What do you think are the reasons for your school to offer physics instruction in an all-girls class?"

Table 3

Girls' (n=12) Comments on Intimidation by Boys (Response #21)

Girls (n=6) who expressed a belief that girls are intimidated by boys:

> Because girls in a mostly guys class are shy to get into the subject and ask questions.
>
> So the girls feel they can have the same chance in the class as the males and won't feel over dominated by them... or intimidated when asking questions.
>
> Many girls are intimidated and feel stupid among boys.
>
> Maybe because some people feel intimidated by boys.
>
> So that the girls who are intimidated by boys are not scared of taking the course.
>
> To provide some girls who do not feel comfortable taking physics with boys.

Girls (n=6) who expressed a belief that the school believes girls are intimidated by boys:

> They believe that girls are intimidated by boys.
>
> Our school thinks that we are intimidated by guys.
>
> They probably feel that girls do better...because they are not as intimidated or embarrassed to ask questions.
>
> They find that boys intimidate girls.
>
> They think girls don't do as well or are intimidated when they are in the same classes with boys.
>
> Their reasons are girls are incapable of thinking when there are high levels of testosterone in the room and girls are intimidated by boys.

It seems reasonable to assume that with 50% of the students focusing on this one reason, they have been told intimidation by boys was a significant factor in the decision to segregate them, and many of them appear to accept it, if not for themselves, then, on behalf of others.

Four of the girls interviewed raised the issue that intimidation by boys has likely increased in the present mixed physics class which was predominantly male due to the lower enrolment of girls caused by having the all-female class. It seems possible that the intimidation by males factor could be heightened given there are only 2 females and 21 males. Upon registration, 2 female students were enroled in the mixed class and the 4 students just noted viewed the situation as unfair to the 2 female students. Their position was that if the school was going to have an all-girls physics class, then all the girls should be in it. I was able to observe one of the mixed class sessions and was informed that 1 of the 2 female students had just dropped the course. During the 40 minute observation, the lone female student spoke once and only in response to a student in front of her turning around to initiate a brief dialogue.

In the six informal observations of the all-girls class, however, there were sessions where two of the students did not speak to anyone though one of the two reported increased participation compared to other classes. The second student did not show up for her scheduled interview time on the last day so her

comments on participation were not obtained. If elimination of intimidation by boys is a concern of the school, then it seems that for those few girls in the mixed physics classes, the possibility of it is certainly increased. It is interesting to note that without the segregation of the sexes, the physics classes would be very close to being balanced in enrolment by gender, which would likely decrease the possibility of an intimidation factor.

Two of the students referred to intimidation by others from a different perspective. With an anxious laugh, they admitted to feeling more intimidated by the other girls in the class who they described as all highly academic orientated -- "brains." These two students believed they were average to above average students in their other academic studies, but below average in this class. An elaboration revealed their awareness that in a mixed class the range in ability and interest was far greater and thus less intimidating for them as they would not be at the bottom of the academic scale. One of the two students commented that confidence in her ability had decreased as a result. The other stated that in a mixed class the boys fool around so much that it makes the girls look like better students. Interestingly, these two students reported very negative comments about the teacher and his teaching style implying a favoritism given to the higher achievers. During instruction, I observed that these students engaged in frequent dialogue with each other and were often interrupted by teacher references to his need for their attention. Possibly, their

ill feelings about marks were easier to deal with in a battle of wills with the instructor rather than a complete acceptance of personal responsibility for their achievement which was lower than their other classes.

One other student reflected on the possibility that male students might actually be intimidated by smart female students and thereby intimated that the intervention might be as much for the boys as for the girls. Considering the principal's comments that the worse thing a girl could do is "show a fellow up" in physics (though to do so in Math was okay) and seeing it as the "equivalent to being on the boy's football team and being the all-star runningback," it is possible that the single-sex program was regarded as being equally beneficial to the boys and the girls.

Girls' Perception of Physics

On the questionnaire, the students were asked their previous expectation and subsequent reality of the subject of physics on a five point scale from very hard to very easy. The expectation of very hard or hard was selected by 60% of the students with this dropping to 25% of the students' present experience. The expectation of neither easy nor hard was chosen by 35% of the students which increased to 55% once they were in the course for four weeks. Clearly, the perception of difficulty is operative in student minds prior to taking physics. Kelly (1987b) reports this perception of difficulty as one reason girls generally

avoid the sciences.

Examining a related open-ended item that asked why girls tend to shy away from physics courses, the word "intimidation" was mentioned only once. The perception of difficulty, however, was mentioned by 45% of the students. A lack of interest in the subject was the second response most reported. Table 4 presents all of the responses.

Table 4

Why Girls Shy Away from Physics

Response	Number of Responses
Perception of Difficulty	9
Interest	6
Unnecessary for Career Plans	3
Math Factor	2
Dull/Boring	2
Applicability to Real Life	1
Intimidation by Boys	1
Male Image	1
Don't Know	1

Note.

Students (n=20) were allowed to check off more than one response.

It is possible that there is a discrepancy between what the school perceives as the problem and what the students perceive as the problem. The school appears to perceive intimidation by boys as more significant than actually reported by the girls.

Learning Styles

A recent report prepared for the B.C. Ministry of Education (Matas, 1992) suggests that girls and boys have different approaches to learning. A consistent finding based on mathematics performance, attitude, and enrolment proposes that females demonstrate a greater interest in collaborative approaches to learning which tend to be in conflict with the usual method of teaching mathematics. This was seen as likely operative within the sciences as well. The present study appears to indicate girls favoring a more collaborative approach especially in the physics class. Two questionnaire items asked the students to select preferred classroom activities in Science classes generally and Physics specifically. For both items, the students overwhelmingly chose laboratory and discussion which can be highly collaborative. Harding (1983) and Smail (1983) suggest that certain classroom activities, particularly laboratories and discussion, are very appealing to girls.

To further explore classroom preferences, the students interviewed were asked specifically whether they preferred working alone or in small groups in

the single-sex class. The responses overwhelmingly favored small group activities. Reasons cited for the preference were: discussion among peers as stimulating more ideas and solutions, getting help with areas they were unsure of, and, simply more enjoyable. One student stated she preferred small group work in this particular class but not her other classes and cited the reason that dealing with the content was easier in small groups. Another student chose small groups with the condition that marks were assigned on an individual basis as she did not appreciate the need to depend upon others for her marks. Only two students preferred working alone and said that discussion in group work wasted valuable time and that too many ideas were confusing to one's own understanding.

The B.C. Status Report on School Mathematics suggests that, traditionally, learning outcomes have been goal- or product-oriented and urgently suggests as much emphasis be placed on a process-orientation. Two students brought up the idea of process- versus goal-orientation in response to the question of whether girls and boys learn differently. One explained that girls need to see things "step-by-step, understanding the why," whereas boys simply accept information as presented. As another student put it:

> I don't think guys are as involved with each other, you know. When the teacher writes something on the board, they write it down and they memorize it and that's the end of it. They don't turn to their friend and say, I don't get it. Whereas the girls will write it down and memorize it

> but not necessarily understand it right away, so we'll talk about it and what not. But with guys, I think it's more like, here, this is the way it is, period. A lot of girls, I think, want to know why this is the way it is.

When asked why she thought there is this difference, she continued:

> I don't know. It might be something in the way our... we think, or maybe process information, or just the way you've been brought up. Who knows?

As these students had just spent thirteen years in classrooms with male and female participants, it seems reasonable that they would have an opinion based on their classroom experiences and observations as to whether boys and girls learn differently or not. Their responses are charted in Table 5.

Table 5

Do Girls and Boys Learn Differently?

Response (n=16)	Number of Responses
Definitely No Difference	7
Probably No Difference	2
Developmental/Maturity Difference	3
Definitely A Difference	2
Probably A Difference	2
Total	16

The recurring comment with the response of "no difference" was that learning style was an individual characteristic regardless of gender. The hesitant responses indicated that boys seemed to learn physics and chemistry with greater ease and they wondered if it was a matter of interest or innate inclination. Interestingly, one student commented that there were differences in approaches to studies and that boys might learn the way they think they are supposed to. The idea is certainly inviting when increased participation is reported in the all-girls class.

The physics teacher, on the other hand, thinks there are differences in the way girls and boys learn. He reported that when he began teaching the all-girls class he realized some changes had to be made.

> I got some insights into the way that I had been teaching for a while and thinking that maybe it wasn't right. Granted I was teaching to the majority of the class, which was male, and I was teaching to their style of learning.

He explained that girls process information through a holistic lens and find it difficult to extract a part for focus without understanding, or at least seeing, its place within the whole context. As a result of this revelation, the teacher has adapted his teaching style by presenting the entire context first and only then proceeding to draw the students' attention to a particular part for analysis. This may not indicate a difference in learning style but rather possibly

an unwillingness to accept information without understanding which may be encouraged more in a more relaxed and cooperative environment. From my own perspective as a classroom teacher, working within a context is always preferable to presenting isolated material and information when student understanding and comprehension is desired.

When the teacher was asked whether his teaching style had changed in the co-ed classes he was also teaching, as a result of this new knowledge, he stated that chemistry does not have the same kinds of content problems especially the three dimensional imaging aspects of physics. When asked specifically if he thought girls learned differently than boys biologically, he responded at length.

> I think so. I think there are differences, and I think there are probably structural differences too. The girls have abilities that the boys don't have and vice versa. The boys are really good at focusing on one thing to the exclusion of all else, which means that when it's required that you have to concentrate hard on one thing, the boys can do it easily without any coaxing, but they lose sight of everything else. It's like getting off topic. Once the boy gets off topic, he rivets on that, you know, he fixes on it. That's a skeletal weakness at the same time, so it's hard to say. Where the girls, what I was telling you before with doing field drawings, where I have to draw something here, something here, and something here, and say, "Okay, let's analyze the field location at this location." And when I first did that, the girls had a lot of trouble with it because I didn't purposely exclude all the other stuff. I said, "I don't want you to look here, here, or here, I just want you to look at this one spot." And now I do that and it's more helpful. But before I didn't, I taught it the way I was teaching it to boys for the last decade and they [the girls] were, "What are you doing?" and that was really helpful for me because I realized that unless you ask them to not look at the whole picture, they'll get the whole picture automatically whereas the boys will automatically

> focus on the things that I point to and everything else is gone, it just doesn't exist for them. And so your approach has to be very different.

The teacher perceives a difference between the learning styles of females and males, and has adjusted his teaching methods to reflect this perception. It is interesting to note, however, that earlier in the lengthy interview he spoke of male students as quick to claim understanding of a concept during instruction time only to frequently appear after class asking questions that demonstrate an actual lack of understanding. It seems that boys as well as girls would benefit from this adaptation of teaching style.

Another difference in learning styles the teacher perceived is that girls have the ability to multi-task, as he called it, or being able to attend to a variety of activities simultaneously. This was illustrated by reference to female students' ability to monitor classroom topics and pay close attention when they need to, or less attention, thus allowing them to converse with a neighbor or stare off at a distance, when they do not need the information discussed. The males, on the other hand, were seen to be unable to bring their attention back when it was needed without teacher intervention. During the week of observations, the teacher referred favorably to this ability in class time with the students more than once. This may be an idea held by the teacher, based on his experiences.

Academic Standing

The intervention of an all-girls class did not seem to enhance the students' academic standing. Fourteen of the 20 students reported that their grades in physics were average when compared to other subjects. Five students reported that their physics grades were worse in comparison and 1 described her grades in physics as slightly better. Another question which focused on interest in science, showed that 12 students reported they had not changed their level of interest because of the class. Seven students did report increased interest in science because of the class. The reasons for the increased interest could be the enthusiasm of the teacher, the positive experience in the class, or the possible influence of other teachers and adults. In combining the two items, Table 6 illustrates the relationship between physics achievement and interest in science more clearly.

Table 6

Relationship between Physics Achievement and Interest in Science (n=20)

Physics Grades Relative to Other Subjects	Interest in Science as a Result of the Intervention		
	Increase	Unchanged	Decrease
Grades worse	3	1	1
Grades average	3	11	0
Grades better	1	0	0

It is possible that the increase in interest in Science could well be related to the majority of students perceiving physics to be a difficult subject to learn prior to taking it. All of the girls in the class had already taken the prerequisite course and the fact that they enroled in grade 12 physics indicates an interest already.

Girls' Perceptions about the Class

On the questionnaire, the students were asked what aspect of the single-sex class they enjoyed the most and the least. The responses fit into two categories, atmosphere and course content. In just under half of the "most," responses, they ranged from a relaxed atmosphere, socializing, and help from others, to not being afraid to speak up. The other comments were directed at

the enjoyment of real-life application of physics, the interesting discussions and the vast knowledge of the teacher. The "least" responses were predominantly content related which may indicate a possible consequence of the relaxed atmosphere. The two major comments were the fear of falling behind the intended curriculum and the constant diversion off the topic at hand. This was summed up by one student who said she refrained from asking questions because of the high risk of having the answer spill out far beyond the question's intent or the answer's need. The relaxed atmosphere appeared to condone constant interjections by student comments and questions, either directed at the class as a whole or to a neighbor. The "least" comments categorized under atmosphere addressed the distraction caused by private conversations among students during class time.

It is likely that the dichotomy of responses is related more to the teacher's teaching style than being a characteristic of the single-sex intervention. The finding that 78% of the responses on what the girls enjoyed least about the class refer to content concerns highlights a serious issue. The fact the all-girls class is behind in the curriculum content, particularly for the provincial exam, could leave them inadequately prepared. In addition, it could serve to reinforce the stereotype that girls experience more difficulty learning physics.

Female Role Models

A number of research studies have proposed the positive stimulus of female role models (Ellis, 1981; Erickson, 1981; Stage, Kreinberg, Eccles & Becker, 1987; Stage, et al., 1985; Rosser, 1990). Sixteen years ago, a National Science Foundation project concluded that the presence of role models during the high school years appeared to be the most effective strategy to increase women's participation in mathematics and sciences (Fox, 1976). With this in mind, the female students were asked how they thought having a female physics teacher might make a difference. While three of the students believed it would make more sense, given that the school was interested in increasing female enrolment, 17 did not believe it would make a difference whatsoever to them, although one of the students elaborated that she found female teachers more able to explain concepts in a way that helped her to understand better. A recurring comment was that teacher personality, attitude, knowledge, and teaching style is what contributes to successful learning. In hindsight, a question addressing their contact with professional women in the sciences may have more clearly indicated the significance of female role models for career aspirations. The teacher was asked if he had invited female scientists and/or engineering professionals into the classroom. He admitted that he had not and immediately talked of the trip his previous class had made to the local university computer lab.

Opinion of An All-Girls Class

As stated earlier, 2 of the 20 girls had specifically registered in the all-girls Physics 30 class and 2 would have transferred in to have this particular teacher had they not been assigned to it. The other 16 simply found an 'F' on their registration cards. Some of the students had assumed the "F" stood for French and were somewhat perplexed. It actually stood for "Female." One of the 2 who chose this particular class did not need physics for her chosen career path and had originally decided not to continue after the first level course. Only after speaking with the popular physics teacher and finding out that a small all-girls Physics 30 class was expected, did she decide to take it. This same student, however, did not think any other courses should be taught in a single-sex setting. The second student required the course for her career intentions. This student thought that girls might benefit from being taught Math 30 and 31 in an all-girls environment. Three other students also suggested Math. One other student thought English would be beneficial for her in a single-sex environment as she found the participation of the boys annoying in a subject she liked very much. Ultimately, the vast majority of these students were not interested in being taught in an all-female environment for another subject. This, and other findings noted earlier, raise the issue of whether the acceptance of the program was more related to the popular teacher teaching the course than to the learning experience of being in an all-girls class.

It was interesting to note the change in handwriting for this particular item -- "Are there other subjects you would like to be taught in an all-girls class?" Looking at all the other item responses, it was noted that 40% of the students switched from cursive to manuscript writing and 50% chose to respond in all capitals with only one having used all capitals on previous responses. One student used an exclamation mark as well as all capitals and another elaborated with a comment that suggested going to a convent school if an all-girls education was what one wanted. It appears reasonable to conclude that this particular item solicited an emotional response that indicated a strong preference for a coeducational environment.

Feminist Views

In the interview, the students were asked if they thought the concept of the all-girls class fit in with any feminist issues they had heard about or read about. Over half of the students reported the idea seemed to be a contradiction that goes against equality by either providing extra privileges to girls, or assuming girls are not as capable as boys. At one extreme, one student used the word "condescending" in referring to the assumption that girls cannot learn with males in the same class. At the other extreme, another student thought it might produce the opposite effect and cause the males to feel intimidated. Three of the girls did not see a connection to feminism at all. One student

defensively claimed that the class was not about women's rights but about learning physics. Though some students talked about women's equality, 75% of those interviewed made no reference to the concept of gender equity.

Four of the students did elaborate that the intervention was giving girls a chance to be successful in a traditionally male area thereby encouraging female participation in the scientific professions. One student noted that it helped her become aware that maybe there has not been equal opportunity for females. This particular student's mother had just returned from New York City where she had read about a research study that found negative differences in the ways girls' questions were responded to by classroom teachers. These reflected on the role of the intervention in addressing gender inequality.

Some of the students admitted knowing little about feminism and all its implications. One student mentioned that the physics teacher was the only teacher, however infrequently, to bring up the issues women face. During one informal observation, the teacher briefly presented a newspaper article describing a historical perspective of women's struggles. The article was then passed around during instruction time. As I observed the girls attending to the newspaper clipping, it was evident that all of them gave it a cursory inspection before handing it to a neighbor. Once circulated it was placed on the back table and remained for two days before disappearing.

It is apparent that the present students accept this class as their only

choice to acquire grade 12 physics with only one seemingly determined to alter her fate. All of the students had positive comments about learning physics, the atmosphere, the teacher's passion and knowledge of the subject, and the teacher himself as a person. Had the girls been given a choice of single-sex or mixed physics instruction in the same scheduling space, it seems reasonable to expect that many would have opted for the mixed class. On the other hand, given their admiration and respect for their current teacher of physics, I expect they would choose his class over any other consideration.

The Previous Year's Students

It was decided to approach the previous year's students who were no longer at the school based on the belief that distance and hindsight might offer a different perspective. Similar questionnaires to those used with the present students were mailed out to 29 students and 11 were returned, providing a 39% return rate.

Analysis of the data indicated similar patterns of response to the present student questionnaire responses on almost all of the items. The one difference that did emerge was on the item that asked what they enjoyed least about the class. The most cited response was the competitiveness of the students in the class. Competitiveness was not mentioned by the present students in any class context outside of one student stating she enjoyed competing with boys.

Summary of the Findings

The school program of an all-girls physics class was started with two goals in mind: increasing female enrolment and decreasing the dropout rate. According to the school administration, the goals are being met though it is not conclusive to the researcher that enrolment increases are due to the intervention itself. Parents appear to be the more influential component of encouragement to pursue high school science courses. Friends and teachers also played a part but given career aspirations are generally explored and constantly adapted throughout childhood and adolescence, it is reasonable that parental encouragement is the greater influence for most students. It is evident that this particular program, in itself, likely does not serve to encourage female students to explore a science course they had not previously considered. Only one student had no intention of taking the course but had decided to after discussing it with the current physics teacher for whom she has tremendous respect and admiration.

It is apparent that the present students accept this class as their only avenue to acquire grade 12 physics. With only 4 of the students specifically selecting the class and 16 adamantly uninterested in single-sex instruction for other subjects, it would seem that given a choice, few students would elect an all-female environment.

Though most of the students did not elect this particular class, the

majority of them had many positive comments about it. The personality and knowledge of the instructor appears to be a significant factor in the girls' acceptance and enjoyment of it. One student referred to the local and national attention the program had experienced as one aspect that the students found exciting. Having a researcher travel from Vancouver may have contributed to a sense of importance as well. At the same time, it may be exciting to be part of something unique though not really comprehending just what it is that is so particularly interesting.

The relaxed atmosphere of the class was generally viewed positively by most of the students though whether it is the result of the single-sex environment or the teaching style of the instructor is unclear. While the students enjoyed the atmosphere the class provided, they also saw it as interfering with the completion of core curriculum through constant excursions off the topic and constant interruptions by student questions and comments directed to the teacher and amongst classmates.

Increased participation was reported by over half of the students in comparison to other classes, though as one student revealed, it was not always course specific. It seems reasonable to expect that a relaxed and possibly non-threatening atmosphere would encourage student participation regardless of the members of the class. However, many variables contribute to the atmosphere of a classroom including the teacher's personality, the cohesiveness of the

group, and individual student personalities. Whether the single-sex environment was a significant factor in stimulating increased participation is uncertain. That it was one variable is probable.

There seemed to be a general acceptance that boys can and do intimidate girls to the point of some girls refraining from participating more fully and feeling less competent. While most of the students did not feel that boys intimidated them personally in their classes, they acknowledged an understanding and acceptance that some girls could be intimidated. It appears this acceptance, coupled with a caring and enthusiastic teacher, served to convince the students that the program was worthy of their agreement to participate.

The teacher's agreement to transfer to the school to teach the class may well have encouraged the students to reconsider their initial responses to the concept. His obvious passion for physics and dynamic display of such may also have contributed to the general enjoyment of the class. With his caring and student centred approach, there seems little doubt that the role he played in creating the amiable atmosphere was significant.

It may be encouraging to see that over a third of the class reported increased interest in Science as a result of this class. The analysis suggests, however, that this increase is not likely due simply to the gender design of the class. The majority of students reporting no change in interest may indicate the

desire to take physics purely as a prerequisite for further possibilities.

Given the career uncertainty of many of the students, it is surprising that the school did not perceive a need to address it with an extension of the intervention program, using female role models from the nearby university. It is expected that such an extension would offer the students an opportunity to explore the realities of scientific and technological professions for women.

Another means to address the school's goal of increasing female enrolment would be to have presentations to female junior high students considering the design of their high school programs. With 75% of the present students reporting their previous perceptions of physics as being a difficult subject and not having interest in it, interaction between these two groups of female students would likely have tremendous potential in eliminating misconceptions. Secondary schools, like post-secondary institutions can offer outreach programs to their feeder schools. This initiative, however, would require further demands on teacher and student schedules.

The student concerns about their preparedness for the provincial exam and their knowledge of being substantially behind the other physics class, predominantly male, are certainly valid concerns and need to be addressed. Despite the enjoyment of learning more of applied physics, it did take away from the required curriculum necessary to be prepared and feel confident to write the final examination.

The physics teacher perceived a difference in learning styles for girls and boys that he had not previously identified in his 10 years teaching experience. This finding appears significant, especially in relation to the content lag in comparison to the other class. In accommodating the revelation of a different learning style, the teacher may have over-emphasized the contextual application of physics thereby consuming necessary core content time. Given that the program was nearing the end of its third year, however, one would expect that the trials of accommodation would have come to a workable and effective assimilation. The possibility of inadvertently perpetuating female inferiority appears very real.

Generally, the present students have accepted the organization of the single-sex class. It appeared that a significant variable in their acceptance of the condition of taking physics appeared to be the admiration and respect for the instructor. His belief in the effectiveness of the intervention and his enjoyment of the class may have likely served to encourage the students to accept the program's premise. That the students had no choice would also cause some acceptance.

That the school began a single-sex physics class for the benefit of its female students demonstrates acknowledgement of a need to address stereotypical conceptions long associated with women and science and particularly physics. To attempt to do something and take the risk of innovation

is admirable. At the same time, a program of this sort must tread with care as its ramifications can be unpredictable. It would seem frequent evaluations to ensure its purposefulness is crucial because of the potential to undermine the very reasons for its inception. From my understanding, the school had determined the success of the program by comparing academic scores between females and males. As the sole measure it seems rather in conflict with the specific mandates originally set out.

Chapter Six

The Conclusions

Prior to this research study I must admit that the idea of single sex schooling being advantageous for female students was already gaining ground in my own mind. As a recent convert to feminism, I was exploring and evaluating the legacy of patriarchal values, beliefs, and practices. As an educator concerned with the potential of youth, I began considering the benefits of female dominated classrooms. Upon hearing of a high school program that segregated females and males for instruction in a subject very much male dominated, I anticipated substantiating some of the ideas formulating in my mind. Recognizing that this bias may have played a part in the design of the questionnaire and interview questions, it was important to me to have my Committee members plus one other professor, peruse the questionnaire and interview questions beforehand. The intent of the study, however, was to uncover what sense the students made of the particular intervention they were involved in. I consciously decided to neutralize my own ideas and simply guide the students to share their understanding.

The understanding of the program's beginnings seemed crucial to place the intervention within a context. Knowing the school's objectives contributes to the evaluation of the program's success. Millam (1989) states the need for

schools to examine themselves in order to set realistic goals in the area of equal opportunity. She offers three stages: collecting and analyzing own data, a diagnosis of the problems or needs, and finally, solutions to reach specific goals. At the school in this study, the idea of intervention began with the concerns of the female Science Department Head at the time. From my understanding, she brought the idea to the school administration's attention and the idea became a reality. What is significant here is that someone perceived a need for intervention to bridge girls and physics, and single-sex instruction became a solution that could readily be injected into the school experience. The principal spoke of two goals of the program: increasing female enrolment in physics and decreasing the female attrition rate. According to him the goals are being met by the current program, though formal statistics were not available.

Martin (1981) and James and Young (1989) discuss the need to present educational issues, and gender equity in particular, to the students in order for them to decide whether change is desirable or not. The premise appears to be that if students do not see a need for change, the chances of one occurring are slim. The school, for whatever reason, did not include student voices in any stage of the intervention development or subsequent program and simply acted in what can only be perceived as the students' best interests. Versey (1990) speaks to the same idea as she acknowledges the great strides made to

encourage the increase in female participation in science courses but cautions that we cannot assume this to be all that is needed and that the girls will simply take it from there. The issues of women and science, and fundamentally the issue of women and society, need to be brought alive for the students. It seems paramount that students become an integral part of a school's self-examination and the subsequent decision making process to address identified problems and needs. This would certainly eliminate misunderstandings such as one student believing the "experiment" was set up by "some guy over in England," and others feeling somewhat insulted at the implication that girls cannot function as well with the presence of boys in the classroom. This lack of participation by the students in the planning process likely contributes to student misconceptions which is significant as the program's intent is to increase female enrolment in physics.

The school had not documented any statistical information to date which is surprising given the program objectives to increase enrolment and decrease female attrition rates. When the principal was asked how the program was being monitored, he replied that they "just look at achievement rates." This was puzzling given his later comment that the program was one of the more significant things the school was doing. The discrepancy between objectives and evaluation may, in part, be due to the departure of the female Science Department Head at the time, as she returned to graduate school the year the

single-sex class began. As the owner of the original idea, she may well have monitored the program differently. Though this intervention was not an official research study, with participants actively interested in contributing to the current knowledge of gender equity, innovative school programs should be monitored and evaluated throughout the process. The school may eventually compile some form of statistical information but the absence of student feedback must be questioned.

That the single-sex program has attracted girls to science, and to physics in particular, is doubtful. All but one of the present students had already chosen to take physics. Girls who feel less competent in science may be more attracted to single-sex instruction but may not make this decision without some encouragement and support. It would seem that encouragement to consider the possibility of option science courses would be most effective before high school decisions are made. Interventions after decisions have been made may encourage students already interested to continue while interventions before decisions have been made would likely serve to broaden and extend the knowledge base from which the decisions are made.

It seems reasonable that students draw on a number of sources prior to designing a high school program including parents, teachers, counsellors, and friends. Astin and Snyder (1984) report that the role of guidance counselling is often ambiguous; students do not make full use of the services, and students

feel that counsellors tend not to influence their course and career decisions. Matyas (1985) states that counsellors and teachers can play a significant role in emphasizing the range of scientific careers available and encouraging girls to keep their options open in the selection of high school course studies. It seems crucial that school staffs be informed of their obligation to present the full range of career possibilities to all students. Though not an intention of this study, the counselling services some of the students received appeared to discourage students from exploring possibilities.

In one of Kelly's (1987) studies she reported that parents viewed non-traditional courses as very important for girls' educational and career prospects more so than the girls' science teachers. In this present study, the students reported that parents were the more significant influence on their decision to study the sciences. One student reported encouragement by her grandmother to study physics. Matyas (1985) emphasises the importance of parental influence beginning at the pre-school level and continuing through extra-curricular activities. Matyas also concludes that the attitudes of parents toward school science can be influential in girls' choices of sciences courses, and it certainly seems to hold true for this study.

The myth that physics is a difficult subject seems to have persisted. DoBoer (1991) reports that in 1930 one of the reasons for low physics enrolment was girls' lack of interest in it. Yet, earlier statistics from 1890-1900

indicate that enrolment and performance for all high school subjects were very much balanced (Tyack & Hansot, 1990). The secondary school curriculum was predominantly academic at this time though early in the twentieth century more diverse programs began. Business and commercial courses were introduced and again, enrolment by sex was basically balanced. Once manual training and home economic courses were introduced, differences in enrolments appeared. Economic and social pressures in the early 1900s were placed on schools to develop curricula that would prepare students for the workforce (Spring, 1990). A 1911 and 1913 New York City survey of high schools listed one advantage of the diverse programs as the "opportunity to adapt instruction to the two sexes" (Spring, 1990, p. 218). With marriage and motherhood as a young girl's expectation and consequent reality for most, the opportunity to study more practical courses must have appeared very attractive.

With the advent of the streaming practices, the study of the sciences and maths became part of the educational tract for students destined for post-secondary education, and consequently was viewed as a superior program which still exists today. DeBoer (1991) discusses the declining enrolments in physics and chemistry courses from 1900-1928 and reports the physics community's concern that physics was too difficult and abstract to attract students. Teachers were implored to make the science content more interesting and meaningful to students' lives in order to compensate for the

abstract quality. With males the predominant physics student, it hardly seems surprising that the content was geared to make the subject more appealing to them which likely contributes to the myth that physics is a masculine subject.

In the current study, the notion of physics as a difficult subject was perceived by the majority of students prior to the course. The students also cited this reason most often when asked why girls generally tend to shy away from studying physics. Kelly's (1987b) research supports this view of female students fearing that physics is too difficult for them. However, in Kelly's research, and this study, once girls became familiar with actual physics content their earlier perceptions of difficulty dissipate dramatically. What appears significant here is the implication that girls may not have the self-confidence to believe they can successfully manage science courses they perceive as difficult.

Many of the students in the present study perceive that the school operates the special class because of the intimidating behaviors of boys in coeducational physics classrooms. Whyte (1986) comments that boys are likely to make negative comments if a girl incorrectly answers a question. Kelly (1987c) notes that "adolescent boys are characteristically scornful of girls...[with] many instances of boys using ridicule to remind girls of their inferior status" (p. 71). This does seem to fit with what the study teacher explained as the need for boys to put down anyone, not girls specifically, to make themselves look good. Interestingly, very few of the girls had experienced or witnessed what

they would describe as intimidating behavior by boys in their many coed classes. Some of the student comments verged on feeling insulted by the implication that they could not stand their ground verbally or academically with male peers in a physics class. One student nonchalantly commented that she had "been the brunt of put downs by boys" but judiciously declared that they had also been the brunt of hers. That boys tend to dominate science classrooms verbally and physically is well documented in the research. With over half of the 20 female students in the study reporting increased participation in the single-sex class when compared to other classes, it certainly seems possible that more subtle intimidation by boys occurs within coeducational classrooms.

With the emergence of females in the educational arena it was apparent that girls could meet the academic standards expected, with performance equal to or better than that of the boys (Tyack & Hansot, 1990). It is noted that the early North American school students studied predominantly an academic curriculum where girls and boys undertook the same subjects. It seems that with the advent of streaming practices envisioned by those interested in the education of the whole child encompassing student differences in "abilities, interests, and destinies in later life" (Tyack & Hansot, 1990, p. 168) was also the advent of feminine and masculine subjects. With the hard won gains to educate girls finally realized, gender distinction took on another form.

The feminist movement of the 1960s and 1970s challenged socialized attitudes based on gender and arguments of superior male intellectual capacity have been questioned. Differences in learning styles and approaches have become the latest gender descriptors, or perhaps more accurately, gender restrictors. The basic tenet of this reasoning is that femininity is concerned with people and masculinity with objects. In psychological circles, the same principle can be heard -- girls seek identity through their connectedness to others and boys through separation from others (Gilligan, 1982). We see this clearly in reports of girls' interest in collaborative activities and boys' interest in competitive activites.

In the current study, the teacher did not describe the girls specifically as more cooperative or less competitive than boys but referred to their willingness to help one another as opposed to the overt smugness of the boys knowing something others do not. The female students' helpfulness was evident in classroom observations where they aided in the answering of classmate questions. The students reported preferences for laboratories and discussion and I judged the activities observed to be highly collaborative, and devoid of a need to be finished first or to prove one's intellectual prowess. Slavin (as cited in Lockheed, 1984) reports that cooperative interactions stimulate student learning. Lockheed (1984) looks at the myriad of positive effects of cooperative learning.

> Cooperation requires students to evaluate information, exercise judgement, take initiative in using different sources of information, synthesize ideas contributed by different people in the group, understanding the perspective of others regarding shared problems (p. 128).

It seems that an emphasis on cooperative learning in any science classroom would reap learning benefits. That girls appear more drawn to cooperative efforts may derive from their gender role of caring for others, but it may also derive from a sense of the need for wholeness. Prominent feminists (Gilligan, 1990; Kelly, 1981) have suggested that females are more relationship orientated, more caring, and more nurturing than males and Kelly (1981) suggests that it is this concern for people over things that disinterests girls in the mechanistic approach prevalent in scientific fields. Kelly also purports that the dominant tenet of science today is one of competition -- for money, status, and the desire to be first.

The teacher reported a revelation, unknown in his previous decade of teaching, that females learn differently from males. He sees his female students as holistic learners viewing information or events within a web of interrelationships. This certainly is substantiated in the literature (Kelly, 1987; Gilligan, 1990). As an educator, I have observed that this kind of learning, or perhaps more accurately described as teaching, is best for all students and stimulates active thinking as opposed to memorization and regurgitation of

facts. It seems clear that to see things in context will produce a wider array of questions and consequently, a wider array of answers. That all students should be taught within a more integrative approach is evident in the B.C. Ministry of Education Year 2000 document. One of the fundamental principles of the curricula legislation is the belief that teaching within contextual frameworks is crucial to learning.

The majority of the female students in the study believed there was a difference in the way girls and boys learn though many expressed a certain hesitancy in their response. They saw differences but seemed reluctant to place too much importance on them. An interesting comment by one student was that perhaps boys learn the way they think they are supposed to. Could it be that boys are more goal orientated and view their learning as an individual endeavour while girls are more interested in collaborative approaches to learning? Most of the female students in this study did cite a preference for the more collaborative classroom activities and half of the class reported increased participation compared to other classes. Research studies have shown that discussion and laboratory activities are very agreeable to girls (Rosser, 1990). Kahle (1985) found that these activities are a significant part of an effective teacher's repertoire since they are equally appealing to boys.

The students demonstrated a desire to understand the whys and hows behind the content presented and as one student put it, "they need to see

things step-by-step." It seems they were not prepared to take leaps without fully understanding. To my mind, this would be desirable for all learners. It may be that being in an all-girls class encouraged the students to feel confident in stating they did not understand or needed further clarification on something. Interestingly, the teacher commented that he gets questioned a lot more in the girls' class and that he is held accountable far more for his part in the learning process. It is possible that the process orientation the students demonstrate is somewhat in conflict with the amount of content they are expected to cover. If students are simply taking in information, as a sponge might water, then it seems reasonable to expect more content could be covered. The other grade 12 physics class, predominantly male, was apparently two units ahead.

At first glance, the single-sex intervention appears to be an exciting innovation to address gender equity in the sciences. That the school was interested in addressing the science and girls issue is most admirable. Lockheed and Klein (1985) report some evidence that single-sex classes, especially for new academic material, may have positive effects on later coeducational classroom interactions. However, they also propose that long-term effects of segregation would likely serve to perpetuate sex stereotypes. Sheinin (1981) discusses the recommendation of single-sex classes for girls in the physical sciences but is clear to indicate its benefits are only in the beginning stages of a course of study. That the students, through their

curriculum concerns, intimated a kind of second-class treatment is certainly worthy of being addressed. Perhaps single-sex instruction in the first-level class would be sufficient to give female students enough encouragement to further explore interest and ability to successfully consider further physics, and as a result, broaden their career options.

Feminism and this class were seen as contradictory for half of the girls, others were unsure of a connection at all, and still others saw the two as totally unrelated. I was reminded of the Canadian documentary, Talk 16, where the 16-year old girls were either little informed or negative about feminism. Filmmakers Lund and Mitchell concluded that the women's movement is not reaching out to young women (Lipovenka, 1992). Having a male teacher and a male administrator seemingly in charge of the whole program may contribute to the lack of the program's relationship to feminism. This is a feminist strategy and the fact that the students do not know it as such is a serious flaw.

The school's concern with enrolment numbers and achievement scores appears to indicate an interest in the product rather than the process. One might even speculate that given no formal monitoring or evaluation of the program and its implications, the school believes that they have done their part by doing, at least, something, and have left the rest to the girls.

The students targeted for the program had not received any information about it before the first day of class. The present class of students, though

near adulthood, had never been asked what they think or how they feel about the program. My mind fills with patriarchal visions and words, "We're doing this for you! What do you want to discuss it for? Just wait, you'll appreciate it later." This might seem a little harsh and unfair, but it seems that women's voices, rights, and feelings are simply being brushed aside once more as irrelevant to the purpose at hand -- increasing enrolment figures and displaying high marks.

Despite the criticism above, the students, for the most part, enjoyed the class. Half of them were participating more than in other classes, and help and encouragement were plentiful. Their teacher is a passionate and popular instructor, and the class was often described as sociable, fun, and full of friends. However, regardless of the more positive aspects of the class, the students had serious concerns about the curriculum being covered and were concerned about their success in the upcoming provincial examination. In Sheinin's (1981) suggestion of the possibility of single-sex intervention, she clearly declares that the course should "NOT be less rigorous with respect to the concepts, theories, and experiments covered" (p. 95). That the students were reluctant to share their concerns with their teacher may be indicative of not wanting to upset the applecart that the school had so graciously set before them. Those most concerned were afraid of offending this teacher who obviously delighted in teaching them. This may suggest the program exists for

the school and not for the students. Student enjoyment of the class may be more of a response to the teacher than the course.

The program has tremendous potential to not only dispel the male myth of physics but to validate girls' learning approaches and concerns that once acknowledged, could strengthen the students' own acceptance and encourage them to acknowledge their needs in a coeducational classroom which would likely benefit male student learning as well. These noted differences in learning may not be that significant as far as optimal learning goes, but I suspect have been over-emphasized, exaggerated or perhaps even created to justify the school's program.

It seems to be crucial that the male myth in physical sciences could also be challenged by the presentation of role models. Not providing role models seems to me rather serious especially given the discrepancy between ideal and expected occupations and the uncertainty of aspirations. However, the school may well be aware of the academic encouragement these students have received from home and believe it to be sufficient. With the city's university a mere two blocks away, however, it seems unfortunate that interaction with role models in scientific and technological careers are not provided. Rosser (1990) discusses the need for girls to know that being a woman, a wife, a mother, and a scientist is compatible and possible:

> A major issue concerning most females is the possibility of combining a scientific career with marriage and/or family... Role models of successful women scientists from a variety of backgrounds who exhibit diverse lifestyles can best address this issue (p. 70).

Most of the students did not believe having a female physics teacher would make a difference though it is evident that a female physics teacher would only be a role model for a female physics teacher not for a female scientist. In hindsight, further discussion with the students may have led to more meaningful possibilities of the influence of female scientist role models. Role models, I believe, are tantamount in expanding the basis of real possibility of a female student in realizing that the possibilities heard of are in fact already a reality for some women.

Connecting with male and female role models from the field would likely contribute to the stereotypical expectations of both sexes. Though some of these interactions might be valuable in segregated quarters, total segregation by sex would not be dealing with the whole issue -- that of male and female conceptions of appropriate careers and roles. The role model idea could be provided for junior high girls by inviting the high school physics students to help dispel the perception of difficulty by preparing and presenting their experience with physics content to the younger students prior to the selection of high school course decisions.

Though the need for the teacher as a role model did not seem significant

for the students in the study, a few of them thought having a woman would make more sense given the program's purpose. Those who had taken the single-sex first level physics course had a female teacher, who unfortunately was a biology teacher and, according to the students, did not like teaching physics and had borrowed much of her material from the male physics specialist in the school. The students were aware of her struggle to present the content and noted discrepancies between the classroom content and the expectations on the borrowed examinations. Harding (1983) suggests from the evidence of teaching influence on girls' choice of sciences courses that teaching style and individual teacher behaviors are likely more influential than the sex of the instructor.

The students did not appear, however, to be aware of actual trends beginning to develop at the post-secondary school level. Sharing the only statistics I inadvertently had, many of the students were delightfully surprised to hear of the female enrolment figures of medical students at the University of British Columbia over the last couple of years. The students had no idea that numbers were rapidly nearing a balance of the sexes. Two of the students eagerly asked if I knew of the engineering school statistics. Unfortunately I could only direct them to telephone the local university and ask the Admissions personnel. It appeared clear to me that these students were not informed of the strides and struggles of women and it seemed the information could affect

their career aspirations. Interaction with women engaged in these less traditional occupations may have given these students a greater basis for their own future decisions. Even statistics, on their own, may encourage young female students to consider a wider range of career possibilities.

The importance of this research study is its presentation of views by those imagined to benefit by the administrative decision. It can help a school dismantle its preoccupation with administrative details and view the implications of its policies and practices on a larger scale. The study has not attempted to prove or disprove the benefits of school programs. It has merely sought to focus attention on the issues raised by both the literature and the students.

Gender issues seem to be a tightrope endeavour these days with daily reports in the media presenting it almost as a tiresome debate. For the school it may well have been easier to simply carry on as it was prior to the intervention. I heartily applaud schools who do respond to the possibility of their responsibility. It would be desirable for more schools to inquire as to their part in the gender drama. However, as Millman (1989) states, gender cannot be compartmentalized but must become an integral part of what a school is with short term objectives and constant monitoring of effects. Without the many facets involved, gender equity becomes trivialized and viewed once again as a personal and individual problem. An isolated strategy is likely not sufficient to

address such a complex issue as women's lower participation in science. Multiple strategies within a team approach context certainly makes more sense in response to the complexity of the issue. Responsibility extends beyond the design of the program to the steering of the project as well. The strength of this school's intent may have become its weakness.

At the same time, the program has shed further light on possible gender differences in learning styles. Kelly (1987b) concludes that girls and boys seem to respond differently to science and that further research in single-sex and coeducational schools may continue to explore learning patterns. These students prefer collaborative activities and are very interested in the application of physics to real life.

This particular school does have a high enrolment of female students in the sciences, and physics in particular, to the point of a near balance between the sexes which seem to be the result of something other than the prescribed intervention. What might be helpful is research to compare and contrast with other high schools with low female enrolments. This could lead to the identification of possible school characteristics and/or policies which tend to foster girls' interest in sciences. Research of this nature, with a control group of students in a mixed physics class in the same school with the same teacher would certainly illuminate any benefits of single-sex instruction in a traditionally male-defined discipline.

Inviting students to become a part of the gender equity issue seems crucial for change to become a reality for them. The desire and need to have women participating fully with acknowledgement and validation of women's concerns must be brought alive within the coming generation. However, women need to be educated in what science is before their voices can be heard. It seems reasonable that science, with its legacy of tradition, will not change without an impetus and it seems two things are crucial to maintain the pressure. More women need to participate in the sciences and feminist concerns must continue to flourish and challenge existing premises. With these two catalysts, the social construction of science will inevitably and continually reconstruct to reflect concerns of all peoples. Change may appear slow but if it is looked upon as small and consistent steps that need to be explored, explicated, and evaluated, then it is hopeful that change in science is inevitable and life will become richer for all because of it.

* * *

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Appendix A

Present Students

SINGLE-SEX PHYSICS INSTRUCTION

You have been invited to participate in a research project designed to collect information regarding the advantages and disadvantages of single-sex physics instruction for female students. The information will help other schools and districts that are considering single-sex instruction for high school physics courses.

The questionnaire does require your name for interview purposes only and you may be assured that your individual identity will be completely anonymous from any written accounts. The study is only interested in group information.

Responding to the questionnaire will take about twenty minutes. It is completely voluntary and will have no influence on your grade or standing in the course. If you complete the questionnaire, it will be assumed that you have signed the consent letter in favor of participation.

Half of the students will be randomly selected for a personal interview with me at a later date so that elaboration of some of the items may be given.

Sylvia D. Brendel
Telephone: 239-6901

Student Name _____

Please read and respond with an "X" to each item.

1. What is your current age?

   [_____] 15 [_____] 17

   [_____] 16 [_____] 18

2. What other Science courses are you presently taking?

   [_____] Chemistry 10 [_____] Biology 10

   [_____] Chemistry 20 [_____] Biology 20

   [_____] Chemistry 30 [_____] Biology 30

   [_____] no others

3. What other Science courses do you expect to take before grade 12 graduation?

   [_____] Chemistry 10 [_____] Biology 10

   [_____] Chemistry 20 [_____] Biology 20

   [_____] Chemistry 30 [_____] Biology 30

4. Which describes your participation in this course?

   [_____] I chose to be in this all girls class.

   [_____] I was assigned to this all girls class.

5. Is there another student with whom you work on physics outside of class time?

   [_____] Yes, another girl

   [_____] Yes, a boy

[_____] No

6. Do you think high school physics should be compulsory for all students?

[_____] yes [_____] no

7. Which describes the grades you get in Physics?

[_____] They are better than in most subjects.

[_____] They are about average when compared with other subjects.

[_____] They are worse than in other subjects.

8. Has this course influenced your interest in science?

[_____] My interest in Science has decreased because of this course.

[_____] My interest in Science has not changed because of this course.

[_____] My interest in Science has increased because of this course.

9. When you do very well on an assignment or test in this class, what do you usually attribute it to?

[_____] ability [_____] effort

[_____] good luck [_____] ease of work

[_____] help received [_____] good day

10. When you do poorly on an assignment or test in this class, what do you usually attribute it to?

[_____] lack of ability [_____] lack of effort

[_____] bad luck [_____] difficulty of work

[_____] help not received [_____] bad day

11. **Before** you took this course, what did you expect the subject of Physics to be like?

[_____] very easy

[_____] easy

[_____] neither easy or hard

[_____] hard

[_____] very hard

12. **Now** that you have taken one course, what do you think of the course?

[_____] very easy

[_____] easy

[_____] neither easy or hard

[_____] hard

[_____] very hard

13. Which describes the subject of Physics for you?

[_____] I like Physics more than most subjects.

[_____] I like Physics about the same as other subjects.

[_____] I like Physics less than most subjects.

14. Which classroom activity do you prefer in Physics?

[_____] laboratory

[_____] discussion

[_____] lecture

[_____] small-group activity

[_____] writing time

15. Which classroom activity is your preference in other Science classes?

[_____] laboratory

[_____] discussion

[_____] lecture

[_____] small-group activity

[_____] writing time

16. Has anyone encouraged you to pursue science as a future career?

[_____] Yes

[_____] No

If yes, who? _____

Please supply a written response to the following questions.

17. With whom did you discuss the decision to take Physics?

_____

_____

_____

_____

18. Why are you taking Physics 10/20?

_____

_____

_____

_____

19. Has taking Physics helped you with any other subjects? How and which subjects?

_____

_____

_____

_____

20. How is taking Physics valuable to your education?

_____

_____

_____

21. What do you think are the reasons for a school to offer physics instruction in an all girls class?

22. What aspect of this class do you enjoy **most**?

23. What aspect of this class do you enjoy **least**?

24. What is the **most significant** difference between this class and other Science classes you are taking or have taken?

_____

25. Why do you think so many girls shy away from selecting Physics for a science class?

_____

_____

_____

_____

26. If you had to describe this class in **one word**, what would that word be?

_____

27. How do you think having a female teacher might make a difference to you?

_____

_____

_____

_____

28. Are there other subjects you would like to be taught in an all-girls class?

_____ If yes, which subjects?

_____

_____

_____

29. If you could change anything about Physics to make it better for you in anyway, what would you do?

_____

_____

_____

_____

30. What are your future working goals at this time?

Ideal Occupation: _____

Expected Occupation: _____

Thank you very much for taking the time to complete this questionnaire.

APPENDIX B

Student Interview Questions

1. When you first heard about this course, what did you think?
2. Were you in the all-girls Physics 10/20 class?
3. If yes, what was it like? If no, what was your class like?
4. Were you assigned this class or did you choose it?
5. What is it like being in this class?
6. What is one thing you think you will always remember about this experience?
7. Has being in this class changed the way you think about yourself or the world? Have you learned anything about yourself?
8. Can you describe your participation in this class?
9. What kinds of activities keep you interested in class?
10. In what ways do you best learn the content of Physics?
11. In this class, do you have a usual preference for working alone or in a small group?
12. Do you think girls and boys learn differently?
13. Is there anything you would like to add that would help me understand your personal experience about this class?

14. Is there a change you would like to see that would serve your academic and/or social needs as a female student in this school?
15. How does the concept of this class fit in with the feminist issues you have heard about?
16. Would you have taken Physics regardless of the class?
17. How do you think the guys view the whole idea of this class?