Female-friendly chemistry:
an experiment to change the attitudes of female cégep students towards applied chemistry

Catherine Gillbert

Administration and Policy Studies in Education

March 1995

A thesis submitted to the Faculty of Graduate Studies
and Research in partial fulfilment of the requirements
of the degree of Doctor of Philosophy

ISBN 0-612-05711-9

Shortened title:

Female - friendly chemistry

ABSTRACT

This experiment demonstrated that it is possible to use classroom intervention to change the attitudes of female college students towards theoretical and applied chemistry. A pilot study was used to test the experimental design, develop measuring instruments and obtain some preliminary information on the attitudes of college science students. The experiment was of the pretest, post-test, experimental, control group design with a total sample size of 204 students. The treatment experienced by the experimental group consisted of a modified curriculum that included information about topics found by the researcher to be of interest to women, information about how chemistry benefits human health and the environment, a laboratory manual containing profiles of prominent Canadian women chemists and visits by women chemical engineers. Regression analysis of the data showed a significant positive change in the attitudes of the female students in the experimental group (p<.05) and there was some indication that more of them were contemplating a career in the theoretical or applied physical sciences. The experiment indicated the importance of sensitizing college instructors to the needs of female students. A series of recommendations for college instructors and the Ministry of Education resulted from this work.

SOMMAIRE

La recherche a montré qu'il est possible de changer l'attitude des jeunes femmes du collégial quant à l'industries chimique. Pour établir la validité du matériel conçu en vue de l'expérimentation, mettre au point les instruments de mesure et connaître les attitudes des élèves inscrites en Sciences, nous avons eu recours à un projet pilote. Le groupe témoin comptait 204 élèves à qui furent administrés le prétest et le post-test. Aux élèves du groupe cible, nous avons proposé un contenu de cours modifié : on y trouvait maintenant de l'information que l'expérimentatrice jugeait propre à intéresser les étudiants et des données qui soulignaient l'apport de la chimie à la santé de la population et à la cause de l'environnement. Le cahier de laboratoire dont se sont servi les élèves présentait le profil de Canadiennes ayant choisi le domaine de la chimie pour y faire carrière, et des femmes ingénieures en chimie vinrent rencontrer le groupe. L'analyse subséquente des données a montré un changement significatif ($p<.05$) des attitudes dans le groupe expérimental. Les étudiantes voyaient maintement la chimie d'un meilleur œil; certains indices révélaient même que le nombre de candidates qui envisageaient une carrière en génie ou en sciences avait augmenté.

ACKNOWLEDGEMENTS

First of all, I would like to express my deep appreciation to Dr Margaret Gillett of McGill University. Her patience and good humour sustained me in my research and she provided invaluable guidance in the preparation of this document. I would also like to thank the members of my committee, Dr David Harpp, Dr Gillian Riskind and Dr Mildred Burns, all of McGill University, for their assistance and, in particular, Dr Elizabeth Henrik of Concordia University for her detailed and thoughtful comments. I would also like to acknowledge the contribution of the members of the Chemistry Department of Champlain College, St. Lambert for participating in the study. Thanks are also due to Fouad and Sammi Assaad for their aid with the statistical analysis, Michèlle Konstantinov for her translations and Suzanne Coulomb and Judy Ferlatte for putting the final draft together. Finally, I would like to thank Gordon Hebert without whose encouragement and editing skills this dissertation would not have been completed.

TABLE OF CONTENTS

TABLE OF TABLES

DEFINITIONS

Attitude

A literature review by Fishbein and Ajzen (1972) found more than 500 operational definitions of "attitude" and they claim that, to some extent, the results of attitude research can be interpreted differently depending on the definition employed. Eagly and Himmelfarb (1978) and Rajechi (1982) define attitudes as "relatively long lasting feelings, beliefs, and behavioral tendencies directed towards specific persons, ideas, objects or groups". This definition will serve for the purposes of this research.

Attitudes towards science

Recent works on attitudes to science discuss the confusion that has existed in much of the earlier literature between "scientific attitudes" and "attitudes to science" (Schibeci, 1983, Munby, 1983a, 1983b; Zeidler, 1984; Koballa, 1985). These authors define attitudes to science as a "system of beliefs about science held to be true". It is this definition of attitudes that this research is concerned with; it is not concerned with whether or not students understand the premises upon which science as a discipline is built.

Achievement in science

In the literature "achievement in science" is defined in various ways, everything from scores on standardized tests to grades and passing courses. Where possible the author has used the term "ability" to denote what is measured by standardized tests and the term "achievement" to denote the grade level obtained for obtaining grades or passing courses. For example, women students in Quebec are not well represented in the first percentile on standardized tests (they have lower levels of ability as measured by standardised tests) but on average obtain higher grades, that is, they have higher achievement.

Nontraditional

For the purpose of this dissertation a "nontraditional" area is considered to be one in which women represent less than 33% of the total number of individuals active in that field.

Curriculum

Curriculum has been defined in several ways. Narrowly it is the texts, workbooks and materials used in the class; more broadly, it can be defined as the world of the student. The definition that perhaps best describes the chemistry curriculum at the cégep "is the planned experiences provided by the institution to obtain learning outcomes to the best of the student's abilities" (Neagley and Evans, p.2).

CHAPTER 1: INTRODUCTION

In the last three decades the lack of women in the theoretical and applied physical sciences in industry, universities and colleges has been recognized as an important issue by many academics, business people, government officials, economists and feminists. A recent report by a Commission of Inquiry into Canadian Universities (Smith, 1992) is the latest in a long line of reports that describes the problem. The Smith report finds that, while there is no evidence of deliberate barriers to the entry of women into the theoretical or applied physical sciences, the reasons lie deep in Canadian culture. The report states that,

> in the early teens, young women appear to turn away from courses in mathematics and natural sciences, possibly because they are perceived to be unrelated to people and to everyday life, matters of great interest to young women at that age. The lack of female role models ... and the remnants of traditional differences in and the remnants of traditional child-rearing practices are ... the main contributors to the problem" (p. 101).

The report recommends a new approach to the teaching of science as one of the ways of addressing the problem. This recommendation is supported by the Association of Universities and Colleges of Canada (1992) which believes that universities should continue in their efforts to increase the numbers of women by creating a more hospitable environment for them.

Women students in Canadian universities in 1989-90 accounted for less than 25% of full-time undergraduate enrollment in mathematics and the physical sciences and only 15 % in engineering and the applied sciences (Secretary of State, 1992). This is despite the fact that for the same year 53% of full-time undergraduate students in Canada were women. Although there was a rapid increase in the number of women entering these nontraditional fields of study in the 1970's there has been a marked levelling off during the past decade (Secretary of State, 1990). According to Uhl and MacKinnon (1992), it will take generations to over-come the inequalities resulting from stereotyping in Canadian society. The situation in the United States, often an indicator of what will occur in Canada, is similar. The percentage of women in engineering has stabilized at about 17% and, if anything, appears to be declining (McMiller, 1987).

With the current rate of participation of women in the theoretical and applied physical sciences at the university level, we must question whether the universities are adequately responding to the needs either of Canadian society in general or the needs of women in particular. Piper (1983) identifies three functions of higher education within a society: to meet the needs within that society for qualified personnel, to retain and develop the cultural values within a society, and to carry out a social service function, that is, to allow the individual the chance of self-improvement and self-actualization. He maintains that the lack of women at all levels of university life from the undergraduate student to faculty and senior administrators both seriously impedes the effective functioning of society and prevents individual women from achieving either financial or social equality.

<u>The consequences for society of the lack of women in the physical sciences</u>

The Science Council of Canada (1982) documents the difficulty Canada will have in maintaining its technological development if it does not utilize the best brains available in the fields of scientific research and development. Assuming women are as able as men, then our faculties of science and engineering should have equal representation of male and female students. This concern has been reiterated by the business community in Quebec (Conseil de la Science et Technologie, 1986) which requested the Ministry of Education to address the problem; in 1989 a similar sentiment was expressed by the Ordre de l'Enginieur du Quebec (Gagnon, 1989).

Perhaps, not only the economic well-being of Canadians but the survival of society as we know it, depends on more women having access to careers in the theoretical and applied physical sciences and thus having a chance to join the scientific elite which to a large extent controls the direction of scientific research and development. Marsha Hanen, president of the University of Winnipeg, is frequently asked to address groups on women in science and engineering. She believes that the most important reason for increasing the participation of women in science and engineering is the special contribution they can make in these areas. She believes that the participation of more women in science and technology will result in new ways of thinking about the fields and "may be transformative in ways that will lead us to solutions to some of society's economic and social problems" (Hanen, 1990 p. 48). Ursula Franklin, who, now retired, was a professor of engineering at the University of Toronto, reiterated this theme in the Massey lecture series for the Canadian Broadcasting Company (CBC) in 1990. She feels that men and women see the world differently; while men attempt to maximize gain, women attempt to minimize disaster. She, therefore, is convinced that female technology will be less hazardous and more "people-friendly" (Franklin, 1990).

The consequences for women

The lack of representation of women in the theoretical and applied physical sciences results in three distinct ways in which women do not have equality in our society. The first way is financial; many writers maintain that the mass entry of women into science is a way to redress the low socio-economic status and high levels of poverty amongst women in Canadian society. The Conseil du Statut de la Femme (1976, 1985) documented the situation of women in the Quebec workforce and their tendency to occupy poorly paid jobs in the "pink collar ghetto". These studies advocate government action to encourage women to enter non-traditional careers. The Quebec business press supports this course of action (Morazain, 1985). Devereaux (1976) and Fuchs (1985) cite the low participation rates of women in science and engineering as an explanation for the lack of women in highly qualified jobs and the fact that the salary and job satisfaction of female graduates is lower than that of males. In a recent survey by the Government of Quebec, five of the top ten growth areas for careers in the year 2000 are in the applied sciences. It would seem that the economic well-being of more women will be improved in the next century if more women are encouraged to study science.

The second aspect of equality encompasses the idea of women having equal access to knowledge and, therefore, to the powerful positions where the decisions that affect the political and cultural future of our nation are determined. A report by Status of Women, Canada on the participation of women in science and math states the following:

> The greatest benefits of equality are derived when all Canadians are equipped with the knowledge and skills to fully participate in a democratic society. Equality (and, concomitantly, social justice and fairness) is an evolutionary process which changes with the development of social roles (Status of Women, Canada, 1989. p. 1).

Kelly (1987), after a lengthy review of the feminist literature of science, describes science as a game played to rules established by white middle class males which ensure their success in the field; it is also a tool used by a white male elite to exploit the rest of the world including women.

With the development of ever more powerful technologies and, thus, the increasing influence of technology over our lives, it is evident that those who can understand science and can control the direction of future technological development will ultimately be part of the power elite. For women to have equal access to power they must, therefore, have access to science.

A third important aspect of equality is inherent in the right of women to have a sense of excitement and purpose in their lives. Many people, including women, have found pleasure and a sense of purpose in the study of science (Gornich, 1983). The writings of many well known women scientists are imbued with the excitement of making original discoveries and reaching new levels of understanding of natural phenomena. This is evident from the biographies of two great women scientists, Marie Curie and Barbara McClintock. Marie Curie was one of the discoverers of radioactivity, who did her best known research in the last years of the nineteenth and the early part of this century and was awarded Nobel Prizes in both physics and chemistry. Having concentrated a residue from pitchblende

> she threw a sweater across her shoulders and rushed to the nearby laboratory of Eugène Demarçay with the day's results...Demarçay could positively identify an element because no two were alike...The element in the vial was unknown" (Pflaum, 1989, p.70)

This unknown element was radium and its discovery led Curie to her most important discovery, that radioactivity was a nuclear phenomenon. Barbara

McClintock, also a Nobel laureate, is a cell geneticist who was working in the 1950's on the transposable elements of DNA and the significance of whose work was not accepted until twenty years later. Her excitement in her own scientific discoveries can be felt as she describes her own work.

> When the first plant was ready, my hand was actually shaking when I opened up the plant to get out the material to be examined. I took it right back to the lab and examined it immediately. It had rings and was doing exactly what it was supposed to do... (Keller, 1983, p.67).

Surely women as much as men have a right to the sense of accomplishment that can be had from successful scientific research. As implied by Bournival (1986), many Quebec girls are deprived of this satisfaction.

<u>The situation of women in sciences within the Quebec educational system</u>

The situation as regards the number of women students in the theoretical and applied physical sciences in Quebec universities is similar to that in the rest of Canada. As elsewhere, the numbers have shown a steady increase but at the current rate of women entering nontraditional careers it will be the year 3000 before equality is reached (Berthelot, 1986). A significant difference between Quebec and the rest of Canada lies in its post-secondary educational system, which in itself has consequences for female students.

Quebec students, who are university bound, spend six years in elementary school, excluding kindergarten, and five years in high school. After obtaining a high school diploma, a Quebec student must attend a College of Professional and General Education (cégep) before entering university. A general diploma requires two years (four semesters) of study before a student can obtain a college diploma (a DEC) and then attend a university. The success of female students in the science program in the cégeps is, therefore, crucial to their entering science at the university.

A brief historical background to the establishment of the cégeps

The cégeps were established in June 1967, when the Quebec legislature enacted Law 21, the Colleges Act, that allowed for the creation of cégeps as legally established public corporations. The creation of the cégeps was just one of the recommendations of the Royal Commission on Education, better known as the Parent Commission after its chairman, Monsegneiur Parent. The establishment of the cégeps has given women unprecedented access to post secondary education and is the most important reason for the increasing level of educational equality within the Province. However, barriers to educational opportunity still exist for women within the cégeps. Both the accessibility to nontraditional programs and the attitude of the colleges towards women pursuing careers in the theoretical and applied physical sciences still require changes.

Prior to the establishment of the cégeps, university-bound, francophone, secondary school graduates attended a collège classique for three years before attending university. The collèges classiques were run by the Catholic Church and most of the teaching staff were clerics. The emphasis was to train young men for the priesthood and the professions including law and medicine; little importance was attached to the teaching of science and lack of adequate financial resources for the construction of well-equipped laboratories further hampered good scientific education (Magnuson, 1988). Anglophone students, most of whom attended Protestant schools, could attend McGill or Bishop's Universities at the end of Grade 11. Thus, they could receive a Bachelor's degree three years prior to their francophone counterparts.

Post-secondary education for francophone girls in the province prior to the establishment of the cégeps was limited; even secondary education was limited to the major centres. However, anglophone girls had the opportunity to attend McGill University from 1884. The Medical School associated with Bishop's University opened its doors to women in 1886, however, in 1905 it became part of McGill University which did not accept women into medicine until 1917 (Gillett, 1981). Bishop's University did not allow women to enter its other faculties until 1903. Sir George Williams College, from its founding in 1926, admitted women and, thus, women were part of the

College when it became a degree granting institution in 1937. Loyola

College, a Jesuit institution, which combined with Sir George Williams University to form Concordia University, did not accept women until 1959. On the other hand, francophone women, like their male counterparts, who wished to attend the University of Montreal or Laval first had to attend a collège classique. By 1960 there were five collèges classiques for young Catholic francophone women and one for anglophones. The first collèges classiques for women, Collège Marguerite Bourgeoys, was established in 1907. The initiative came from nuns and was encouraged by the women of the Societé St. Jean-Baptiste who saw the need for the education of middle-class girls. The collèges classiques for girls were established as a result of changing social patterns amongst urban, middle-class girls. Many young girls were touring Europe after their graduation from the convents. The girls were aware of their lack of education compared with European women and their difficulty in appreciating the richness of the culture. As a result, parents were considering sending their daughters to colleges in Europe or the United States or to McGill University to finish their education. It was feared this would lead to a loss of their essential québecois culture and roots. It was in response to this trend that Collège Marguerite Bourgeoys was founded in 1907 (Saint-Stanislas-de-Jesus, 1974). Establishment of the College and its affiliation with the University of Laval did not stop the public debate. Most of the clergy were opposed to the experiment as they believed it would turn the girls away from marriage and family life. Public opinion seems to have considered the schools an "extravagance pédantesques" (Galarneau, 1973). It is not surprising, therefore, that it was 25 years before the next college for girls appeared. Collège Sainte-Anne was established in Lachine in 1932 and in its records we find a comprehensive list of reasons for its founding. Among them are the demand of girls for further education, the need for a trained elite to act as teachers in secondary schools and the fear that the girls would enter a lay institution, namely McGill University.

Despite the fact that many writers consider the publication of the Parent Report (1963-1967) one of the most significant acts of the "Quiet Revolution", the time of rapid social, economic, political and cultural change that took place in Quebec during the 1960's, it is more accurate to regard this report as the culmination of ten years of questioning of Quebec's educational system by its intellectual elite. Ten years earlier, the Government of Quebec had established a Royal Commission of Inquiry into Constitutional Problems (the Tremblay Commission). Although, as the name implies, the Commission was mandated to investigate constitutional problems, the majority of the briefs presented to it related to education (Burgess, 1978). In a brief to the Royal Commission on the Constitution, the Tremblay Commission, a representative for the women's colleges recommended increased funding so that they could hire more qualified teachers, especially science specialists, which the religious orders could not provide (Saint-Stanislas-de-Jesus, 1973).

Further impetus for educational change came from many sources, three of which should be mentioned here. The first was the influence of the Faculty of Social Science at the Université Laval. Under the deanship of Father Georges-Henri Lévèque, an outspoken critic of the Union National Government of the time, many of the leaders of the Quiet Revolution were inculcated with the belief that a secular system of education is necessary in order to develop a modern industrial and democratic society. These included Jean Lesage, the leader of the Liberal Party of Quebec during those important years and Pierre Elliot Trudeau, who came to prominence as a result of his support of the workers during the asbestos strike of 1963 (Burgess, 1978). The second influence was the publication of Les insolences du Frère Untel, a run-away best-seller of 1960, written by an anonymous cleric who was later known to be Jean-Paul Desbiens, a young Catholic teaching brother. This work criticised the Catholic Church for influencing the public towards conformity, security and obedience to the church (Gillett, 1966). A third factor was Le mouvement laïque de langue française that was calling for the establishment of a non-sectarian school system. Its publications attacked the backwardness of the school system and called for division along cultural rather than religious lines (Leblanc, 1972).

The problems facing the reformers of the Quiet Revolution were to expand access to post-secondary education, to re-orient post-secondary training towards science, business and technology and to harmonize the French and English systems without causing chaos throughout Quebec society or igniting unassailable opposition from the church and political elites. The proposed solution, the establishment of the cégeps, according to Henchey and Burgess (1987) "was bold, imaginative and rational, with all the strengths and weaknesses which these characteristics bring to a public policy" (p. 100).

There was also at the time a system of training colleges open to young women which included nursing schools, secretarial colleges, and institut familiaux that trained girls in the arts of becoming a good wife. (For a history of these institutions see Thiverge, 1983). Following the implementation of the recommendations of the Parent Report, these, like the collèges classiques, were integrated into the cégeps. Teacher training schools, known as normal schools, were, on the other hand, integrated into the universities.

There is little discussion in the Parent Report about making education in Quebec coeducational. Briefs by women's groups to the Parent Commission recommended coeducational schooling as a way to ensure that girls had equal access to text books, trained teachers and science courses, amongst other things. (See for example the brief presented to the Parent Commission by the University Women's Club of Montreal (1974)). The Commission's response was that, since there is no evidence that mixed classes are harmful to boys, it recommended that all public educational institutions, including the cégeps, become coeducational (Province of Quebec, 1967). It would appear that educational equality for women had been realized.

<u>The current situation of women in the cégeps</u>

By 1989, 54% of cégep students were women. They passed their courses more frequently than their male peers (Corriveau, 1991), so that, as far as providing women with access to post-secondary education, the cégeps have been successful. However, as early as 1972, only five years after the founding of the cégeps, it was evident that females were overly represented in programs that led to careers in the humanities and the social sciences and that they were less happy than male students with the courses in which they were enrolled (Favreau, 1972). A more recent study of the situation in the cégeps reached the same conclusions (Rheaume, 1985). Women are under-represented in the programs training students for such careers as electricians and mechanical technicians; women still cluster in the traditionally female disciplines of social science, health science, nursing, secretarial science and early childhood education. Reflecting the society which created them, the cégeps have reinforced the gender differences within Quebec.

In 1988, 45% of cégep students in the Natural Science Program were female and they pass their courses more frequently than the male students (Rouleau, 1985). However, on graduation, the majority of female students choose to enter the universities in the biological or health sciences or they leave the sciences altogether. Only a small minority chose to continue their education in the physical or applied sciences. At Champlain College, St. Lambert, Quebec, where this research was carried out, the number of women in the science program is almost equal to the number of men, however, the vast majority of these women are planning careers in the health sciences or in fields unrelated to science (Gillbert, 1988).

The organization of the dissertation

The second chapter of this dissertation is a review of the literature of attitudes and attitude change with reference to science. The following chapters describe the background of the study followed by a chapter that describes the methodology of the experiment. This is followed by the results of the study and a discussion of these results.

CHAPTER 2: LITERATURE REVIEW

Attitudes and their measurement

Social psychology has been called the study of attitudes and, certainly, research into attitudes has been one of the major focuses of this discipline since it was first developed at the beginning of this century (McGuire, 1985). According to Allport (1935), attitudes are central to the discipline of social psychology since they influence all our behaviour. It is appropriate, then, that research into gender differences in science should focus on gender differences in attitudes to science, on the consequences of these attitude differences and on efforts to change females attitudes to science.

There seem to be two distinct ways in which attitudes are learnt from others: instrumental conditioning and social learning. Instrumental conditioning is based on the principle that individuals learn to perform actions that yield positive outcomes and avoid actions that yield negative results. Early childhood upbringing, brain-washing and religious cult conversions are examples of instrumental conditioning (McGuire, 1985).

Social learning theory, one of the most important of the psychological theories that attempt to explain attitude development, is based on the work of Bandura (1971), who postulated that our personalities are formed primarily through learning from other members of society. He believed that imitating or modelling the behaviour of others plays a major role in human learning, especially when it comes to learning appropriate sex roles. As children grow they learn to carry out two types of analyses that will determine how they will act in a given situation. They learn to generalize, that is, they learn to anticipate reactions to certain behaviours. They also learn to discriminate, they are able to judge that the same behaviour will result in different reactions in different circumstances (Mischel, 1976). For this reason there is a wide variety of human behaviour, since experiences of individuals differ widely (McNeil and Rubin, 1977). Social learning theory stresses the vicarious reinforcement obtainable from imitating others, adopting their thoughts, empathizing with their feelings and matching their behaviours (Johnson, Cheek and Smithers, 1983). Frequently the model does not intend that his or her behaviour be copied; nevertheless, behaviour acquired by imitation is powerful and exerts a long-lasting effect on attitudes (Baron and Byrne, 1984).

Social learning can occur through social institutions. In the early years of life, the family is the most influential social institution and as a result young children tend to express views that reflect the attitudes held by their parents (Zern, 1983). Later the peer group, the school, the media and other institutions replace the family as the major influence in the acquisition of attitudes.

There is a considerable body of evidence which indicates that, as a result of societal pressures acting on them, especially through their adolescent years, girls acquire attitudes different from those of boys to many attitude objects. There is also some evidence that girls are more influenceable; McGuire (1987), suggests that this is because they are taught to conform in their early years. Among these gender differences in attitudes is girls' more negative attitudes to the physical sciences.

It is reasonable to assume that many of the attitudes to science held by young women have been developed through social learning. From the portrayal of women in the media, from the attitudes of close friends and family and, unfortunately, from teachers and counsellors within their schools, they learn that careers in the theoretical and applied physical sciences, the so called "hard" sciences, are only intended for men. As we will see later, most of the attempts to change young women's attitudes to science rely on providing them with the chance to directly experience science, the attitude object.

One of the most difficult problems encountered in the study of attitudes is their measurement. Only if attitudes can be successfully measured is it possible to test theories of attitude development or know if attitudes have changed. The various methods designed to measure attitudes can be divided broadly into three groups: those that are based on written questionnaires that solicit opinions from respondents and then use the answers from the questions to assess the attitudes of the respondents (these are sometimes referred to as psychometric techniques), those that infer attitude from overt behaviour and, thirdly, those methods that use physiological responses to determine attitudes. Almost all the literature on the measurement of attitudes to science is based on the use psychometric measurement techniques. A few studies also infer attitudes to science from the number of science related activities a subject engages in or the number of science courses taken.

The psychometric measuring instruments commonly used in educational research are of four types the Thurstone, Likert, Guttman and semantic differential. The semantic differential scale can be differentiated from the other three since it consists of a set of bipolar, evaluative adjectives, e.g. good-bad. The respondent is asked to position an attitude object on this scale. The Thurstone , Likert and Guttman scales view an attitude as existing along a continuum. A sentence referring to the attitude object is written above the scale. The midpoint in the continuum represents change in direction with the midpoint frequently representing "don't know". The distance from the midpoint in either direction represents intensity. Guttman scales are cumulative; a positive response to a sentence positioned somewhere along the response continuum implies a positive response to all statements to the left of that statement on the continuum. Thurstone scales are non-cumulative; the assumption is made that positive responses should cluster around a point on the continuum. Likert scales can be differentiated from the other two as they ignore positions close to the midpoint and ask the respondent to commit themselves to a definite response or else "don't know". All these four types of scales have been used to measure attitudes to science with the Likert scale being used most frequently (Keeves 1988).

The largest study of instruments for measuring attitudes to science was carried out by Munby (1983a). He analyzed all the instruments cited in the literature between 1967 and 1977, 56 in all. His general conclusion was that there are many problems with research in this area and much improvement is needed before meaningful comparisons between studies can be made. He thought that, for many of the instruments, both the reliability and the validity were definition of attitudes to science. Researchers seemed to define attitudes to science as everything from "scientific attitudes, through attitudes to science courses and activities, to career and interest preferences" (p.141). He recommended that "all of the following pass as legitimate attitudinal targets: scientists, scientific courses, the difficulty of science, financial support of science, control of science, scientific knowledge, science teachers and so on" (p.142). Unfortunately, nearly a decade later, things are no clearer. There are still no widely accepted instruments, merely a multiplicity of instruments.

Gender differences in attitudes to science

For the purpose of this dissertation, attitudes to science is defined as "a system of beliefs about science held to be true". Since, however, many of the researchers into attitudes to science fail to make their definitions clear, we cannot always be sure what precisely is being measured and discussed in the literature. Discussion, therefore, of gender differences in attitudes to science is only as valid as the measuring instruments used to measure these differences. The research studies summarized here used internationally accepted instruments.

Research into the causes of gender differences in attitudes to science focuses on five distinct areas: 1. girls' lower achievement in mathematics and science and the relationship between achievement and attitudes, 2. girls' lack of science related activities, 3. girls' image of science, 4. girls' negative experiences in the science classroom and 5. the absence of female role models.

Girls' lack of achievement in mathematics and science and the correlates with attitude

Steinkamp and Maehr (1983) in a review of research in this area carried out a quantitative synthesis of fifty empirical studies. They concluded that affect is more strongly related to achievement level than to cognitive abilities. They further suggest that a positive feeling towards science is more likely to develop as one succeeds in science subjects and suggest that efforts should, therefore, be made to ensure higher achievement levels for girls. Recent work in this area indicates that science attitudes, science achievement and science participation are interrelated and are still the best explanation of gender differences (Haggerty, 1991).

It has been argued that, since mathematical ability, mathematical achievement and attitudes to mathematics, which are usually related, are the most reliable predictors for the success of students in science, girls' inferior performance in mathematics is the best explanation for the lower participation rates of girls in science. (For an example of recent work in this area see Maple, 1991.)

Mathematical ability

Maccoby and Jacklin (1974), in their classic study of the research into gender-related differences, concluded that there was a well-established statistical difference in the mathematical reasoning and problem-solving ability of males and females. The attempt to find an explanation for these differences, however, has created a heated debate in the scientific literature for the past fifteen years which shows no evidence of being resolved. (See for example Schafer and Gray, 1981, and Baringa, 1991.)

Researchers on this subject can be divided broadly into two groups, those who believe that mathematical ability is genetically determined and that males have a predisposition towards superior ability, and those who believe that mathematical ability is culturally determined and that it is girls' upbringing that results in their lower levels of achievement.

In many studies, two abilities that have been shown to correlate with performance on tests designed to measure mathematical reasoning and problem solving abilities: visual-spatial ability and field independence. Visual-spatial ability is the capacity to relate a drawing or diagram in two dimensions (for example a map) to a three dimensional object or world. Field independence is the ability to see and analyze a shape independent of its surroundings. The usual way to measure field independence is with the rod-and-frame test in which a subject is seated in a dark room facing a luminous rod inside a luminous frame; both are tilted to the vertical and the subject is asked to adjust the rod to the true vertical.

Many researchers have attempted to provide biological explanations for gender differences in performances on these two types of test. Those who believe that these traits are biologically determined attempted to demonstrate that levels of ability in mathematics are linked to the X- chromosome. Stafford (1961, 1972) established a link between superior mathematical ability and the X-chromosome by an analysis of spatial visualization and mathematical reasoning as determined by standardised tests of mothers and sons. Using dichotomic analysis, he found that, although the two tests had some variance in common, the scores of mothers and sons on these tests indicated an independent heredity unit on the X chromosome. Benbow and Stanley (1980) claimed that visual-spatial ability is biologically determined and linked to the X-chromosome and that it is this ability that assists in mathematical reasoning and problem solving. A further study by Beckwith and Durkin (1981) concluded that male superiority in spatial tasks is probably an expression of a combination of both endogenous and exogenous variables. Gray (1984) supports the idea that differences in mathematical ability are biologically determined and applauds the difference as adding variety to life, adding "Why would one try to change this?"

On the other hand, Fennema and Sherman (1977) and Sherman and Fennema (1978) concluded from a literature review of studies in this area that the X-linked recessive hypothesis of spatial visualization ability was never strongly supported and their studies disputed the hypothesis that there is a genetic component to spatial-visualization ability. They believed that the evidence for the X-linked theory was based on small sample size and inaccurate analysis. They found that socio-cultural factors are a better indicator of mathematical reasoning and visual-spatial skills and that gender differences are in turn due to different early experiences of boys and girls particularly in their play experiences.

Later research into biologically determined differences focuses on the differences between the male and female brain and whether this is one way of accounting for differences in ability. Weber (1977) showed that there is a positive correlation between spatial ability and the degree of lateralization of the brain, which he maintained could account for females' poorer performance in this area. This finding has not, however, been consistently supported since both Gur (1982) and Deutsch (1988) were unable to duplicate these results.

The latest research in this area focuses on hormonal differences during fetal development as the cause of differences in left and right brain development and, thus, in differences in abilities, particularly those related to visual-spatial tasks and mathematical reasoning. Much of the work in this field is based on animal studies where we know that early exposure to increased levels of testosterone in the foetus results in gender differences in the pathology of the brain. Researchers then extended this evidence to humans based on two pieces of evidence. Firstly, the higher level of left-handedness amongst males which could be due to increased right hemisphere development. Secondly on autopsies of male homosexual and heterosexual brains, which showed that the hypothalamus of male homosexuals were similar in size to those of women rather than those of heterosexual men (Geschwind and Galaburda, 1987, and Baringa, 1991). Hyde (1990), on the other hand, in a meta analysis of 16 studies on quantitative ability, 10 studies on visual spatial ability and 20 studies of field articulation (the rod and frame test) concluded that, although cognitive differences between male and female students exist, they are very small and tend to account only for between one and five percent of the population variance. She maintained in an interview with Holden (1991) that since "the gender gap in test scores is waning we've come to question the very existence of the phenomenon that the brain theories were constituted to explain" (p.959).

The evidence that gender differences in mathematical abilities result from environmental rather than biological differences focuses on two different areas: difference in modes of thinking between males and females and lack of self-confidence in females. Maccoby (1970) attributed males' superior ability in mathematics to a different mode of thinking resulting from independence at an earlier age. This evidence is based on cross-cultural studies that relate field-independence to early experience of the outdoors, as opposed to being kept close to mother.

Mura (1983) in a study of the mathematical abilities of Quebec high school girls demonstrated that gender differences in this discipline can be attributed to different socialization processes. These result in girls believing that mathematics is not for them and that they do not have the ability to study the subject; they lack self-confidence. This conclusion was supported by more recent work by Mura, which showed that girls have a lower perception of their own abilities in mathematics than do boys, despite the fact that they perform better in courses (Mura, Cloutier, Kimball, 1985 and Mura, 1985). A recent study (Blair, 1993), carried out in three Alberta universities, looked at the qualities and attitudes of female students who persist in mathematics at the university level. The study showed that females who persist in mathematics tend to be more confident, have a high level of determination to succeed in a difficult field and were encouraged by parents to attempt a non-traditional career.

Further evidence that the gender gap in mathematical ability is culturally determined is found in the fact that, as the upbringing of girls is changing, the gap is closing. Willms (1990) indicates that the gender gap in mathematical ability among young people in British Columbia is declining and this supports the idea that the achievement differences can be attributable to social factors. The Educational Testing Service (1989) reports similar findings from the United States. According to its analyses the performance differences are slowly declining, but girls still lag behind in some aspects of spatial ability and in achievement at the top levels of mathematics. Results of female students on the Graduate Record Examinations (GRE) and the Scholastic Aptitude Test (SAT) still show female students scoring on the average 30-34 points below men on the GRE and a similar difference on the SAT. According to Chamberlain (1992) these differences can be explained by a difference in the number of mathematics courses taken by male and female students, the larger number of female students who take these exams, the higher percentage of women test-takers who are members of minority groups and differences in the type of high school attended. She claims that, if allowance were made for these factors, achievement on the tests would be the same for men and women.

Perhaps the best argument against biological determinism is provided by the experiments carried out to improve spatial-visualization abilities in students. If this ability is entirely genetically determined it would not be possible to improve it significantly with practice. Witkin (1948) showed that spatial-visual perception, which he called space orientation skills, improved for a group of engineering students over the course of a three year engineering program and that students with the least previous exposure to these skills improved the most. Blade and Watson (1955) reported similar results with a group of male engineering students. Brinkmann (1963a, 1963b) used a programmed learning instruction approach with a class of elementary school children using a matched control group with a pretest, post-test type experimental design. By teaching the class traditional geometry he was able to improve the spatial-visualization scores of the experimental group. Allaire and Pallascio (1987) worked with a group of children in an elementary school in Longueuil, Quebec. Using both styrofoam models and a computerized instruction program, they were able to improve the spatial-visual ability of their experimental group compared to a control group. These limited experiments seem to show that students' spatial- visual skills can be enhanced through practice, thus providing evidence that these skills are not entirely genetically determined.

Attitudes and ability

Kelly (1978) analyzed data from the first International Science Survey (ISS), sponsored by the International Association for the Evaluation of Educational Achievement (IEA), which surveyed ten year old children, fourteen year old children, and pre-university students in nineteen countries in 1970. Kelly found that gender differences in scientific knowledge and problem solving ability exist at all levels and in all countries; the least difference was between the ten year old boys and girls and the most between the pre-university students. Her results do not, however, support the idea that girls achieve less well than boys in science simply because society does not encourage or expect girls to achieve. She found that the differences in relative achievement between the sexes in a particular society did not necessarily correlate with that society's attitudes to women in science. For example, in Hungary, where women are well represented in university science and engineering programs, the highest percentage of girls were found in the top five percent at all age levels. On the other hand, Japan also had a high percentage of girls in the top five percent, yet women in engineering and science programs at the university in that country are rare. Kelly found that gender differences are reduced when most of the material tested for has been explicitly taught, thus minimizing the effect of extra-curricular learning. Girls also did better when they took as many science courses as the boys. There was also preliminary evidence to indicate that girls perform less well in science because girls have less favourable attitudes to science.

Hobbs (1980), reporting on the results of the ISS in British Columbia, concluded that boys perform better than girls in concepts and applications in the physical sciences and that girls participate in fewer mechanical investigations in the home. While reviewing this study, Erickson and Erickson

(1984) discussed evidence for biological determinism as a cause of girls' lower scores on standardised tests. They suggested, however, that these results could best be explained by socio-cultural factors in a girl's background, which can be minimized by appropriate educational strategies. This conclusion supports previous work by Erickson (1981).

The largest study of science achievement and attitudes implemented in Canada was the latest IEA study, the Second International Science Study (SISS), which was carried out in 1984. Tests to measure students' ability in, and attitude to, science were carried out in all Canadian provinces. The study concluded that there were significant differences between boys and girls in their attitudes to science and in their perceptions of their own abilities in science. These differences increased with age, and tended to correlate with an increasing difference in achievement (Connelly, Crocker and Kass, 1988).

Many other studies have shown a correlation between attitudes and achievement in science. Sandermann (1979) reported on a study of 158 students in schools under the Ottawa Board of Education. She found that boys achieved higher grades in grade twelve science and that these grades correlated better with their marks in grade nine than did the girls, who achieved lower grades in grade twelve and for whom their grade nine marks were no longer an indicator of success. She also found a significant difference in the number of boys and girls enrolled in grade twelve physics and chemistry. She attributed the problems to sex role stereotyping within the schools, manifested, among other things, in gender-biased counselling.

Recent studies from the Netherlands (Alting and Pelgrum, 1990) and Sweden (Engstrom and Noonan, 1990) show that gender differences in attitudes and achievement persist among high school students in these countries but, once again, the authors explain the differences as a result of sex-role stereotyping.

Recent studies of girls and boys in the United States show no significant differences in attitudes to, or achievement in, science at the elementary school level (Shaw and Dean, 1990, and Blosser, 1990). It is only in the later years that the differences manifest themselves. Since earlier studies from the United States (Kelly, 1978) showed a gender gap in attitudes to science amongst students in elementary school, we might conclude that the gap in achievement as well as mathematical abilities is closing; however, since the instruments in the two studies were very different, this conclusion is not necessarily valid. It is worth noting, however, that using the 1990 data, it would appear that differences in attitudes and achievement in science in the United States occur at the same age as a loss of self-confidence in girls. This is supported by studies by Crandall (1969) and Dweck (1976) who have shown that girls tend to have less confidence in their ability to solve test items and, therefore, have lower expectations of success. A nationwide poll of American elementary and high school students funded by the American Association of University Women (1991) discovered a severe drop in self-esteem in girls during their high school years. The survey finds a strong relationship between performance in mathematics and science and adolescent self-esteem for both boys and girls. As girls learn "they are not good at these subjects their sense of self-worth deteriorates" (p.12). According to the study, most girls who dislike science say science is "not interesting" while boys who dislike science are more likely to discount the importance of science. The authors conclude that success at mathematics and science, and a girl's level of self-esteem and confidence to choose a challenging career are causally related.

Recent studies from Thailand (Klainin, 1989), where women scientists are not common, show that girls are "overachieving" in both physics and chemistry in grades 10 through 12 in that country; however, no information is available about the attitudes of these girls to science.

In summary, a survey of the literature of the relationships between ability achievement and attitudes to science, demonstrates that, when girls exhibit a lower level achievement in science, the phenomenon can best be explained by factors in their upbringing rather than by their inherent lack of ability. It suggests that as girls reach adolescence there is societal pressure on them not to perform in traditionally masculine fields, at the same time their level of self esteem falls and they soon believe that they are no longer capable of mathematics and science so earlier negative attitudes are reenforced. It also appears that North American society is in a time of rapid change; girls' levels of achievement in science are approaching those of boys and at the same time their attitudes are becoming more positive despite the fact that they are still outperformed by boys on certain measures of mathematical ability. In some cultures in which women are not necessarily valued for their contribution to science and technology, girls have equal or higher levels of achievement to boys. It appears, therefore, that the relationship between achievement and attitude is extremely complex and culturally determined but we can assume that as more girls are encouraged to perform in science more of them will achieve high grades and the more positive will be their attitudes.

<u>Attitude and achievement resulting from fewer science related activities</u>

Many of the studies of the relationship between attitudes to science and achievement have shown that girls have fewer science related hobbies than boys, except in the biological areas where they have as many pets 1977). Kahle and Lakes (1983) found that girls in the United States between thirteen and seventeen expressed interest in, but did not engage in, as many science related activities as boys. In the United Kingdom Smail, Whyte and Kelly (1982) showed that girls were less likely to play with a chemistry set and, in

Canada, Hobbs and Erickson (1980) showed that more girls than boys had never successfully designed and carried out their own scientific experiment. Before assuming that this indicates that girls have a more negative attitude to science, we should remember the warning of Koballa (1985) that it is important to distinguish between behaviour such as watching science related programs on television or reading science magazines, and attitudes to science. However if we assume that attitudes are one of the moderators of behaviour then hobbies related to science should at least be partly attributable to a positive attitudes to science.

Girls' image of science

Research has identified at least four prevalent images of science which may be held by girls. Ormerod and Duckworth (1975), in their classic survey of the literature on attitudes to science, found very few gender differences. He did, however, find a strong belief in "humanitarianism" in girls' attitudes. Ormerod (1979), in a study of 2100 mixed ability high school students in the United Kingdom, found that girls have more concern about the social implications of science. He looked at four sub-categories based on the students' feelings about the impact of science on the environment, the practical value of science, the value of science in creating jobs and increasing wealth, and scientists as people and found gender differences in each case. These data could be linked to the research of Gilligan (1982) who demonstrated the difference in moral attitudes of middle class boys and girls in the United States and explained the differences by attributing to girls' a greater concern for human relationships and feelings.

The second concern of girls is that science is intended only for men. Kelly (1978) believed that science and technology are frequently viewed by young girls as masculine pursuits. Despite significant improvements in the past ten years, text books still show science being done by men and the media still portrays the scientist as a white, middle class, middle-aged man. The stereotype of the engineer is still the conservative male more interested in numbers and machines than in people.

Thirdly, many people believe that science is difficult and this myth is encouraged by many science teachers. Also, there is a pervasive belief in our society that there is a talent for doing science that some people just do not have. Girls' lower self-esteem interacts negatively with this image of science and they can easily be discouraged from entering science courses.

A fourth image of science that is a deterrent for girls is the myth that science is rational and linear and that scientific discoveries have come from the rigorous application of the scientific method. On the contrary, many great scientific advances resulted from a scientist's intuition, a talent supposedly more often found in females, and yet this is rarely mentioned.

How to overcome the images of science that deter women from entering the field has been a concern of feminist writers for the past decade. A recent publication by the Direction générale de l'enseignement collégial (1990) gives an excellent account of how these myths and others have been applied to chemistry and ways of "debunking" them. This publication takes a myth such as "chemistry is dangerous" or "science is always right" or "males have a gift for science" and follows it with a practical exercise for students to carry out, for example a demonstration on handling flammable materials or an account of a scientific theory that was accepted for many years and eventually rejected or a survey of the chemistry grades of males and females within the school. The book then provides suggestions for a class discussion on the results of the activity.

Attitudes to science resulting from girls' classroom experiences

In a comprehensive survey of gender differences, Maccoby and Jacklin (1974) found significant behaviourial differences between males and females were reported in many different pieces of research. These included, the difference in mathematical abilities, males' higher level of aggressiveness or competitiveness, and females' greater verbal ability. These differences manifest themselves in the school environment, not only in achievement as measured by grades, but in classroom behaviour. Male students respond better to classes structured around the lecture followed by a question and answer period. One explanation for this may be that boys are more self-confident and respond to a competitive environment, one in which the student asking an intelligent question is the centre of attention and has high status in the class (Spender, 1984). Rich (1979) has pointed out that the lecture format is adversarial and produces a competitive environment within the classroom where only the confident express an opinion or venture a question; students in this type of environment are almost never asked for their opinions. The teacher establishes himself as an authority figure. He is proud of his rigour and the difficulty of his discipline. "The students admire it too" (Belenky and others, 1986, p.215). The subject matter is "the property of the teacher" (Friere, 1990, p. 63). Thus the more timid or less self-confident are effectively silenced and may be "turned-off".

In a survey of science teachers and their ability to engender interest in science among girls in England, it was found that female teachers, on the average, were more successful. An analysis of teaching styles (Samuel, 1981), however, indicated that the significant variable was the teachers who fostered a cooperative learning atmosphere in the classroom, and that these were more frequently women.

There is some recent evidence (Cobern, 1989) that teachers assume that all students in their science classes hold a similar world-view and that this view is similar to their own. They teach as if science is exact and beneficial and the only valid optic through which to view the world. They seem to be surprised to learn that such a thing as gender differences in terms of world view actually exist and that their view, be they male or female teachers, is more likely to conform to that of the boys within the class.

There is some evidence that males are more likely to respond to theory based on pure reason, whereas females prefer an application to real world problems be provided along with the theory. Ormerod (1981) suggests that this might be one reason why girls prefer biology, since this science generally starts with empirical data and a description of the visible world and theory is taught only in the more advanced courses. Other researchers have shown that girls are more likely to be interested in science that is related to such topics as the environment or health (Smail, Whyte & Kelly, 1984) or "humanistic-aesthetic issues" (Lie and Brylim, 1983), whereas boys prefer the more mechanical aspects of science such as the workings of the internal combustion engine (Jones and Kirk, 1990).

Many feminist writers, for example Rossner (1986) and Whyte, Deem, Kant & Cruickshank (1985), claim that the typical science class in the high school or college can be an inhospitable environment for women, the lessons are taught using a lecture format, question periods are short and discussion is limited or nonexistent, the subject matter is entirely theoretical, the examples used have industrial or mechanical connections and the instructor frequently holds the position that the scientific viewpoint is the only valid way of viewing the world.

Attitudes to science and the lack of role models for girls

The lack of role models for girls in science is considered by many feminist authors as being one of the many socio-cultural factors that contributes to girls' negative attitudes to science. Crabbe (1985) developed the ideas of Bandura in the context of girls in secondary schools and points out the consequence for girls of the lack of appropriate role models. She reminded us that social learning by imitation is reinforced if the model is of the same sex. For women to choose a science career, they must either de-feminize themselves and copy a masculine role model, or continually attempt to reconcile the dual roles of their professional and female goals.

However, Lee (1984), in a survey of the literature of factors affecting the choice of a nontraditional career for girls, stated that there is conflicting evidence concerning the importance of role models and that more research should be done in this area. In one study in the United States (Johnson, 1989) a group of high school girls were introduced to several women who were successful in nontraditional careers. The experimental group showed significantly more interest in choosing a career in a nontraditional scientific area than did a control group. Role models who emphasize the usefulness of mathematics also seem to be important in persuading girls to take mathematics courses in high school and, thus, be able to study science at a higher level (Rogers, 1986).

Despite the limited number of studies investigating the importance of role models, educational authorities clearly consider this is an important factor since many of the experiments designed to change the attitudes of female students to science involved a role model component. (See p.52 of this dissertation.)

Attitudes and behaviour

Since much of the concern about gender differences in attitudes to science results from the paucity of women in careers in the theoretical and applied physical sciences, the relationship between attitude and career choice is important. For young women in the cégeps, choosing to study the physical or applied sciences at the university is the necessary first step to a career in these fields. The behaviourial intention to make this educational decision is, therefore, the first step along this career path. For this reason it is appropriate at this time to briefly review the literature on the relationship between attitudes, behavioral intentions and behaviour.

LaPiere (1934), in his classic study on prejudice, asked a group of motel owners from around the United States whether they would accept a Chinese couple as guests in their motel. Many respondents replied negatively but, when the couple toured the US, they were hardly ever refused accommodation. Since then many studies have been carried out which attempt to correlate attitude and behaviour. McGuire (1985), in a review of the literature on attitudes and behaviour, states that there is some evidence of attitudes being good predictors of current behaviour. He cites a figure between twenty and forty percent as the amount of a person's behaviour that is governed by his/her attitudes. Whether one thinks this is significant or insignificant depends to some extent on one's own attitudes to social science research.

Behavioral intentions, according to Rosenberg (1960), depend on two factors: subjective norms, that is, the subject's perception of the views of significant others, and on an individual's attitude. The relative importance of subjective norms will vary from individual to individual (McGuire, 1985). Societal norms are one of the causal agents in attitude development. In this model, however, we are considering only the influences on the subject at the time of making the decision.

Ajzen and Fishbein (1980), in their literature review on the relationship between attitude and behaviour, point out many problems that can result in incorrect interpretation of results in this field of study. First they caution the researcher to be sure to define behaviour and make the distinction between behaviour and outcomes. For example, success in exams can be due not only to studying but also cheating so success in an examination should be considered an outcome, whereas studying is a behaviour. Thus, choosing to study applied science at the university level is a behaviour, whereas becoming an engineer is an outcome. It is also important to distinguish between single actions and behaviourial categories; deciding one day that one would consider a career in the physical sciences is not the same as following through on this dream. We should also be aware of the target, the context and the time of the action; deciding to consider a career in the applied sciences immediately after an intervention aimed at promoting this career field is not the same as making the decision six months later. Also, we might be more interested in behaviour over a long term, compared to short term behaviour.

Measurement of behaviour is also problematical. Ajzen and Fishbein (1980) reported that behavioral intentions are a good indicator of behaviour if the subject is questioned close to the action. Self reports of behaviour are sometimes suspect and observation by a researcher is a more reliable way of determining behaviour.

There is a great deal of evidence that, not only do attitudes influence behaviour, but there is a feed-back mechanism that results in behaviour affecting attitudes (McGuire, 1985). According to the Theory of Cognitive Dissonance individuals will develop attitudes that are commensurate with their behaviour in order to avoid cognitive dissonance (Festinger, 1957), they feel uncomfortable if their actions do not reflect their espoused beliefs so they adjust their attitudes to justify their actions. As far as girls' participation in the physical sciences is concerned, we can assume, therefore, that the less they participate in science related activities the less likely they are to think science is appropriate for them.

The relationships between attitudes and choice of a career in science

Given that a review of the literature shows a relationship between behaviour and attitudes, it is not surprising that many authors mention the importance of positive attitudes to science as a necessary factor in choosing a career in science or engineering. Several researchers (Hasan, 1975; Gardner, 1976; Kahle, 1983; Turner, 1983) showed a correlation between positive attitudes to science and the intent to make a career in science. However, the author was unable to find any longitudinal studies that followed students from secondary school through university or college to ascertain the relationship between attitude and actual career choice, as opposed to interest in a career.

Choosing a career is a complex process and the final choice results from a combination of factors that are closely tied to a girl's upbringing and other factors, such as her psychological aptitude and her interaction with the social environment. Fortunately, there is increased interest in attempting to understand these factors and, consequently, to establish the nature of the barriers that prevent their participation in certain fields. Only, if this knowledge is available, can society make the necessary changes that will allow more women into nontraditional professions. Although the process is by no means completely understood, Gagné and Poirier (1990) give us some important insights into the decision making process concerning the choice of a nontraditional career. Girls, more often than boys, express the desire to work in a field that will help others and they seem to be less concerned about status and salary and more concerned with personal satisfaction. Some of the important variables are a girl's ability to make rational decisions for herself, her concept of what is appropriate behaviour for a female, her socio-economic status, the education level of her parents and her level of emotional maturity. Other authors indicate that other factors are also important, such as the level of support from parents, teachers and friends (Neville, Gibbins and Codding, 1988), academic achievement (Ethington, 1988) and the motivation level to master a new skill (Farmer, 1985). Research has also shown (Fassinger, 1990) that women who pursue nontraditional fields of study differ from those who choose traditional ones in the following characteristics: ability, self-esteem, mothers' employment and fathers' support, work experience as an adolescent and socio-economic background. Guilbert (1987) has shown that young women studying in nontraditional fields at the university have less conservative attitudes to the role of women in such areas as the need for daycare, the appropriateness of women continuing their career soon after the birth of their child and the importance of affirmative action policies. A recent study by Tarquinio (1992) has shown that the above characteristics are also true of women students following the pure and applied profile in anglophone cégeps. Much more research needs to be done in this field but we are already aware of some of the societal barriers that impede girls from choosing a nontraditional career.

Changing the attitudes of girls to science

As we would expect, the suggestions for changing the attitudes of female students to science attempt to remedy the problem by attacking the perceived causes of the problem, namely, girls' lack of exposure to science, the masculine image of science, the inhospitable classroom, and the lack of role models.

Many authors, for example Erickson (1981), Women in Science, Hopefully, WISH (1988), Arbanas and Linquist (1989), Modeer (1989), Ramsden (1990) and Blosser (1990) have made suggestions on ways to make the attitudes of female students to science more positive. The Science Council of Canada (1982), the Superior Council of Education (1984b), the Conseil de la Science et de la technologie (1986), Status of Women, Canada (1989) and The Canadian Committee on Women in Engineering (1992) have also taken up the issue. Their suggestions include curriculum changes within high school, college and university science courses, especially integrating more social concerns into the course material; allowing female students to spend more time in laboratories; providing role models; and discussing career options. It is worth noting here that, although most of the ways in which we assume girls acquire their attitudes to science is through social learning situations, many of the intervention strategies that attempt to change women's attitudes to science focus on providing direct experience of an attitude object. This is based on McGuire's (1968) work that the more one is familiar with an attitude object the more one can empathize with it.

There is also a considerable body of literature on how to make the science classroom more conducive to learning for female students. Women seem to feel happier in situations in which group learning is encouraged, in what Belenky, Clinchy, Goldberger and Tarule (1986) call a "connected" class, in which each student takes responsibility for the others' learning and the teacher fosters the learning experience rather than acts as the authoritarian voice. Since women almost automatically seem to defer to male authority

Churgin (1978) recommends that male teachers adopt a teaching style that is open to the opinions of the students in order that women feel that they are a part of the process.

Rossner (1986) talks about the establishment of an atmosphere within the science class room at the college level that fosters a sense of community, trust and mutual respect. This allows women to build their self-esteem and become confident enough to express their opinions in class, thus building their self-confidence still further. She also suggests that a model of shared leadership is possible, even in science classes, through team teaching, guest lecturers and allowing students to lead a class.

Pomfret and Gilbert (1991) attempted to determine why women with high levels of ability drop out of pure and applied science programs at the University of Guelph. They concluded that women see their world as inter-connected with others, simply because they are fellow human beings, reflecting the conclusions of Gilligan (1982). They recommend that teachers use ethical "voices" in their engineering and science classes that better reflect women's view of the world and makes them feel as if they belong.

Dunlap (1990) suggested that sensitivity to students and to the life forms being used in experiments or for demonstration purposes has its place in the science classroom and that recognition of intuitive learning as an effective part of scientific thinking should be emphasised for the benefit of both sexes. In an experiment at Vanier College, a Montreal area cégep, Davis, Steiger and Tennenhouse (1989,1990) encouraged a team of teachers to incorporate feminist pedagogy into the science classroom. Students were organized into triads to build bonds within the classroom and provide each other with support in studying outside class hours; the teachers were expected to discuss in their classrooms their personal experiences in, and feelings about, science and students were encouraged to respond in a like manner. Other strategies included more personal, verbal feedback from the teacher and the encouragement of journal writing. The experiment was successful to the extent that students appreciated the experience, as did the teachers, and the degree to which the success rate of the students in the courses matched that of those in regular classes.

The report of the Canadian Committee on Women in Engineering (1992) emphasises the importance of teacher training at all levels from elementary to university. It recommends compulsory courses on gender differences be implemented by all Faculties of Education. One example is a graduate course offered to science teachers at Slippery Rock University of Pennsylvania that demonstrates ways of maximizing the learning of female students (Giese, 1993).

Few experiments specifically designed to change attitudes, however, have been carried out. Schibeci (1983) was unable to find any examples of controlled studies attempting to change students' attitudes to science. He resorts to a study attempting to change students' attitudes about racism to identify the problems of attempting to change attitudes. He questions the advisability of attempting to change attitudes since, with the racism study, although the experience was, on the whole, positive, some students became more negative. Schibeci also questions the right of the educator to adopt the role of a "brainwasher".

Even without definitive research results, several intervention programs have recently been established in Canada in an effort to increase the participation rate of females in science and engineering. The University of Calgary has organized summer courses for high school girls to give them a chance to work in the laboratories and see at first hand what the engineering program involves. One of the most extensive of these intervention programs was set up in 1988 in the faculty of engineering at the Laval University in an attempt to recruit more women into engineering, to encourage them to stay in the program and to see that they are placed in suitable jobs upon graduation (Doran, Moisan and Morneau, 1988). The process involves first working with high schools and colleges to provide more information about engineering, and using displays, publications, visits and participation in workshops.

Scholarships open only to women students have been established. Then, to help to reduce the number of female students dropping out of engineering, female engineers are available as resource people and a course on women in science is offered. Women graduates are helped in finding a compatible environment when they are looking for their first job. Finally, research is being carried out to determine why women students change out of engineering programs.

Similar types of programs have been implemented in several American universities, Illinois Institute of Technology, University of Chicago and University of Washington all have mentoring programs for women in engineering programs (National Research Council (1991). Also in the United States, the Marian Sarah Parker Pipeline program has been established at the University of Michigan to follow women undergraduates in the engineering program through their junior and senior years; seminars are conducted on career issues, discussion groups are organized to address social problems and advice is given on the availability of scholarships to encourage women to attend graduate school (Davis and Hollenshead, 1993).

An interesting program has been implemented in the science classes at Riverdale High School in Montreal. The teacher has developed a cooperative form of teaching and learning in his classroom that has improved the grades of both male and female students and has allowed "female students to take on leadership roles" (Allen, 1993, p.35).

Similar kinds of efforts have been made by private industry as well as research and professional organizations. The Association of Professional Engineers of Ontario has put together a list of women engineers who are prepared to visit high schools and act as role models. Many companies, for example Hydro Quebec and Dow Chemical, are offering scholarships to women engineering students. The National Research Council (NRC) offers the most valuable scholarships and these involve the promise of summer jobs in its research facilities as well as substantial cash awards.

The Girls into Science and Technology Program (GIST)

The most comprehensive experiment to change attitudes to science is the Girls Into Science and Technology (GIST) program undertaken by the Manchester Education Authority (Smail, Whyte and Kelly, 1982 and 1984; Whyte, Deem, Kant and Cruickshank, 1985). The goal of the program was to increase the participation rate of girls in upper level high school (Advanced Level) physical science and technology courses. This goal was to be met by adapting lower level science courses to meet the specific needs of girls. The experiment was implemented in several high schools belonging to the Manchester Educational Authority; the remainder were the control group.

In the planning portion of the program, studies were carried out to find the interests of the female students and the following modifications were made to the existing science courses:

1. Aspects of the courses which were shown to be more interesting to boys were replaced by modules that were designed to be equally interesting to both sexes.

2. Several women scientists were trained to respond to girls concerned about balancing their careers and family life, and a visiting scientists program was implemented.

3. Special emphasis was placed on improving the visual- spatial capabilities of the children using exercises with models.

4. More material emphasizing the positive aspects of science and the benefits of science to society were incorporated in the courses.

5. Teachers were specifically trained to teach the new program and they were encouraged to engage in extra-curricular activities with the girls, for example, the establishment of a girls' science club.

After five years, the program was considered a success; the gap between boys and girls in both attitude and achievement closed, although it did not disappear altogether in the experimental schools. A substantially higher proportion of girls opted for A Level physical science and technology courses compared to the control group.

Summary

The idea that attitudes are one determinant of behaviour is well supported by the literature and it is, therefore, reasonable to assume that one of the causes of young women's avoidance of careers in the theoretical and applied physical sciences is their attitudes to these fields of study. That female students generally have more negative attitudes to science is generally accepted; a wide variety of causes have been proposed to explain these attitudes. Among the most commonly cited are parental and societal pressures, lack of self-confidence, lack of role models, lower levels of ability and/or achievement, the masculine image of science and its anti-humanitarian image. The causal interrelationships between these variables are not well established.

The possibility of changing attitudes is less well defined, despite 2500 years of human history, in which, at least during times of intellectual freedom, politicians and others have attempted to change opinions by means other than coercion and the millions of dollars spent on advertising and propaganda every year, the best way to change attitudes has not been agreed upon. Nevertheless, we know that attitudes do change and attempts to change attitudes can be successful.

During the past few years many suggestions have been made as to the best way to encourage more women to overcome their negative attitudes and enter the theoretical and applied physical sciences. It is too early to judge, however, the success of many of the experiments currently being carried out around the world to achieve these ends. One well documented longitudinal study, the GIST program was carried out by the Manchester Education Authority program. Because of its demonstrated success, the GIST program was used as the model for the research reported in this dissertation.

In conclusion, female students appear to have the intellectual capacity and learning skills to succeed in the physical sciences and since there appears to be no discrimination practised by the universities to prevent their entry, we can assume that the young women's decisions are influenced by their attitudes. Attitudes developed throughout their childhood and reinforced, or at least not dramatically modified, during their stay in both high school and cégep steer them to careers outside the theoretical and applied physical sciences.

CHAPTER 3: BACKGROUND FOR THE STUDY

This study focused on one of the two physical sciences studied by all science students in the cégeps, namely chemistry. Its purpose was to determine whether it is possible, by adapting the course content and providing role models, to change the attitudes of the female science students to one of the physical sciences, chemistry, and thus change the gender bias in the choice of university science programs.

Theoretical Framework

There is an adequate body of research to suggest that male and female students have different attitudes to science and that these differences can be measured with appropriate psychometric instruments. It is generally accepted that these differences result, at least in part, from the environment in which children are raised rather than from genetic differences. Attributing these differences to the child's environment is justified since differences in child-rearing practices and differences in the portrayal of males and females in the media and in advertising, to name but two environmental differences, are well documented.

This research focuses on three subsets of attitudes towards the physical sciences. Firstly, the differences in attitudes towards the benefits and costs of scientific endeavour to both the individual and society as a whole. Ormerod and Duckworth (1975) found in a review of the literature of attitudes towards science that the only reported gender differences concerned the humanitarian aspects of science. These findings were confirmed by Ormerod (1979) when he used an instrument designed specifically to measure attitudes towards the humanitarian aspects of science.

The second area of theoretical research has centred on the idea that girls believe that science is a masculine pursuit. However, despite the fact that many writers proffer this explanation for the lack of women in the physical sciences very little experimental data is available to support this assumption. The success of experimental programs designed to increase the retention rate of girls in science by the provision of role models (Rogers, 1986, National Research Council, 1991, and Doran, Moissan and Morneau, 1988) indicates that female students are more likely to continue in the physical sciences if they have first-hand evidence that there are already women in the field. The fear of stress from working in a nontraditional field has also been documented (Ricard, 1988)

The third aspect of attitude differences to the physical sciences that has been established is in the differences in fields of scientific interest of boys and girls. Boys are more likely to pursue hobbies related to the physical sciences

(Bottomley and Ormerod, 1977, Erickson 1980, Kahle and Lake, 1983, Smail, Whyte and Kelly, 1982) and girls in the biological sciences (Bottomley and Ormerod, 1977). Girls are less interested in learning about phenomena related to the physical sciences (Smail, Whyte and Kelly, 1982 and 1984).

This research attempts to confirm these findings for one of the physical sciences, chemistry, and then attempts to show that, with the appropriate interventions in the classroom, it is possible to mitigate female students' negative attitudes towards chemistry.

<u>Questions to be answered</u>

The main questions to be answered by this study were:

1. Are the attitudes of female students to chemistry as a subject of study in cégep more negative than those of male students?
2. Are the attitudes of female students to the chemical industry more negative than those of male students?
3. Is it possible with appropriate material to increase the level of interest of female students in the content of a chemistry course?
4. Is it possible, with appropriate intervention strategies, to change the attitudes of women to chemistry and the chemical industry?
5. Would these intervention strategies result in more female students considering careers in the theoretical or applied physical sciences.

6. What would be the impact of the intervention strategies on the male students in the classes?

Environment of the study

This study was carried out between 1988 and 1991 in the chemistry department at Champlain College, St. Lambert Campus. The College, one of four English language cégeps in the Montreal region, was founded in 1972, five years after the first francophone cégep. Champlain College is a regional college with three campuses, one of which is located in St. Lambert on the south shore of the St. Lawrence River, with easy access by public transportation from the Island of Montreal. In the years 1988-91, about half of the 2300 students came from Montreal and Laval; the remainder came from the Monteregie, a region that is part of suburban Montreal. The College is ethnically mixed: the largest ethnic group is comprised of students of Italian origin, about 30% of the population; other large groups are Greeks, 25%, and Francophones, 18%; the remaining students are English Canadians and Asians with a small number of students of Caribbean origin. The College offers both general education (education intended for students who plan to continue their education at the university) and professional education for those who plan to enter the workforce upon graduation from the cégep.

Chemistry is a well-established and key discipline in the sciences. The chemistry curriculum in the cégeps was established when they were founded and has undergone only minor modifications in the following decades. Since the introduction of the cégeps resulted in a reduction of the undergraduate programs at Quebec universities from a four year to a three year course of study, it was not surprising that the old university freshman chemistry course became, essentially, the college chemistry curriculum. The textbooks used in the anglophone cégeps are first-year university chemistry texts and most of the laboratory exercises are similar to those done by freshmen in American universities. The courses, therefore, reflect the practice of university teaching during the 1960's. Since the inception of the cégeps, students have been required to take two compulsory chemistry courses, Chemistry 101 and 201, in order to receive a Diplôme Educatif Collégial (DEC) in natural sciences.

Chemistry, as taught at the freshman level, underwent a profound change in the 1950's. It moved away from courses with a descriptive bias to courses almost entirely concerned with theory. This reflected the educational thought of the period, which emphasized that, since the amount of knowledge was increasing rapidly, it was impossible to teach students all the facts. Thus, educational theorists emphasized the importance of understanding the underlying principles of a discipline in order to make a subject more comprehensible and more easily remembered (Bruner, 1960). The curriculum attempted to provide an "understanding of the inner logic of the subject" (Phenix, 1964, p.307).

The chemistry departments of the new cégeps were staffed with young people, mainly men with Ph.D.'s, who had just graduated from Quebec universities. It was not surprising, therefore, that they established a curriculum with which they were familiar. It is difficult to ascertain to what extent this initial curriculum was rooted in sound pedagogical research. The author is unable to find evidence of any research being consulted when the curriculum w established, but it is evident that little evaluation and development has been done since then.

The ultimate responsibility for the curriculum lies with the Direction Général Enseignement Collégial (DGEC). Providing advice on curriculum development to DGEC has been the responsibility of the curriculum coordinating committee. This committee is made up of a representative from each college. However, since the objectives of the curriculum cannot be agreed upon, attempts to change the prescribed curriculum content have met with little success. Perhaps this is because, as Popham (1972) informs us, "there are no formulas that allow us to define sound educational goals, they are always a value judgement" (p.72). On the one hand, the teachers see their role as preparing students to study pure and applied science at the university with an emphasis on scientific rigour while, on the other hand, the Conseil des Collèges (1990), the advisory committee to the Ministry of Post-secondary Education and Science (MESS), wants to see the failure rate and dropout rate decreased and more students encouraged to study science. The challenge to educators is to attempt to reconcile these two objectives.

Studies carried out throughout the cégep sector (Lamonde, 1984) and data from Cégep de Lévis-Lauzon (Rouleau, 1985) and John Abbott College (Boisset, MacKenzie and Sidorenko, 1989) show that achievement in chemistry, as measured by marks and passing rates in courses, shows no significant difference between male and female students. However, if we use student course profiles as an indicator of the career interests of students, we find that the vast majority of female students select a health science profile with an emphasis on biology and organic chemistry that prepares them to study the biological and health related sciences at the university. On the other hand, the majority of male students select a pure and applied profile with an emphasis on mathematics that prepares them for university studies in all branches of engineering.

The Chemistry Department at Champlain College has a total staff of seven instructors, four men and three women, one of whom was the major researcher for this study. The seniority of the instructors is high, since two of them were hired for the first year of the College's operation and the least senior had been on staff for eleven years when the study took place. Only one instructor has resigned from the department since its inception.

Unpublished studies of student achievement indicate that the situation of students studying chemistry at Champlain College is similar to that at other cégeps. Female students pass courses at the same rate as male students and obtain similar grades. As is true throughout the network, however, they are more likely to select courses within the science program that will prepare them for entry into the biological, rather than the physical, sciences at the university level (Gillbert 1988).

<u>The model for the study</u>

The study was modelled on the experiment to encourage more girls to take physical science and technology courses carried out in schools under the Manchester (England) Education Authority, the GIST program. The interventions paralleled as closely as possible those used in the GIST program (see p. 52-55 of this thesis).

In this study the following changes were made in the method of teaching the Chemistry 101 course: 1. The perceived lack of relevance of chemistry to female students was addressed by including material in the course that female students had expressed interest in. The perception that chemistry is anti-humanitarian was addressed by incorporating examples as to how chemistry had in the past or could in the future benefit humanity. 2. The lack of role models for women was addressed by inviting chemical engineers to visit the class and by incorporating profiles of female chemists in the laboratory manual. 3. In the pilot study only, the lower visual spatial ability of females was addressed by incorporating special exercises designed to improve visual-spatial ability. The study deviated from the GIST program in that very little effort was made to change the teaching styles of the instructors and no special provision was made for science clubs for female students.

Because of the resistance of the instructors to change and the fact that the Department insists on enforcing uniformity in the various sections of all chemistry courses, making major curriculum changes for this research would have been impossible. The most that could be done was to make modifications that could easily be incorporated into the existing curriculum.

The interventions were made in Chemistry 101, the first college-level course taken by students in the natural science program. The only students taking Chemistry 101 at Champlain College are those enrolled in the natural science program, so no allowance had to be made in the experiment for students taking the course merely for interest. Chemistry 101 is offered at Champlain

College in both the Fall and Winter semesters. All students, regardless of the instructor, complete the same laboratory exercises, the courses have common learning objectives and the students take a common final exam.

Students who arrive at the College with a substantial background in chemistry are enrolled in Chemistry 101. The requirement is either a minimum of 70% in Chemistry 552, the highest level chemistry course offered in Quebec high schools at the time of the study, or a minimum of 80% in Chemistry 452, the Secondary 4, Grade 10 high school course. Fewer sections of Chemistry 101 are offered in the Winter semester than in the Fall semester. Students enrolled in the Winter semester are of two types. One group is made up of those who arrived at the College in the previous Fall without the necessary background and enrolled in Chemistry 111 (a high school equivalent course) in the previous semester. The remainder are students who enrolled in Chemistry 101 in the Fall semester and either abandoned or failed it.

In summary, the study focused on any differences in attitudes between male and female students on their arrival at the College and any change in attitudes resulting from their experience in their first semester courses with or without specific female-friendly content.

CHAPTER 4: METHODOLOGY

Organization of the study

The experiment was carried out in two parts. The first year comprised a pilot study which allowed the researcher to prepare a modified curriculum and to develop the first edition of an attitude measuring instrument to test the applicability of the intervention techniques. The instrument was used to measure students' attitudes to chemistry and the chemical industry. In the second year of the experiment, the main study was carried out using the intervention techniques developed in the pilot. For the pilot study, the author was also the experimenter whereas, in the main experiment, the author was involved as a consultant only and all the members of the chemistry department at Champlain College became actively involved in the experiment. Both the pilot study and the main experiment used the same pretest-post-test control group design.

The proposal for the experiment was presented to the Research and Development Committee at the College. The committee decided that students at the College could be participants in the experiment and that, since the interventions had been agreed to by the Chemistry Department and constituted valid pedagogy, the students did not need to be debriefed at the end of the experiment.

Participants

The participants in the study were all students who were taking Chemistry 101 course for the first time, those students who were taking the course for the second time were rejected from the sample. In the pilot study, the experimental group comprised those students who were assigned to the experimenter's section and the control group were those students who were assigned to a male colleague's section during the same semester. The experimental group consisted of 38 students, 20 males and 18 females. There were 37 students in the control group, 19 males and 18 females.

The main study consisted of 56 male students and 52 female students in the experimental groups assigned to two male and two female instructors over the course of two semesters. The control group consisted of 51 male and 38 female students assigned to two male and one female instructor over the course of two semesters.

Research design

A diagram of the conceptual framework for the experiment can be seen in Figure 3.1. Using this framework, it was possible to determine whether the planned interventions influenced attitudes and thus the career choices of female students.

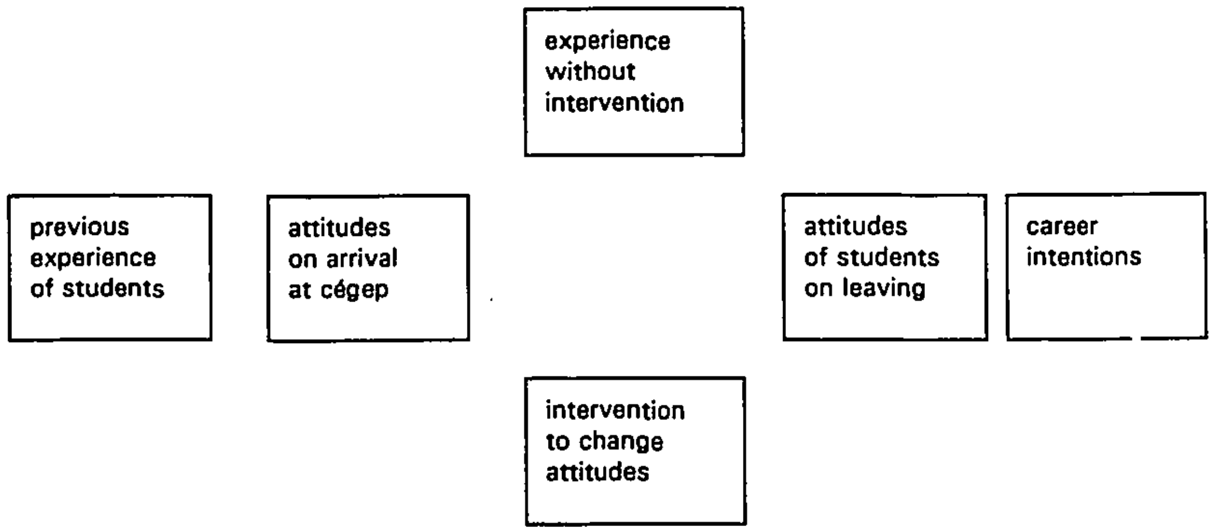


Figure 3.1. The conceptual framework

In both the pilot study and the main experiment, a pretest-post-test control group design was used. This can be represented schematically as:

$$R\ O_1\ X\ O_2$$
$$R\ O_3\quad O_4$$

This diagram represents two groups of subjects that have been randomly assigned. Some characteristic of the members of the two groups is measured (O) at the beginning of the experiment. One group is subjected to an intervention (X) and the other group is not. The same characteristic of the two groups is measured (O) at the end of the experiment. This, according to Cambell and Stanley (1963), represents a true experimental design.

At the time the experiment was carried out, random assignment of students by group in chemistry courses was assured. Students were preregistered in their science courses prior to registration day and were placed in sections of the required courses at random by a computer; they were not given the opportunity to change sections, or to select their instructor or to choose who else would be in their class. Participation in the experiment, either in the experimental or in the control group, was compulsory.

According to Cambell and Stanley, most of the problems that threaten the internal validity of experiments in educational research can be controlled for in this type of design. Maturation was controlled for since it could be expected to occur equally in both the experimental and control groups. History was controlled for in so far as general historical events were concerned since both experimental and control groups were taught at the same time. Regression was also expected to affect equally both the experimental and the control group. It was necessary to administer a pretest since the experiment was concerned with the measurement of changes in attitudes during the course of the semester, however, the effect of testing was expected to affect both groups equally.

Pilot study

The intervention consisted of 1. the introduction of a female-friendly curriculum that included topics of interest to female students 2. the provision of role models both in the form of profiles in the laboratory manuals and visitors to the class 3. training in visual-spatial perception.

Measuring instruments were developed to measure the attitude of students to the subject of chemistry and the chemical industry. Standardised tests were used to measure visual-spatial ability.

The decision was made to use the same learning objectives for the experimental and control groups and it was decided that the groups should do the same laboratory exercises and the same final examination. Any intervention had to take these constraints into consideration. Students could be asked to do extra work, but the only place that this extra work could receive recognition in the form of grades was within the 20% of the grade reserved for laboratory reports.

Preparation for the interventions

Three types of preparation were necessary before the pilot study could be carried out, a curriculum of interest to female students was developed, possible role models were and exercises to improve visual-spatial skills were researched.

Female-friendly curriculum

A questionnaire, the Student Interest Instrument, modelled on the one used in the GIST experiment (Unpublished document, GIST, 1983) was developed to survey the students to find the type of additional material that the female students would be interested in learning. Each question asked the students to rate their degree of interest in learning more about a particular topic. The topics surveyed were of three types: topics believed to be of interest to female students (these included topics relating to the environment, health, the arts and beauty); topics believed to be of interest to male students (these included topics relating to automobiles, heavy industry and computers), and topics that were part of the standard curriculum.

A draft version of the questionnaire was discussed with a focus group of five male and five female students to clarify the questions. The final version of the questionnaire was distributed to 62 science students (30 male and 32 female students) at Champlain College. None of these students became participants in the experiment. These students comprised all the students in the two sections of Chemistry 201 in one semester in the Fall 1988 semester. A copy of the questionnaire and the method of scoring it can be found in Appendix A.

Since both male and female students showed a high level of interest in topics related to health and the environment, the following topics were incorporated into the Chemistry 101 syllabus: 1. a module on nuclear medicine into the section on atomic theory 2. the relationship between molecular shape and smell into the section on the covalent bond 3. acid rain, the greenhouse effect and the fluoridation of teeth into the section on descriptive chemistry 4. the chemistry of gems and jewels into the section on intermolecular forces 5. the mechanism of ozone layer depletion into the section on chemical kinetics. In addition, emphasis was placed on the ways in which chemistry could be used to solve environmental problems.

Role Models

Following the example of the GIST program, two approaches were adopted to provide the female students with role models who were active in chemical research or in the chemical industry. Profiles of practising chemists working in fields that related to the course content were inserted in the laboratory manual. Also, women working as chemical engineers in the Montreal region were invited to visit the class.

The chemistry departments of 44 Canadian universities and several research centres were contacted in 1987 to gain information about women whose work could be described in the laboratory manual. A copy of the letter, both English and French versions, can be found in Appendix B. The departments were asked to supply outlines of the research interests of all the women working in the fields of physical or inorganic chemistry within their institutions. Since the content of Chemistry 101 at Champlain College is exclusively in the areas of physical and inorganic chemistry and since the research of the women chemists was intended to be directly applicable to the course content, the narrowing of the search was important. Seventeen universities responded to the request and 10 of these stated that they had no women working in either physical or inorganic chemistry, however, of these 10, five stated in their letters that they had women working in organic or biochemistry, the more traditional areas for women researchers.

Five women researchers whose work directly related to topics discussed in Chemistry 101 were selected. They were asked if they would be interested in becoming involved in the research. They were requested to provide some information about their own research, such as published papers, and any other information that they thought might interest female students. Profiles were prepared for the following women: Penelope Codding and Louise Fortier, x-ray crystallographers from the University of Calgary and Queen's University respectively; Margaret Back, a chemical kineticist from the University of Ottawa; Truis Smyth-Palmer, a researcher into acid rain from St. Francis Xavier University; Mary Ann White, an inorganic chemist from Dalhousie University specializing in the transition points of inorganic crystals . The profiles included, not only their academic and research achievements, but also some personal background about their family life, hobbies, ambitions and a photograph (see Appendix C).

In addition, profiles were prepared on two deceased women scientists: Jane

Marcet, a nineteenth century British chemist who wrote a popular chemistry text book and Harriet Brooks, who worked with Ernest Rutherford at McGill University.

The profiles were included in the laboratory manual under the following topics: Jane Marcet, discussion of the textbook; Harriet Brooks, atomic theory; Suzanne Fortier, the nature of the covalent bond; Penelope Codding, the importance of the shapes of molecules in drug effectiveness and drug synthesis; Truis Smyth Palmer, sulphur chemistry and the connection to acid rain; Mary Ann White, the strength of dispersive forces and their application to solar energy storage; Margaret Back, kinetics of the combustion of coal.

Similar profiles were prepared of four young chemical engineers working in Canadian industries. These profiles included the women's career paths and expectations for the future, as well as their education and a few details of their family life (see Appendix D).

To find women chemical engineers who would be interested in visiting the class, the public relations officers of several large chemical companies with plants in the Montreal region were contacted in Fall 1987. Two young women chemical engineers, one from Petro Canada and one from Dow Chemical, were approached. They both agreed to talk for one hour in the classroom and the author discussed with them the type of information they would give the class. They were asked to talk about their current jobs, their career expectations, how they organized their family life and the atmosphere for women engineers in the university and in the workplace.

Training in Visual-Spatial Perception

Following the GIST model, the third type of intervention planned was to incorporate special exercises into the course that were designed to improve the visual-spatial ability of the students. A computer program for use on the Macintosh computer, that had been used to help elementary and secondary students improve their visual-spatial perception, was provided by Richard Palascio, a researcher in the Department of Education at Université du Québec à Montréal. The program allowed students to rotate drawings of three-dimensional shapes about the x, y and z axes. Since the College was equipped with a Macintosh laboratory for student use, this made an ideal teaching tool. It had the additional advantage that it would give students the opportunity to operate a user-friendly computer. The program was modified to make it suitable for college-level students by preparing exercises that required the students to identify shapes rather than simply find an identical one, as in the original exercises.

Construction materials that were used to teach students three-dimensional geometry were provided by Janos Baracs from the Architecture Department at the University of Montreal. His unpublished research has led him to believe that female students in architecture programs benefited from this type of exercise. Three-dimensional models were prepared by the author to match the models on the computer program. In this way, students were able to move from a three-dimensional shape to a two dimensional representation on a screen.

Measuring instruments

Two measuring instruments were necessary for both the pretest and posttest, one that measured attitudes to chemistry and the chemical industry and one that measured visual-spatial ability.

Attitudes

Since the literature review did not produce any satisfactory instrument, it was decided to develop an appropriate instrument to measure attitudes to chemistry as a subject for study and to the chemical industry. A questionnaire was developed based on the following considerations: the fact that the research was specifically targeting female students, the fact that attitudes to objects that might influence career decisions were being investigated, and the fact that previous work in the development of instruments to measure attitudes to science should be incorporated.

Edwards (1957) identified fourteen criteria for statements to be used by developers of an attitude scale and, as much as possible, these were used in the development of this instrument. Statements were choser that referred to the present and future, factual statements were deliberately avoided, ambiguity was eliminated as much as possible, statements that were likely to be endorsed by almost everyone or almost no one were eliminated, simple language was used, each statement contained only one complete thought, and categoricals such as "never" were avoided.

Two versions of the attitude measuring instrument were developed, one for the pretest, Version 1, and one for the post-test, Version 2. The post-test version contained the same attitude questions as did the pretest version; questions relating to background information on the participant were omitted from the post-test version. The two versions used in the pilot study are found in Appendix E and F.

The instrument consisted of 43 questions. Questions #1-11 were designed to measure attitude to the chemical industry. Questions #s 1,2,3 6,7 and 8 measured the students attitudes to the humanitarian aspects of the chemical industry. Question #s 1 and 6 dealt with attitudes to chemicals in the environment. Question #s 3, 7 and 8 measured attitudes to toxic chemicals and human health. Question #2 was attempting to measure the concern of the relationship between chemistry and war, Question #s 4 and 5 related to the economic role of the chemical industry, Question #s 9, 10 and 11 were open-ended questions that were used to confirm attitudes specified in the closed questions.

Question #s 12-21 were designed to measure attitudes to the study of chemistry. Question # 12 was an open-ended question asking the respondents to describe chemistry. Question #s 13-15 focused on the difficulty of chemistry as a subject. Question #s 16-19 assessed attitudes to physics and chemistry teachers and Question #20 on laboratory work. Question #21 referred to the attitude of male students at Champlain College.

Question #s 22-32 were designed to measure attitudes to working as an engineer in a predominantly male environment. Question #s 22-24 address attitudes to engineering as a lucrative career. Question #s 25, 27 and 28 measure the perceived attitude to women workers by their male colleagues and Question #s 26 and 29 address the problem of the perception of stress experienced by women working in predominantly male environments. Question #s 30-32 ask students about any women scientists or engineers they know personally.

Question #s 33-39 ask students to provide some personal information and ask them about their family background. Question #s 40, 42 and 43 ascertain the career intentions of the students.

For both versions, Questions #s 1-5 were adapted from the IEA/SISS test (Connelly, Crocker and Kass, 1985). The questions associated with stress (#s 20, 21, 25, 26, 27, 28 and 29) and those associated with teacher attitudes (#s 18 and 19) came from a measuring instrument developed at Cégep de Rosemont to look at attitudes to careers of female students in non-traditional programs at the cégep (Ricard, 1988). Question #s 38 and 39, associated with extra-curricular activities came, from several attitude measures (e.g. Estes, 1975, Swan, 1965, National Assessment of Science, 1969-1970). The remaining questions were devised by the researcher.

The first testing of the attitude measurement instrument was done in Fall 1987 with a focus group of ten students from Champlain College, five male and five female, who would not be part of the experiment and who graduated from the College before the experiment started. This was to ensure that there was as little discussion as possible in the College about the experiment before it started. Each question was discussed with the group to ascertain perceived meaning and the clarity of the questions. In light of this, several small modifications were made. For example, Question #2 was clarified by giving an example of a chemical weapon and Question #23 had the term "job prospects" added.

Simple questions concerning personal information about students and their career intentions were not tested for reliability. A variation of the alternate-forms method of testing reliability was used for the seventeen attitude-measuring questions (Question #s 1-5, 7, 8, 20-29), that required respondents to rate their beliefs on an ordinal scale (Tuckman, 1972). The questionnaire was expanded to add questions that tested the same attitudes but in a negative manner. The expanded questionnaire was then administered to a group of students in Chemistry 101 at John Abbott College in Fall 1987. John Abbott College was chosen because it is an anglophone cégep with a cultural and socio-economic mix that is similar to that of Champlain College. The completed questionnaires were handed to a consultant socio-metrician to prepare the final instrument. The 17 questions retained had a reliability greater than or equal to 0.95. The final instrument contained 9 statements that reflected negative attitudes to chemistry or the chemical industry and 9 statements that reflected a positive attitudes to chemistry or the chemical industry. On each attitude-measuring question a score of 1 was assigned to the most positive attitude to chemistry or the chemical industry and a score of 5 to the most negative attitude. The method of scoring the instrument is also found in Appendix E.

Visual-spatial ability

The instrument for measuring visual spatial ability was the Space Relations Subset of the Differential Aptitude test. Two different versions of this test were used, one (Version S) for the pretest and the other (Version T) for the post-test. The reliability coefficients for both these subsets are .96. (Bennett, Seashore and Wesman, 1972).

Procedure

The intervention was carried out in the Winter 1988 semester and the instructor was the experimenter. The schedule for the intervention is summarized in Figure 4.1.

Pre-test

In the first class of the semester students were asked if they would agree to participate in the experiment; they were not obliged to fill out the attitude measuring instruments but no student refused. They were told that the purpose was to make the course more interesting to students; they were not told that the experiment had anything to do with gender. Version 1 of the Attitude Measuring Instrument, and the Space Relations Subset of the Differential Aptitude Test, Version S, were completed by all the students in both groups in the first week of the semester. The questionnaires were distributed and collected by a qualified counsellor. Anonymity was

WEEK	STANDARD CURRICULUM	INTERVENTION- Female-friendly CURRICULUM AND ROLE MODELS
1		pretest
1-3	Unit I. Atomic theory	nuclear medicine profile of Harriet Brooks
4-6	Unit 2. Chemical bonding and molecular shapes	smells and pharmaceutical profile of Penelope Codding and Suzanne Fortier
5		visit of female chemical engineer
7-9	Unit 3 Intermolecular forces	gem stones profile of Mary Ann White
10		visit of female chemical engineer
10-12	Unit 4 Descriptive chemistry	acid rain, greenhouse effect, fluoridation of teeth profile of Truis Smith Palmer
13-15	Unit 5 Kinetics	decomposition of the ozone layer profile of Margaret Back
15		post-test

Table 4.1. The schema of the intervention in the pilot study

guaranteed since the students used a code on both the questionnaire and the Space Relations Test. The counsellor was the only person to have the key to the code. The only information she provided to the author was the code numbers of students in the experimental and control groups.

Implementation of the intervention

The intervention was of three types: a female-friendly curriculum, the provision of role models and visual-spatial training.

The course content of Chemistry 101 at Champlain College is divided into five units, each of approximately three weeks in length. One or two topics of interest to females were included in each unit. In Week 1 a ten minute lecture discussed how a PET scan is used to diagnose and cure diseases of the brain and how it is used to understand the workings of the brain. In Week 4 a series of slides was shown which demonstrated the importance of molecular shape in determining both the smells of organic compounds and also the effectiveness of pharmaceuticals. In Week 7 a series of slides was presented which depicted the beauty of gem stones, their manufacture and industrial uses. In Weeks 10-12 the causes of, and cures for, acid rain and the greenhouse effect were discussed. When discussing the element fluorine, the students had a brief lecture on the chemistry of the fluoridation of teeth and the pros and cons of the fluoridation of drinking water. In Week 14 the students were lectured on the kinetics of the destruction of the ozone layer by fluorochlorocarbons. All the additional content was focused on the ways in which the discoveries discussed could be used for the benefit of humankind.

The provision of role models was of two types, the visits to the class of chemical engineers and descriptions of the work of Canadian chemists in the laboratory manual. The visits of the chemical engineers to the class took place as planned. They each gave a presentation which included their experiences at university, their early years as chemical engineers, a description of the work they were presently doing and their career aspirations. During the question time the researcher encouraged them to talk about their home life and how they reconciled this with a challenging career.

Students were encouraged to read in their laboratory manuals about Canadian women scientists at the point in the course where their work was relevant to the theory under discussion.

To implement the visual spatial training, in the first laboratory session the students were taken to the Macintosh laboratory and shown how to use the visual-spatial training program. They were then expected to complete the exercises each week on their own time and hand in answer sheets. The students were told that 2% of the final grade would be used to assess these exercises. All students successfully completed all the exercises. A sample exercise is included in Appendix F.

The Post-test

Version 2 of the Attitude Measuring Instrument and a second version, Version T, of the Spatial Relations Subset of the Differential Aptitude Test were administered by the counsellor who administered the pretest. The students used the same numerical code that they had been assigned for the pretest to identify themselves.

Main study

The pilot study was replicated using other instructors because of the possible confounding effect of the researcher also being the teacher. At the same time, other important modifications were made as a result of the experience of the pilot study. The following is a summary of the changes: 1. All the instructors in the chemistry department at Champlain College were involved in the experiment and the author was involved as the researcher. 2. No direct attempt was made to change the attitudes of students to the subject of chemistry since the attitudes of female students to chemistry as a subject of study were more positive in the Pilot Study than those of male students. 3. The method of delivering the female-friendly curriculum was modified to include the extensive use of audio-visual aids. 4. The visual-spatial exercises were not included since there was no significant difference between the scores of the control group and the experimental group in the pilot study on the Space Relations Test for either males or females on the post-test. 5. A new measuring instrument was prepared that targeted only those attitude objects directly addressed by the intervention.

<u>Recruitment and training of instructors</u>

Instructors volunteered to teach an experimental group and the remainder taught the control groups. Both male and female instructors taught both experimental and control groups. Two instructors, Male A and Female B, taught both an experimental and a control group. The details of the assignment of groups can be found in Table 4.2.

Instructors were asked not to tell their students that the department was conducting an experiment involving gender differences. They were asked to

Teacher	Experimental Male	Experimental Female	Control Male	Control Female
Male A	18	13		
Male B			11	13
Female A	15	16		
Female B			16	17
Male C	14	10		
Male A			24	8
Female B	9	13		
Total	56	52	51	38
Total M+F	108		89	

Table 4.2 Assignment of instructors to experimental and control groups

tell the students that the purpose of the survey was to give the department feedback on the course.

The instructors were encouraged to introduce the visitors simply as engineers; no emphasis was to be placed on their gender. The instructors were also asked to ensure that the engineers talked about their jobs and their experiences at university during their presentation. If the instructors thought that important material had been omitted from the presentation, they were asked to intervene in the question period to elicit this material. No direct attempt was made to change the attitudes of the instructors. No attempt was made to train the instructors in alternative forms of pedagogy as the research shows this is a long and difficult process and is only effective if teachers believe in the change.

Preparation for the intervention

To prepare for the intervention the female friendly curriculum used in the pilot study was improved and new role models were trained.

Female-friendly curriculum

The same topics were introduced into the course material for this experiment as in the pilot study. However, since the instructors involved were not familiar with the topics, teaching aids were prepared. Slide and video presentations were prepared for each topic; in this way it was easy for them to incorporate the material into their lecture sessions. Each instructor was provided with the material summarized in Appendix G. The emphasis in the environmental videos was on the possible solutions that chemistry could provide to the problems under discussion. The slide presentations were accompanied by a fact-sheet that provided background material on each slide.

Role models

No changes were made from the pilot study; the same profiles were included in the laboratory manual. Four more chemical engineers were contacted and trained as described in the pilot study because the engineers who helped in the original study had been transferred by their companies out of the Montreal area.

<u>Attitude measuring instruments</u>

The attitude questionnaire used in the pilot study was reworked and an instrument to measure the attitudes of instructors was developed.

Student attitudes

A new measuring instrument Version 3 was prepared using experience acquired during the pilot study. This version of the attitude measuring instrument can be found in Appendix H.

A series of new attitude questions was developed that focused on the chemical industry and in which the attitude objects were subjects addressed by the intervention. As with the pilot study, alternate forms of the instrument were prepared in which each attitude was assessed by both a positive and a negative statement. The first testing, which was done with a focus group of ten students at Champlain College, was used to clarify the questions. The instrument was once again tested in the Fall 1989 at John Abbott College. Only those questions with a reliability of .95 were retained.

Factor analysis of the completed Attitude Measuring Instruments from the pretest allowed the researcher to develop two subscales, an Attitude to the Chemical Industry Subscale (ACIS) and a Stress Subscale. The responses to Question #s 4-7 and #s 10-12 of the pretest, Version 3, (Questions #s 2-5 and 8-10 on the post-tests, Version 4 and 5,) formed one factor and were considered to form a scale. Each question was scored on a five point scale where one corresponded to a positive attitudes to the industry and five corresponded to a negative attitude. The ACIS scale had a minimum value of seven corresponding to an extremely positive attitude to the chemical industry, and a response of 35, corresponding to an extremely negative value. The scale measures the students' overall attitude to the chemical industry. In order to determine the intervention effect, the difference in the score for each student on the ACIS scale between the pretest and post-test was computed.

Factor analysis of the scores for female students produced a second subscale, the Stress Subscale. The scale measured the students' perceived stress from working in a male environment. The scale was composed of Questions #s 14-15 on the pretest Version 3 (#s 12-13 on the post-tests, Versions 4 and 5). Each question was scored on a five point scale where one corresponded to a positive attitudes to stress from working in a male-dominated environment and five corresponded to a negative attitude. The resulting scale was a nine-point scale on which a low score indicated low-level fear of stress from working in a predominately male environment. In order to determine if there was an intervention effect, the difference in the score on the pre and post-test was computed.

Question #s 8 and 9 on the pretest, Version 3 (#s 6 and 7 on the post-test, Version 4 and 5) measured the attitudes to environmental pollutants and Question #s 13 -17 on the pretest, Version 3 (#s 11-15 on the post-tests) measured attitudes to working in a predominantly male environment.

An additional question, Question #21, was added to the post-tests that was intended to assess the students' attitudes to the course content. Three additional questions were added to the post-test for the experimental group that were used to assess the students' response to the intervention.

Instructors' attitudes

An interview protocol was prepared by the researcher. The protocol was intended to gauge the affective response and attitudinal orientation of the instructors after the completion of the study (see Appendix K).

The procedure

The intervention was carried out in the Fall 1990 and Winter 1991 semesters. As in the pilot study, students were randomly assigned to chemistry sections and were then preregistered in their courses. Apart from the additions listed below, both groups followed the same course, used the same textbook, did the same laboratory exercises and took the same final examinations. The schedule of the intervention was the same as for the pilot study.

Pretest

The pretest, Version 3 of the Attitude Measuring Instrument, was administered by a counsellor who assigned the students numbers to ensure anonymity, as in the pilot study.

Intervention

The order of the intervention was the same as for the pilot study and is summarized in Table 4.1. which can be found on page 83. The female-friendly content was taught with the use of audio-visual aids. In Week 1 a slide presentation, accompanied by background material on each slide that showed the chemistry of the PET scan along with its uses in the diagnosis and treatment of brain disorders as well as knowledge on the functioning of the brain, was shown to the students. In Week 4 a slide presentation, with a commentary provided by the researcher that showed the connection between molecular shape and the smell of an organic molecule or the effectiveness of a pharmaceutical, was shown to the student. In Week 5 a female chemical engineer from Dow Pharmaceuticals visited the classes. In Week 7 a series of slides was shown to the students; it had a commentary provided by the researcher that showed the beauty of gemstones, techniques of making "artificial" gems that are chemically the same as the natural stones and industrial uses of gemstones. In Week 10 a second female chemical engineer, this time from PetroCanada, visited the class. In the same week a video on the chemistry of acid rain made by the National Film Board was followed by a video on the solutions to the problem which was made by the researcher. In Week 11 a video made by

CBC on the greenhouse effect was followed by a video made by the researcher on alternatives to fossil fuels. In Week 12 the mechanism of the prevention of cavities with the fluoride ion was discussed with the class and in Week 14 a video provided by Dupont Canada on the destruction of the ozone layer by chlorofluorocarbons and the development of alternatives by the chemical industry was shown to the experimental groups.

Post-test

Version 4 of the Attitude Measuring Instrument was administered to the experimental groups and Version 5 to the control groups. At the end of each session, each participating teacher was interviewed by the researcher using the interview protocol (See Appendix K).

CHAPTER 5: RESULTS

The results of this experiment have shed some light on the possibility of changing, in a classroom setting, the attitudes of female students to the chemical industry. There is some evidence that curriculum intervention is one way of encouraging more females to attend university in programs in the fields of the theoretical and applied physical sciences. These results will be discussed in the order in which the experiments were carried out. First the results of the survey to determine subjects of interest to female students will be considered. This will be followed by a description of the results of the pilot study and, finally, the results of the main experiment will be provided.

Determination of topics of interest to students

The results of the survey using the Student Interest Instrument supported the findings of the GIST study. Females claimed to want to know more about topics related to health issues and the environment than did male students. On the five questions that focused on health issues, the combined mean score was 1.6 for males and 1.3 for females. For the six questions relating to the environment, the mean score was 1.6 for males and 1.4 for females. A lower score indicates a higher level of interest on a 3 point scale and on each question related to one of these issues the mean score of female students was lower than the mean of male students. An analysis of variance was used on each item to test for the differences between the mean score of males and females. The differences were significant on two questions in the health and environment category (Questions #19 and #29): for Question #19, "the health effects of lead" (females $\underline{M}=1.2$, males $\underline{M}=1.6$, $F(1,49) = 6.15$, $p \leq .05$) and for question #29, "radioactive isotopes in medicine" (females $\underline{M}=1.0$, males $\underline{M}=1.4$, $F(1,49) = 5,27$, $p \leq .01$). A table of the mean scores for males and females for each question can be found in Appendix L.

The other question in which females were significantly more interested than males was Question #12, "why diamonds sparkle". The mean score for females, 1.2, was significantly lower than that for males, 1.9, $F(1,49) = 8.53$, $p \leq .01$).

The mean score for males on all questions related tc the applied physical sciences was lower than that for females. Males were significantly more interested than females in three questions regarding the applied physical sciences. On Question #8, "linear accelerators", the mean score for females (2.5) was significantly greater than the mean score for males (1.8), $F(1,49) = 11.89$, $p \leq .01$. For Question #23, "silicon chips", the mean score for females (2.0) was significantly greater than for males (1.4), $F(1,49) = 7.13$, $p \leq .01$. On Question #28, "rocket fuels", the mean score for males (1.4) was significantly greater than for females (1.9), $F(1,49) = 4.85$, $p \leq .05$.

Female students were less interested in learning more about some of the compulsory curriculum than were male students. On Question #6 on "the nature of the electron" the mean score for male students (1.7) was significantly lower for female students (2.2), $F(1,49) = 4.95$, $p \leq .05$ and on Question #21, "why atoms join together", for male students the mean score (1.7) was significantly lower than for females (2.1), $F(1,49) = 4.90$, $p \leq .05$.

Results of the pilot study

The results of the student data are followed by a description of the reaction of the instructor (the researcher) to the teaching experience.

To verify whether the randomly assigned groups were comparable on their initial attitudes the mean scores on each item for males in the experimental group were compared to the mean scores for males in the control group, and similarly for females, using analysis of variance. No significant differences were found between the responses of males in the two groups or the responses of females in the two groups on any of the items.

In order to limit the probability of significant effects being found through chance, a t-test was only carried out in those instances when F was found to be significant.

Results of the pretest

Since no significant differences were found on the pretest between experimental and control groups, males from both groups were grouped and, similarly, females were grouped for these analyses. Version 1 of the Attitude Measuring Instrument was used to determine attitudes of all students prior to the intervention.

Attitudes to chemistry as a subject of study

1. On the pretest, using chi-square analysis, significantly more female students than male students held positive attitudes to chemistry as a subject (Question #12). 69% of the female students used positive words, whereas only 42% of the male students used positive words to describe chemistry as a subject of study, 37% of the females were neutral, compared to 44% of the male students, and none of the females were negative, whereas 14% the males were negative, X^2 (2,N = 71) = 8.3, $p \leq .05$.

2. Using an analysis of variance, there was no significant difference between the mean scores of male and female students (2.2 and 2.3 respectively) concerning the perception of the degree of difficulty of chemistry as a subject in high school (Question #13). Since a score of 3 indicated that students found chemistry "about as difficult as other

courses" and 2 indicated "one of the easiest", these scores indicate that students, on average, found chemistry somewhat easier than other courses taken at high school.

Attitudes to the chemical industry

1. Using analysis of variance, there was no significant difference between male and female students in their attitudes to the chemical industry as measured by Question #s 1-5. However, on every question the mean response of the females was higher than the response of the mean response of the male students. Chi-square analysis was used to analyze the open ended question on attitudes to the chemical industry (Question #11); 49% of the male students used words that denoted a positive attitude to the industry and 13% used negative words, whereas only 24% of females used positive words and 33% used negative words, $X^2(2, \underline{N} = 71) = 6.01$, $p \leq .05$.

2. There was no significant difference, as indicated by a chi-squared analysis, between male and female students as far as their knowledge of chemical pollution in the Montreal area (Question #6). Only 37% of males compared with 53% of females could accurately describe a pollution problem in the Montreal area.

3. Using chi-square analysis, significantly fewer male students (25%) compared to female students (50%) indicated that they felt that their health had suffered to some extent as a result of pollutants in the environment. More males (25%) than females (15%) felt that pollutants in the environment had no significant impact on their health, 50% of males and 35% of females did not know ($X^2(2, \underline{N} = 73) = 5.72$, $p \leq .05$, Question #7).

Attitudes of students to chemistry instructors

1. 50% of the students had never had a female chemistry teacher and 75% had never had a female physics teacher (Question #16 and 17).

2. There was no significant differences between male and female students using analysis of variance in their attitudes to teachers, therefore, for this analysis the two genders were grouped. Female teachers were considered to be more supportive than male teachers (Question #18). Analysis of variance indicated a significant difference in perceived teacher attitudes between male and female teachers; male teachers were considered less helpful ($\underline{M} = 2.2$) than female teachers ($\underline{M} = 1.5$) when a student makes a mistake in class (a lower score indicates a more helpful attitude), $F(1,70) = 5.98$, $p \leq .05$. On Question #19, female teachers were also seen to respond to a student's success

more positively ($\underline{M}$=1.7) than male teachers ($\underline{M}$=2.1), F (1,69) = 2.8, $p \leq .05$).

Attitudes to a university education and a career in the applied sciences

1. Using chi-square analysis on Question #20, significantly more female (70%) than male students (10%) considered that a laboratory was a stressful environment; only 15% of female students exhibited no concern about stress in the laboratory whereas 50% of male students responded in this manner; 15% of female students and 40% of male students did not know, X^2 (2, $\underline{N}$ = 70) = 25.6, $p \leq .01$.

2. Analysis of variance indicated that males were significantly more positive ($\underline{M}$=1.9) than female students ($\underline{M}$=2.5) about a future career in engineering (Question 23), F (1,69) = 4.92, $p \leq .05$. Also, males ($\underline{M}$=2.2) were significantly more positive than females ($\underline{M}$=2.8) about the chances of promotion in an engineering related job (Question #24), F (1,69) = 4.98, $p \leq .05$.

3. There was some evidence that female students were concerned about operating in a male-dominated environment. Fifty percent of the female students thought that women would not be treated as equals in jobs in the engineering field, (Question #25). Twenty percent of the female

students thought that women students in engineering programs at university would have to out-perform males to receive the same grades and 25% were not sure (Question #27). Ten percent of the female students believed that they would not be treated as equals by male engineering students, and 35% were not sure (Question #28). Forty percent of females believed that engineering would be more stressful for female students than for male students (Question #29).

Chi-square analysis showed that there was a significant relationship between the perception of stress in engineering related jobs, Question #26, and the consideration of a career in the physical sciences or engineering, Question #42. The perception of stress was rated on a five point scale and career intentions were grouped as physical sciences and engineering, health and other. Female students who did not believe that women engineers felt stress working in a predominately male environment were more likely to consider a career in the physical sciences and engineering, (X^2 (6, N = 36) = 22.8, $p \leq .05$.

4. Too few female students knew a female scientist to allow for an analysis of the influence of personal contacts on attitudes. (Question #31 and #32).

5. Using chi-square analysis, there was a significant difference found between career choice of males and females (Question #42). More male students (60%) than female students (30%) were planning a career in engineering, the physical sciences or related professions. Fewer males (40%) than females (70%) were planning a career in the health science professions or some other field, X^2 (2, $\underline{N}=75$) = 6.61, $p \leq 0.05$.

6. Their parents' occupation did not appear to be an influential factor in career choice for either male or female students. However, the sample size was too small to make it likely that the influence of this variable would be detectable. (Question #s 36 and 37 and #42)

Visual-spatial abilities

Analysis of variances was unable to detect a significant difference between male and female students on the Space Relations Subset of the Differential Aptitude Tests (Version S). The mean score of the male students was 43 and of the females was 40. The national average for boys in grade 12 is 34-35 and for girls is 29-30 (Bennett, Seashore & Wesman, 1972). Both sexes were approximately 10 points above the national average.

Hobbies in science-related fields

1. Using chi-square analysis, there was a significant difference between the hobbies of male and female students, only 6% of the female students, compared with 25% of the male students, had enjoyable hobbies with a direct connection to science. (X^2 (2, $\underline{N}=75$) = 3.73, $p \leq 0.05$). No relationship was found between the female students' hobbies and their choice of a future career. (Question #38 and #42)

2. As many female students as male students claimed to have repaired household objects.

Results of the post-test

Version 2 of the Attitude Measuring Instrument was used for the post-test. Using either chi-square analysis or analysis of variance, no significant difference was found between the experimental group and the control group for either males or females except where indicated below.

Attitudes to the chemical industry

The opened ended question (Question #12) where students were asked to use words to describe the chemical industry indicated that 44% of the females in the experimental group as compared to 33% in the control group had a positive attitude to the chemical industry. Although 37% in the control group still had a negative attitude to the chemical industry, none of the experimental group fell into this category, $X^2(2, \underline{N}=32) = 7.47$, $p \leq .05$. This compares to 24% of female students who had a positive attitude at the start of the experiment and 33% who had a negative attitude.

Careers in the physical or applied sciences

After the intervention, five female students in the experimental group who had not previously considered a career in the physical or applied sciences were doing so at the end of the semester. No male student changed in either group changed his career plans. Amongst the control group, fewer female students were considering careers in the physical or applied sciences than at the start of the semester.

Visual-spatial perception

The mean score for both males and females on the Space Relation Subset of the Differential Aptitude Test increased during the semester. The mean for the males increased from 43-44 to 47-48 and for the females from 40-41 to 42-43. However, no significant difference, using a 2x2 analysis of variance for gender and interaction, was found between the experimental and control groups for either the males or the females.

Summary of the results of the pilot study

The post-test indicated that, as measured by some of the attitude measuring questions, more female students in the experimental group than in the control group had a positive attitude to the chemical industry and were considering a career in the theoretical or applied physical sciences. It also indicated that the perception that there was a high degree of stress in working in a predominately male environment could be a contributing factor to the reluctance of women to enter theoretical and applied physical sciences. The visual-spatial exercises did not improve significantly the visual-spatial skills of the students.

The teaching experience

Teaching the course in this manner was an extremely enjoyable experience. The students were not informed about the nature of the experiment; they appeared unaware that any special emphasis was being placed on the women students. All the details of women chemists were incorporated as if they were just examples of interesting research. The female guests were well received and more questions were asked by the male students than by the female students. In fact, it was the male students who said that this was a good idea and more teachers should invite guests to the class.

The female-friendly content was easily incorporated into the regular curriculum and there was no evidence that the male students were bored by it.

The students seemed to enjoy the visual-spatial exercises. Using the computer appeared to be fun for all the students and, although many of the students, particularly the females, were unfamiliar with the operation of the Macintosh computer, they were soon using it with speed and confidence.

The results of the main study

The randomly assigned groups were found to be comparable on their initial attitudes. Using analysis of variance, the mean scores on each item for males in the experimental group were compared to the mean scores for males in the control group, and, similarly, for females. No significant differences were found between the responses of males in the two groups or the responses of females in the two groups on any of the items.

Attitudes to the chemical industry

The results of the pretests (Version 3 of the Attitude Measuring Instrument), showed that, as anticipated, male students had more positive attitudes to the chemical industry than did female students, as measured by the Attitude to Chemical Industry Scale. This scale resulted from summing the scores on seven of the items on the Attitude Measuring Instrument. The scores were on a 28-point scale where a lower score corresponded to a more positive attitude. The mean score for male students (16,5, N=107) was significantly lower than the mean score for females (17,2, N=90), $t(196) = 2.04$, $p \leq .05$.

<u>Interest in course content</u>

The level of interest in the course content was determined using Question #21 on the two post-test versions of the Attitude Measuring Instrument, Versions 4 and 5. The level of interest in the course content was dependant on the instructor, since there were significant differences in the mean scores from one group to another for both male and females on this question using a t-test. This was anticipated since the overall ability to inspire interest in a course will depend on the teacher's style and presentation. For this reason, an analysis of the level of interest in the course content was carried out for the two instructors who taught both an experimental and a control group, Male A and Female B. The level of interest in the course was measured on a 5 point scale where a score of one indicated a high level of interest. For female students taught by Male A, those students experiencing the intervention had a mean score (1.9) that was significantly lower than the mean score for those in a control group (3.1), $t(33) = 2.40$, $p \leq .05$. Similarly for the female students taught by Female B, the mean score for the students experiencing the intervention was 2.1 and for the control group was

2.9, $t(33) = 3.04$, $p \leq .05$. There was no significant difference in the attitudes of the male students for either instructor.

<u>Changes in attitudes to the chemical industry resulting from the intervention</u>

To assess the change in attitudes to the chemical industry resulting from the intervention, difference-scores on the Attitude to Chemical Industry Subscale were used. For each student, the difference in score on the scale between the pretest and post-test scores was calculated. A change in attitude score was computed for each participant by subtracting the post-test score from the pretest score. In this way, a participant whose attitude became more positive had a positive difference-score and the greater the attitude change the larger the difference-score. The results indicated that females in the experimental group had become more positive in their attitudes to the chemical industry as measured by the ACIS scale during the course of the semester than did the control group. Females in the experimental group the mean difference-score was + 1.32 ($\underline{N} = 52$) and in the control group, the mean difference-score was +.03 ($\underline{N} = 38$). The intervention did not appear to have had an effect on male students. For males in the experimental group the mean difference-score was -.07 ($\underline{N} = 56$) and in the control group the mean difference-score was -.08 ($\underline{N} = 51$).

		Sample size	Mean difference score	SD
Females	Experimental Control	52 38	1.32 .03	1.6 .64
Males	Experimental Control	56 51	.07 .08	1.3 1.2

Table 5.1 Standard deviations of the means difference scores on the Attitude to Chemical Industry Subscale

Evidence for the existence of a significant gender x treatment effect was obtained from a hierarchical regression analysis of these difference-scores. Hierarchical regression analysis was used to handle the data because of the unequal sample size for females between the experimental and the control group. The variables were entered in the following order: gender, treatment, interaction. There was no significant main effect for either gender or treatment, however, there was evidence of a significant gender x treatment effect, $\underline{F}(3, 194) = 12.15$, $p \leq .05$. These results are summarized in Table 5.1. and they are represented pictorially in Fig. 5.1. The regression equation was

$$y = .17 \text{ (gender)} + .049 \text{ (treatment)} + 1.2 \text{ (gender x treatment)} -.12$$

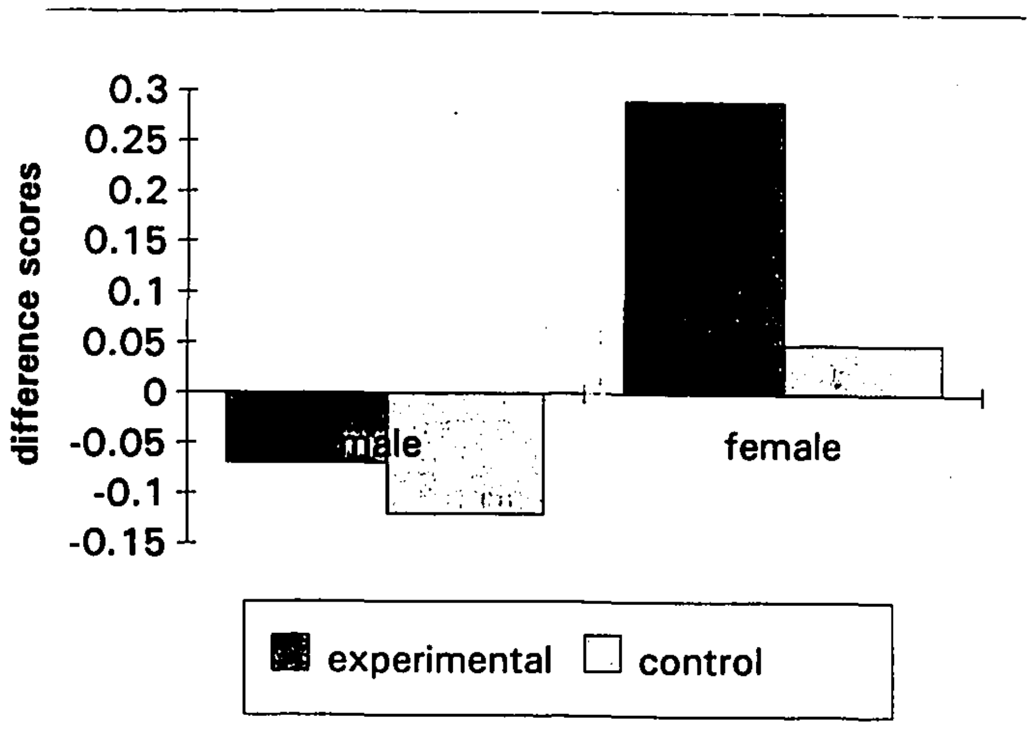


Fig. 5.1. Means of difference scores on the Attitude to Chemistry Subscales

<u>Changes in attitudes to stress when functioning in a male dominated environment</u>

To assess changes in the perception of female students to the stress involved in working in a male-dominated environment resulting from the intervention, a difference-score between pretest and post-test was calculated on the Stress Subscale. The more positive the value, the greater was the change in the student's perception during the semester; a positive value indicated a more positive perception of the stress resulting from working in a male dominated environment at the end of the semester than at the beginning of the semester. The mean change for female students in the experimental group ($\underline{N}$ = 52) was

1.3, whereas, the mean change for female students in the control group (N = 38) was 0.01. Linear regression of difference scores against treatment showed a treatment effect for female students. Female students who received the treatment had significantly greater change in their perception of the stress involved in working in a male dominated work place than did students who did not receive the treatment, correlation coefficient = 0.279, $p \leq .05$.

<u>The career intentions of students</u>

Students' career intentions were determined at the start of the semester using Question #s 21-23 on the pretest, Version 3 of the Attitude Measuring Instrument, and at the end of the semester on the post-test by Question #s 18-20, Version 4 and 5 of the Attitude Measuring Instrument. Results indicated that, for students who completed the course, the number of female students interested in a career in the physical or applied sciences increased and that the increase was greater in the experimental groups than in the control groups. Some males who completed the course turned away from engineering, but there were no obvious differences between the experimental and control groups. These results are summarized in Table 5.2.

	Females			Males		
	initial	final	difference	initial	final	difference
Experimental	14	23	+7	43	41	-2
Control	16	15	-1	35	35	0

Table 5.2 Mean change in interest in engineering as a career for both male and female students with and without the intervention.

Student responses to the interventions

The visits of the female engineers were considered interesting by about 80% of both male and female students (see Table 5.3). No students commented on the fact that the visitors were women. This would indicate that, to some extent, women engineers are being accepted as normal. Using chi-square analysis the differences were not significant.

	Males (N=59)	Females (N=54)
Very interesting	28%	18%
Interesting	48%	65%
Don't know	12%	4%
Not interesting	12%	9%
Very negative	0%	4%

Table 5.3 The interest in the visiting engineers of male and female students

Only 30% of the students, both male and female, in the experimental groups indicated that they read the profiles of women chemists and chemical engineers inserted in the lab manuals. Although the teachers pointed out the existence of the profiles they did not insist that the students read them.

Sixty-seven percent of the male students and 83% of the female students stated that they found the material on the environment interesting (see Table 5.4). Using chi-square analysis, no significance can be accorded to these differences.

	Males	Females
Very Interesting	13.3%	22.2%
Interesting	53.3%	59.3%
Don't Know	16.7%	11.1%
Not Interesting	16.7%	7.4%

Table 5.4 The students' level of interest in the environmental material presented to the experimental groups.

Instructors' responses to the intervention

All the instructors responsible for the experimental groups were positive about the experience. They said that they found the additional material interesting and they could easily fit it into the course. None of the instructors had a problem completing the curriculum, despite the addition of the extra material. All of them said that they would be prepared to make the changes permanent if they were shown to be beneficial. Three instructors also said that the department should consider making similar changes in the other chemistry courses. One instructor said that he enjoyed using the slide presentations as he found that they encouraged students to ask questions and facilitated classroom discussion. Another commented that the visits of the engineers brought a "taste of the real world into the classroom".

All the instructors agreed that it is important to have more women scientists and engineers, but they do not necessarily view the problem in the same way. Male instructors see the lack of women in these professions as being due to the fact that science is difficult, logical and a lot of work, and that both male or female students find the program daunting. The female instructors, however, responded that the problem was with society. They felt that when men accept women as being intelligent and career-minded, girls will no longer be deterred from the field.

The significance of these results will be discussed in the following chapter.

CHAPTER 6: DISCUSSION

The results of this experiment shed some new light on the attitudes of female students that lead them to avoid university studies in the fields of theoretical and applied physical sciences. There is evidence that it is possible, using a female- friendly curriculum, to change the attitudes of these students to applied chemistry. There is also some indication that this attitude change can increase the interest of female science students in a career in the theoretical or applied physical sciences. This being the case, it is evident that there is need for a change in the way that the physical sciences are taught at the college level in order to promote the entry of more women into these fields.

Attitudes of female cégep students

The pretest results of both the pilot study and the main experiment demonstrated that female science students at the college level have more negative attitudes than male students, both to the societal role of the chemical industry and to the chemical industry as a potential employer. This is in line with a large body of literature that indicates that the attitudes of female students to the theoretical and applied physical sciences are more negative than those of male students. The results of much of this research is difficult to interpret, however, since the definition of attitudes to science varies from one researcher to another as the attitude object is defined differently. In this experiment, a measuring instrument was developed specifically to measure students' attitudes to the chemical industry, both as a potential employer and as a part of society.

One explanation for these more negative attitudes views them as a result of females' lower levels of ability in mathematical problem solving skills and visual-spatial skills (Steinkamp and Maehr, 1983, The Educational Testing Service, 1989, Haggerty, 1991, Maple, 1991). The pilot study demonstrated that amongst science students at Champlain College, St. Lambert, as in the population at large, there is a significant gender-difference in visual-spatial ability; the ability of males is superior as measured by standardised tests. The study also confirmed other studies (Witkin, 1948, Blade and Watson, 1955, Brinkmann, 1963a, 1963b, Allaire and Pallascio, 1987) that experience in a science program will improve these abilities in students; however, the special exercises did not appear to provide any additional benefits. The fact that the visual-spatial abilities of the female student are lower than those of males is usually explained by their lack of experience in activities, such as outdoor play, equipment repair, map reading and model building, that develop this ability. If this were true, then, as a result of the special exercises, the gender gap would have closed if experience is the primary determinant of this ability. However, since both male and female scores increased during the first semester, an alternative explanation seems necessary.

Since, however, in Quebec's college system the achievement of female students in all programs, including science, is equal or even superior to that of male students, it is unlikely that mathematical ability as evidenced by problem-solving skills or visual-spatial skills is the determining factor in the development of attitudes to the physical and applied sciences. This hypothesis is indirectly supported by the results of this experiment. Visual-spatial training was included as a component of the pilot study, since it was designed to emulate the GIST study as closely as possible. The lack of any obvious benefits would seem to indicate that it is more profitable to attempt to change students attitudes directly than to attempt to develop skills in a short time span. This is not intended to imply that any attempt to improve the mathematical ability of female students is not important; the elimination of this gender gap should be of concern to all educators.

The results of the pretest in the pilot study indicated that the attitudes to the chemical industry and the role of chemistry in the world were independent of the students' interest in chemistry as an academic subject. Female students used more positive words to describe chemistry as a subject of study than did male students.

The best explanation for the more negative attitudes of female students is that it is based on the perception that chemicals are harmful to the environment and that the chemical industry poses a threat, both to society in general and to women in particular. These results support previous findings that female students are more concerned with the humanitarian aspects of science than with technology as a marvel or as a driving force for the economy. This gender difference supports the findings of Gilligan (1982), that females are more concerned with the effects of ethical decisions on individuals than with a commitment to any absolute idea of right and wrong.

The reliability of the attitude measuring instruments

The measuring instruments used in both the pilot and the main studies can be considered to be reliable since several internal checks were put in place: focus groups of similar students were used in the preparation of both the instruments, both instruments were tested at another cégep using both negative and positive forms of the attitude questions; all instrument testing was done with students who were not directly involved in the experiment. Most of the questions on the instrument used in the pilot study were modified versions of questions from other well-tested instruments; those used in the main study were, however, developed by the researcher.

Career aspirations of female cégep science students

The results of the pretest, in both the pilot study and the main study, indicated that significantly fewer female than male students were anticipating a career in the applied or theoretical physical sciences. This was expected since the enrollment rate of female students in both the engineering and physical science faculties in Quebec universities is around 20% and 35% respectively.

The research supports the hypothesis that one of the contributing factors to this phenomenon is females' fear of the stress inherent in working in a male-dominated environment. The pretest results of both the pilot and the main studies supported previous findings that female students in cégep in nontraditional programs are concerned about the level of stress they will encounter in nontraditional careers (Ricard, 1988). The results also indicate that there is a relationship between the perception of stress and the willingness to contemplate a career in the theoretical or applied physical sciences.

There are several possible sources of this concern. The image of industry, especially the chemical industry, portrayed by the media is of an alienating, mechanistic, anti-human environment dominated by white-coated, unfeeling males. Also, since girls are used to relying on friends, especially other girls, to accompany them to new places or to meet new people and are in the habit of sharing the events of the day with female companions, a predominately male environment does not appear to be welcoming or supportive.

Changing attitudes of female students to the societal role of the chemical industry

The results of the main study indicated that, with the implementation of a female-friendly curriculum and the provision of appropriate role models, it is possible to encourage female students to develop a more positive attitude to the chemical industry without negatively affecting the attitudes of male students.

One aspect of the female-friendly curriculum was developed on the assumption, supported by research, that the more negative attitudes of female students derive, at least in part, from females' different interests was to include information about some of the practical applications of chemistry that were of interest to female students and to include some of the ways that chemistry has in the past, and could in the future, improve the quality of both human life and the physical and biological environment.

The responses to the Student Interest Questionnaire confirmed previous findings, that, despite the higher level of approval expressed by female students in the subject matter of chemistry, they are interested in different aspects of the subject from males. The findings supported previous research that female students are interested in matters concerning health and the environment. Males were shown to have a lower level of interest in these areas (Smail, Whyte & Kelly, 1982) and a higher level of interest in subjects with a direct application to engineering.

The other focus of the intervention was to demonstrate to the female students that the goals and values of the chemical industry do not necessarily conflict with a their ideas of right and wrong. This was done by incorporating into the syllabus information about practical applications of chemistry that had resulted in an increased quality of life or that were instrumental in protecting the environment. These values were further emphasized by the visiting engineers.

The results indicated that, with a multi-factored intervention, it is possible to change the attitudes of female students to the chemical industry and that this attitude change persists over several weeks. This confirms the results of the GIST study, (Smail, Whyte & Kelly, 1984) which, using somewhat more extensive interventions, achieved comparable results.

Changing the career aspirations of female students

The data from the main study indicated that, as a result of the intervention, female students were less concerned about the level of stress entailed in working in a male-dominated environment and were more ready to consider a career in the theoretical or applied physical sciences.

The influence of the role models in the classroom in promoting these attitude changes can not be underestimated. It is quite possible that young female adults have very little information about what it is like to be a female in an engineering class, what types of summer jobs are available and what it is really like for a woman to work in an engineering-related industry. They are also, perhaps, unaware of the variety of jobs that are available. The visitors to the class were apparently happy, well-adjusted women, who enjoyed working in a predominantly male environment and did not feel their chances of advancement were reduced because they were female. In fact, the women provided examples of how the chemical industry is adapting to having larger numbers of women in supervisory positions. If a woman is seeking a transfer, the company will help place the husband in a suitable job in the new location. Maternity leave benefits are improving and women are less likely to be relegated to the sidelines if they take maternity leave. The interventions emphasized that chemistry and chemical engineering are certainly fields where women can achieve satisfaction and material success.

We can probably assume that this type of information, coming from a highly reliable source, could influence women students. If intention to act is a an indicator of action and, if intention is mitigated by both the individual's perception of the perceived norms of influential others and the individual's own attitudes, it is possible that the role models could influence the former as well as the latter.

If we assume that female students' attitudes have been learnt from significant others, then the exposure to positive role models, who had found rewarding careers in the chemical industry, should have affected their attitudes and should also have encouraged them to copy this behaviour. It is not surprising that students in the experimental group were more open to careers in the applied sciences, since attitude has been shown to be one determinant of career choice.

It is frequently argued, usually by women (Franklin, 1990, Hanen, 1990), that it is important that more women enter the theoretical and applied physical sciences, since women's viewpoint is different from that of men, and should be reflected in the development of new technologies. This difference is confirmed by this research. The belief that women are more interested in topics related to health and the environment than they are in topics related to heavy industry and are more concerned about the negative impacts of the chemical industry in these areas has been supported. It seems reasonable, then, to assume that, if more women become involved in the decisions that influence the direction of scientific research and the application of research findings to production, the priorities of new technologies might change in the direction of making more of an effort to preserve the health of both the individual and the planet.

Validity of the results

The results can be accepted as having a high level of internal validity since all the necessary precautions were taken. The experimental design used (pretest-post-test, experimental-control group) eliminated all the major threats to internal validity (see pp. 68-69). The samples were valid since all students in the course for one year were involved in the experiment; students were randomly assigned between experimental and control groups and the pretest confirmed that the experimental and control groups were comparable. There should not have been a problem of regression towards the mean as the students were not especially selected. All first year students in the science program at the College were part of the experiment, either in an experimental or a control group. The problem with validity concerned the influence of the instructors. Since they were aware that they were part of an experiment, this could have been a problem if they had a hidden desire that the experiment would show some positive results. Subsequent behaviour on the part of the instructors indicates that they probably were not trying to influence the results either favourably or unfavourably.

Alternative approaches to the problem

The quantitative research yielded some interesting results but gives us a limited picture of how female chemistry students feel about being in a so-called masculine science. We do not know how they come to choose science as a discipline of study or what are the factors that cause them to change into a different field. An alternative approach would have been to interview students at various times during their cégep career and discuss with them their fears, problems, triumphs and aspirations within the field. This however, was not the methodology used in the GIST study and this experiemnt, as much as possible replicated that study.

Role of the instructors

The results indicate that all the instructors involved in the experiment found the female-friendly curriculum interesting and rewarding to teach, some enjoyed the opportunity of using media to present information and all claimed to have thought the visits of the female engineers were beneficial to the students.

The instructors incorporated the changes to the curriculum into their courses and made time for the visits of the female engineers despite an exceptionally full curriculum. In an interview following the experiment, both male and female instructors claimed to have enjoyed the discussions that the extra material provoked and realized that the visits from the engineers were interesting and valuable to the students.

It is at first difficult to understand why, therefore, since completion of the experiment, and despite its positive results, none of the instructors has modified his or her teaching. The audio-visual material has not been borrowed from the resource centre and no more visits from engineers, either male or female, have been organized.

This unwillingness to incorporate into their courses techniques that they have seen to be beneficial is the most disturbing outcome of the experiment. It shows that there is unlikely to be any permanent changes made to the way the sciences are taught at the college level until the instructors are convinced of the need for change. The level of autonomy of all teachers is high but this is particularly true of college teachers. There is some indication that post-secondary teachers are inclined to practice the kind of teaching style that they were exposed to at university. They were successful during this stage of their education and, therefore, tend to believe that what was beneficial for them is good for the next generation. It is sometimes difficult for them to believe that a new generation of students, raised with different values in a different world, need new techniques to motivate them.

There has been some discussion, in both the literature and at the recently held Parliamentary Commission on the Future of the Cégeps, that college teachers should, in future, be required to have professional training in pedagogy before they are hired. If this were to come about, the inclusion of a course on the importance of teaching all subjects, particularly the physical sciences, in a way that encourages the participation of women should be mandatory. Incorporating the importance of gender differences in all teacher training was one of the recommendations of the Canadian Committee on Women in Engineering (1992). This recommendation would be equally valid for post-secondary education, but it can only be implemented universally if such courses in pedagogy are compulsory. An alternative to compulsory accreditation is professional development. Trained facilitators working with professional instructors who are willing to question their techniques is one way of instigating change.

Implications for educational institutions

It is not just individual instructors, but the educational system in general that has a role to play in ensuring that girls and young women have an opportunity to participate fully in the physical and applied sciences. We can assume that new child-rearing patterns will develop in the Canadian culture which will encourage girls to seek rewarding and challenging careers. In fact, there already is evidence that parents are concerned that their daughters, as well as their sons, are able to support themselves. However, there is no evidence that other influences on the attitudes of girls are equally benign. The media and advertising are still objectifying women and emphasizing the importance of a woman's sexuality over a woman's career and intellectual potential. If the trend towards increasing the number of women participating in the pure and applied sciences is to be maintained, the role of the educational institution, as a third important influence on young women, will be vital.

If one is to take seriously the concerns of Canada's major scientific advisory bodies mentioned above that we maximize our human potential in order to compete in the global market place, then the colleges clearly have a vital role to play in ensuring that women enter the physical and applied sciences in even greater numbers. It is no longer sufficient for Canadian colleges to approach the teaching of the physical sciences in a manner that was appropriate a quarter of a century ago. In responding to the needs of a more diverse student body, educational institutions must acknowledge the crucial role they play in the career choices of all their students. To this end they need to address the professional development of instructors, particularly those in disciplines that are still dominated by white males, with a view to encouraging them to implement new curricula and attempt new teaching strategies that better respond to the interests and learning styles of women and other marginalized groups.

Although the results of this research indicated the possibility of changing the attitudes of students through curriculum intervention, no claim is made that the techniques are universally applicable. It is important that other educational institutions conduct similar experiments in order to test the external validity of these results. The experiment also did not test one of the crucial factors student motivation, namely teaching methods. It would be interesting if the Colleges would find the means to encourage instructors to experiment with more cooperative styles of teaching.

The Quebec Ministry of Education is in the process of reviewing the science curriculum in the cégeps and several experiments are under way in various cégeps that are intended to advise the Ministry on desirable changes. None of these experiments addresses the particular interests of female or minority students. Since one of the contributing factors to the high failure and drop-out rates in the colleges is the lack of motivation amongst the students, it is unfortunate that students are not being asked what could be done to increase their level of interest in their science courses.

Recommendations

1. That teacher training become compulsory for all cégep instructors. This should consist of both theoretical studies and classroom experience.
2. That all teacher training should include instruction in the different interests and learning styles of female students and appropraite pedagogical techniques to complement these differences.
3. That all chemistry courses should be rewritten to include more material of interest to female students.
4. That introductory chemistry courses should include more descriptive material and less theortical material.
5. That more research be funded on ways of increasing the retention rate of women in the theoretical and applied physical sciences.

BIBLIOGRAPHY

Ajzen, I. & M. Fishbein (1980). Understanding attitudes and predicting social behaviour. Englewood Cliffs, N.J. Prentice-Hall.

Allaire, R., & Pallascio, R. (1987). Developpement d'habilités perceptives d'objets géometriques à l'aide d'un environnement ordinateur. Montreal: Département de mathématiques et d'informatique, Université du Québec à Montréal.

Allen J.S. (1993). Cooperative learning program lauded. Sentinel, 9(2), 14.

Allport, G.W. (1935). Attitudes. In C. Murchison (Ed.), Handbook of social psychology (Vol. 2) Worchester, MA: Clark University Press.

Alting, A. & Pelgrum, W.J. (1990). The SISS in the Netherlands: Descriptives and gender differences. Studies in Educational Evaluation, 16, (3), 421-41.

American Association of University Women (1991). Shortchanging girls, shortchanging America. AAUW: Washington.

Arbanas, R. J. & Lindquist, J.R. (1990). Girls + math + science = choices: A hand book for educators. Marshall, MI: Calhoun Intermediate School District.

Association des collèges classiques de jeunes filles du Québec (1955). La signification et les besoins de l'enseignement classique pour jeunes filles. Memoire à la commission royale d'enquête sur les problèmes constitutionels, Montreal: Fides.

Bandura, A. (1977). Social learning theory. Toronto: Prentice-Hall.

Baracs, J. (1987). Twelve exercises on spatial perception. Montréal: Université de Montréal.

Baringa, M. (1991). Is "gender gap" narrowing? Science, 25, 959.

Baron, R.A., & Byrne, D. (1984). Social psychology: understanding human interaction. Boston, MA: Allyn and Bacon.

Barrows, T.S. (Ed.) (1981). College students' knowledge and beliefs: a survey of global understanding. New Rochelle, NY: Change.

Beckwith, V. & Durkin, J. (1981, September/October). Girls, boys and math. Science for the People, 6-9, 32-35.

Belenky, M.F., Clinchy, B,M, Goldberger, A & Tarule J.M. (1986). Women's ways of knowing: the development of self, voice and mind. New York: Basic books.

Benbow, C.E. & Stanley, J. (1980, December). Sex differences in mathematical ability: Fact or artifact? Science, 210, 1262-1264.

Bennett, G.K., Seashore, H.G. & Wesman, A.G. (1972). Differential aptitude tests: Administrator's Handbook. New York: The Psychological Corporation.

Berthelot, M. (1986, April). L'orientation des filles vers les metiers non traditionnels avant l'an 3000. Communication presented at the Estates General on the Quality of Education, Montreal.

Blade, M. & Watson, W. (1955). Increase in spatial visualization test scores during engineering study. Examples of test questions (Psychological Monographs: General and Applied, No. 397). New York: American Psychological Association, Inc.

Blair, V. (1993). University females: Persistence in math. Paper presented at the annual conference of the CSSE, June 12, 1993, Ottawa.

Bleier, R (1984) Science and Gender. Oxford: Pergamon Press.

Blosser, E. (1984). Attitude research in science education. Columbus, Ohio: Eric Clearinghouse of Science, Mathematics and Environmental Education.

Blosser, P.E. (1990). Procedures to increase the entry of women into science related careers. Science Education Digest, No. 1. Columbus, OH: Ohio University Press.

Boisset, A., MacKenzie, J., & Siderenko, C. (1989). Persistence in science: gender and program differences. Montreal: Cégep John Abbott College.

Bottomley, J., & Ormerod, M.B. (1977). Middle school science activities and their association with liking for science. Uxbridge, England: Department of Education, Brunel University.

Bournival, M.T. (1986, November-December). Profession? Femme de sciences! La Gazette des femmes, 8.

Brinkmann, E. (1963a). Educability in visualization of objects in space: A programmed instruction approach. Ann Arbor MI: Unpublished doctoral thesis, University of Michigan.

Brinkmann, E. (1963b). Programmed instructions as a technique for improving spatial visualization. Journal of Applied Psychology, 50(2), 179-184.

Bruner J.E. (1960). The process of education. Cambridge: Harvard University Press.

Burgess, D. A. (1978). Education and social change, a Quebec case study. Unpublished doctoral thesis, Harvard University, Boston.

Burke, K. (1962). A grammar of motives, and a rhetoric of motives. Cleveland: World.

Campbell, D.T. & Stanley, J.C. (1963). Experimental and quasi experimental designs for educational research. Boston: Houghton-Mifflin.

Canadian Committee on Women in Engineering (1992). More than just numbers. Fredericton: University of New Brunswick.

Carpentier, R. (1988). Les filles et les formations non traditionelles: de l'intérêt mais beaucoup d'obstacles. Quebec: Ministère de l'Éducation du Québec.

Chamberlain, M.K. (1992). Women in academe: Progress and prospects. New York: Russell Sage Foundation.

Churgin, J.R. (1978). The new woman and the old and academe: sexism and higher education. New York: Libra.

Ciborowski, J. (1980). A career education: Seminars for high school females. School Counsellor, 27(4), 315-317.

Cobern, W.W. (1989, March). World view and science education research: Fundamental epistemological structures as a critical factor in science learning and attitude development. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Collette, J.P. (1980). Mesures des attitudes des étudiants du collège à l'égard des mathematiques. Quebec: DGEC, Ministry of Higher Education and Science.

Connelly, F.M., Crocker, R.K. & Kass, H. (1985). Achievement and its correlates: Science education in Canada, Vol. 1. Toronto: Ontario Institute for Studies in Education.

Connelly, F.M., Crocker, R.K. & Kass, H. (1989). Achievement and its correlates: Science education in Canada, Vol. 2. Toronto: Ontario Institute for Studies in Education.

Conseil de la science et de la technologie, (1986). Avis: la participation des femmes en science et technologie au Québec. Quebec: Government of Québec.

Conseil du statut de la femme (1976). L'access à l'education pour les femmes. Quebec: Government of Quebec.

Conseil du statut de la femme (1985). La femme en Québec. Background paper prepared for the Decisions '85 conference, Quebec.

Corriveau, L. (1991) Les cégeps: Question d'avenir. Quebec: Institut québécois de recherche sur la culture.

Crabbé, L., Delfosse, M-L., Verlaecht, G. & Giardo, L. (1985). Les femmes dans les livres scolaires. Bruxelles: Pierre Mardaga.

Crandall, V.C. (1969) Sex differences in expectancy of intellectual and academic reinforcement. In C.P. Smith (Ed.), Achievement related motives in children. New York: Russell Sage.

Davis, C-S & Hollenshead, C. (1993). Mary Sarah Parker Scholars: A pipeline program for undergraduate women in engineering. Proceedings of the Gasat 7 conference, University of Waterloo: Ontario Women's Directorate.

Davis, F., Steiger, A. & Tennenhouse, K. (1989). Stratégies féministes dans la classe de mathématiques in L. Lafortune (Ed.), Quelles différences? Les femmes et l'enseignement des mathématiques. Montréal: Les éditions du remue-ménage.

Davis, F., Steiger, A., & Tennenhouse, K. (1990). A practical assessment of feminist pedagogy. Québec: Direction générale de l'enseignement collégial.

Defense Research Establishment, Valcartier (1992). Women and science at DREV. Ottawa: Government of Canada.

Deutsch, G. (1988). Visuo-spatial tasks compared via activation of regional cerebral blood flow, Neuropsychologia, 26(3), 445-452.

Direction générale de l'enseignement collégial (1990). Démythification de la chimie: matériel didactique "Operation boules à mythes". Québec: Gouvernement du Québec.

Dohment, M. & Barthe, M. (1973). La femme au Québec. Montréal: Les presses libres.

Doran, M-A., Moisan, M.G., & Morneau, J. (1988). Plan d'action pour le recrutement et l'intégration de la clientele femininine. Quebec: Université Laval.

Dunlap, J. (1990). Hearing female voices in the life science classroom. Humane Innovations and Alternatives in Animal Experimentation, 4, 142-143.

Dweck, C. S. (1976) Children's interpretation of evaluative feedback: The effect of social cues in learning helplessness. Merrill-Palmer Quarterly, 22(2), 105-109.

Educational Testing Service (1989). The gender gap. ETS Policy Notes, 2(1).

Engstrom, J.A., & Noonan, R. (1990). Science achievement and attitude in Swedish schools. Studies in Educational Evaluation, 16(3), 443-56.

Edwards A.L. (1957). Techniques of attitude scale construction. Boston: Allyn and Bacon.

Erickson, G.L. (1981). Intervention Techniques for Girls in Science: Assessment and Recommendations. Paper presented to the Workshop the Science Education of Women in Canada. Ottawa: Science Council of Canada.

Erickson, G.L. & Erickson, L. (1984). Females and science achievement: Evidence, explanations & implications. Science Education, 68(2), 63-89.

Ethington, C.A., & Lee, M.W. (1988). Women's selection of quantitative undergraduate fields of study: Direct and indirect influences. American Educational Research Journal, 25(2), 157-175.

Farmer, H. (1985). Model of career and achievement. Motivation for women and men. Journal of Counselling Psychology. 32(3), 363-390.

Fassinger, R.W. (1990). Causal model of career choice on two samples of college women. Journal of Vocational Behaviour, 6, 225-258.

Favreau, M (1972, April). Les étudiants au cégep: y préparer un nouveau type de femme. Châtelaine, 22.

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

Festinger, L.A. (1957). A theory of cognitive dissonance. Evanston, IL: Row, Peterson.

Fishbein, M. & Ajzen, I. (1975). Belief, attitude, intention, and behaviour. Reading, MA.: Addison-Wesley.

Fishbein, M & Ajzen, I. (1972). In P.H. Mussen and M.R. Rosenzweig (Eds.), Annual Review of Psychology, 23, 487-544.

Franklin, U. (1990). The Massey Lectures, Ottawa: CBC.

Friere, P. (1990) Pedagogy of the oppressed. New York: Continuum.

Fuchs, V.R. (1986). Sex differences in economic well-being. Science, 232, 459-464.

Gagné, E., & Poirier, P. (1990). Le choix de carrière de la femme dans une perspective systémique. Ottawa: Les presses de l'Université d'Ottawa.

Gagnon, C. (1989). Favoriser la présence des femmes en génie, L'Ordre des ingénieurs du Québec, Plan, 36-40.

Galarneau, C. (1973). Les collèges classiques au Canada français. Montreal: Fides.

Gardner, J. (1976). Attitudes towards physics: Personal and environmental influences. Journal of Research in Science Teaching, 13, 111-125.

Geschwind, N. (1987). Cerebral lateralization. Cambridge, MA: M.I.T. Press.

Giese, P.A. (1993). Helping teachers maximize the learning of female students. Proceedings of the Gasat 7 Conference, Waterloo, Canada.

Gillbert, C. (1988). Women-friendly chemistry. St. Lambert: Champlain College.

Gillett, M. (1966). A history of education; thought and practice. Toronto: McGraw-Hill.

Gillett, M. (1981). We walked very warily. Montreal: Eden Press Women's Publications.

Gilligan, C. (1982). In a different voice: Psychological theory and women's development. Cambridge, MA: Harvard University Press.

Gornich, V. (1984). Women in science: Portraits from a world in transition. New York: Simon and Shuster.

Government of Quebec (1964). The report of the Royal Commission of Inquiry on Education: The Parent report. Quebec: Province of Quebec.

Government of Quebec (1955). Report of the Royal Commission of Inquiry into the Constitution: the Tremblay Commission. Quebec: Province of Quebec.

Gouvernment of Québec (1984). La réussite scolaire. Bulletin Statistique,. 9 (7).

Gray, J.A. (1984). A biological basis for sex differences in achievement in science? In A. Kelly. (Ed.), The missing half: Girls and science education. Manchester: Manchester University Press.

Guilbert, C. (1987). Caractéristques d'étudiantes dans des disciplines traditionnelles ou non traditionelles. Unpublished Ph.D. thesis, McGill University.

Guilbert, L. (1985, October). L'entrée des femmes dans les sciences, le génie et la technologie. Spectre, 10.

Gur, R. C. (1980). Differences in the distribution of gray and white matter in human cerebral hemispheres. Science, 207, 659-661.

Haggerty, S.M. (1991). Gender and school science: Achievement and participation in Canada. Alberta Journal of Educational Research, 37(3), 195-208.

Hanen, M. (1990, June-July). Women in science and technology: The why matters as much as the how. Affaires Universitaires, 48.

Hasan, M. (1985). An investigation into factors affecting science interest of secondary school students. Journal of Research in Science Teaching, 12(3), 255-261.

Harding, S.A. (1991) Whose science? Whose Knowledge? Ithica, NY: Cornell University Press.

Henchey, N & Burgess D. (1987). Between past and future: Quebec education in transition. Calgary, Alberta: Detselig.

Hobbs, E.D., & Erickson, G.L. (1980). Assessment of science in British Columbia. Canadian Journal of Education, 5(12), 63-80.

Holden, C. (1991). Is "gender gap " narrowing? Science, 25, 959-960.

Hyde, J.S. (1990). Gender differences in mathematics performance: a meta analysis. Psychological bulletin, 107, 139-55.

Hyde, J.S. (1985). Half the human experience. Toronto: Heath.

Jean, M. (1974). Québécoises du 20e siècle. Montréal: Éditions du jour.

Johnson, J. (1989, February). The effects of successful female role models on young women's attitudes towards traditional male careers. Proceedings of the Annual Meeting of the Association for Educational Communications and Technology, Dallas, TX.

Johnson, J.A., Cheek, J.M., & Smither, R. (1983). The structure of empathy. Journal of Personality and Social Psychology, 45, 1200-1312.

Jones, A.T. & Kirk, C.M. (1990). Gender differences in students' interests in applications of school physics. Physics Education, 25(6), 308-13.

Kahle, J.B., & Lakes, M. (1983). The myth of equality in the science classrooms. Journal of Research in Science Teaching, 20(2), 131-140.

Keeves, J.P. (1988). Educational research, methodology and measurement: an inter national handbook. Toronto: Pergamon Press.

Keller, E.F. (1983). A feeling for the organism: The life and work of Barbara McClintock New York: Freeman.

Kelly, A. (1984). The missing half: Girls and science education. Manchester: Manchester University Press.

Kelly, A. (1978). Girls and science. Stockholm: Corals.

Kiesler, C.A., Collins, B.E. & Miller, N. (1969). Attitude change: A critical analysis of theoretical approaches. New York: John Wiley.

Klainin, S. (1989). The superior achievement of girls in chemistry and physics in upper secondary schools in Thailand. Research in Science and Technology Education, 7(1), 5-14.

Koballa, T.R. & Crawley, F.E. (1985). The influence of attitudes on science teaching and learning. School Science and Mathematics, 85(3), 222-232.

Lamonde, J. (1984). La réussite scolaire au collegial. Bulletin statistique, recherche et developpement, 9(7).

LaPiere, R.T. (1934). Attitudes versus action. Social Forces, 18, 230-237.

Leblanc, A. (1972). The educational literature of the quiet revolution. McGill Journal of Education, 7(2), 175-188.

Lee, L. (1987). Des épouvantails qui effraient les femmes. Revue québécoise de psychologie, 8(3), 154-164.

Lee, L. (1984). Étude des facteurs limitant l'orientation des adolescentes dans les programmes de formation non-traditionnels. Working document. Quebec: Ministry of Education.

Lie, S. & Brylim, E. (1983). Girls and physics: Attitudes, experiences and underachievement. Paper presented at the second GASAT conference. Oslo

University, Oslo.

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

Maccoby, E.E. (1970). Feminine intellect and the demands of science. Impact of Science on Society, 10(1), 13-28.

Maple, S.A. (1991). Influences on the choice of math/science major by gender and ethnicity. American Educational Research Journal, 28(1), 37-60.

McGuire, W.J. (1968) Theory of the structure of human thought. In R.P. Abelson (Ed.), Theories of cognitive consistency : a source book. Chicago: Rand McNally.

McGuire, W.J., (1985). Attitudes and attitude change. In Lindzey G. & Anderson, E. (Eds.), Handbook of social psychology. New York: Random House.

McMiller, L. (1987, August). Step up recruitment of women into science or risk loss of competitive edge in field, colleges warned. Chronicle of Higher Education, 9, 12.

McNeil, E.B. & Rubin, Z. (1977). The psychology of being human. New York: Canfield Press.

Ministère de l'Éducation (1988). Les filles et les formations non traditionnelles: de l'intérêt mais beaucoup d'obstacles. Québec: Gouvernement du Québec.

Mischel, W. (1966) A social-learning view of sex differences in behaviour. In E.E.Maccoby (Ed.), The development of sex differences. Stanford, CA: Stanford University Press.

Montreal University Women's Club (1974). Étude sur le rôle des sciences domestiques dans la formation de la jeunes. In M. Jean (Ed.), Québécoises du 20e siècle. Montréal: Éditions du jour.

Morazain, J. (1985, September-October). Pourquoi les filles boudent les sciences? Ma Caisse, 22(5), 18-23.

Munby, H. (1983a). An investigation into the measurement of attitudes in science education. Columbus, OH: Ohio State University Information Reference Center for Science, Mathematics and Environmental Education.

Munby, H. (1983b). Thirty students involving the "Scientific Attitude Inventory": What confidence can we have in this instrument. Journal of Research in Science Teaching, 20(2), 141-162.

Mura, R., Cloutier R. & Kimball, M. (1985). Les filles et les sciences. Proceedings of the International Conference of the Position of Girls: Le temps d'y voir. Montreal.

Mura, R. (1983). Doorways to Science Education, Women & Mathematics. Proceedings of the First National Conference of Women in Science, Engineering and Technology. Vancouver, BC.

Mura, R. (1985). Filles et garçons face à la mathématique: égalité des chances. Congrès de APAME, Trois Rivières. Reprinted in September 1985, Instantes Mathematiques.

National Research Council (1991). Women in science and engineering: Increasing their numbers in the 1990's. Washington D.C.: National Academy Press.

Neagley, R.L. & Evans, N.D. (1967). Handbook for effective curriculum development. Englewood Cliffs, NJ: Prentice-Hall.

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

Ormerod, M.B. & Duckworth, D. (1975). Pupils attitudes to science. A review of research. Slough, England: NFER Publishing.

Ormerod, M.B. (1981). Factors differentially affecting the science subject preferences, choices and attitude of girls and boys. In A. Kelly (Ed.), The missing half. Manchester: Manchester University Press.

Ormerod, M.B. (1979 April-June). Pupils attitudes to the social implications of science. European Journal of Science Education, 1(2), 178-189.

Phenix, P.H. (1960). The topography of higher learning. Phi Delta Kappan, 41, 307.

Phenix, P.H. (1964). Realms of meaning. New York: McGraw-Hill.

Pflaum, R. (1989). Grand obession. New York: Doubleday.

Piper, D.W. (1982) The Question of fairness. In S. Akker & D.W. Piper (Eds.), Is higher education fair to women? London: SRHE & NFER-Nelson.

Place, C. (1979). The visiting women scientist program, 1978-79 (Final report). Durham, NC: Center for Educational Research and Evaluation Research Triangle Institute.

Pomfret D.A. & Gilbert, S.N. (1991, May). "Did they jump or were they pushed?":

Gender preferences affecting attrition among science and engineering students. Paper presented at Women in Engineering: More than just numbers conference, University of New Brunswick.

Popham, W.J. (1972). Educational needs assessment. In J. Weiss (Ed.), Curriculum theory network, Monograph supplement, curriculum evaluation: Potentiality and reality. Toronto: OISE.

Ramsden, J.M. (1990). All quiet on the gender front? School Science Review, 72(259), 49-55.

Rhéaume, C. (1985). La situation des femmes en éducation collégial, 1978-1984. Québec: Service de la recherche et du developpement, DGEC.

Ricard, C. P. (1988). Sexisme et education - analyse des attitudes sexistes des étudiants et étudiantes, et des pédagogues des collèges. Montréal: Collège de Rosemont.

Rich, A. (1979). On lies, secrets and silence: selected prose. New York: Norton.

Robitaille, D.F., & Schroeder, T.L. (1992). Mathematics '90: A status report on school mathematics in British Columbia. Vancouver: University of British Columbia, Government of British Columbia.

Rogers, P. (December, 1986). Real women don't do math: A mathematics camp for grade 10 girls. Ontario Mathematics Gazette, 25, 38-43.

Rosenberg, M.J. (1960). An analysis of affective-cognitive consistency. In M.J.Rosenberg (Ed.), Attitude organization and change. New Haven: Yale University Press.

Rosser, S.V. (1986). Teaching science and health from a feminist perspective. New York: Pergamon Press.

Rosser, S.V. (1991) Female friendly science: Applying women's studies methods and theories to attract students. New York: Pergamon Press.

Rouleau, D. (1985). Étude du phénomène d'échecs et d'abandons en chimie générale. Lauzon, Québec: Cégep de Lévis-Lauzon.

Saint-Stanislas-de-Jésus (1974). L'enseignement classique féminin dans notre province, Adresse au Club Richelieu, Montréal, le 15 juin 1954. In M. Jean (Ed.), Québécoise au 20e siecle. Montréal: Editions du jour.

Samuel, J. (1981). Feminism and science teaching - Some classroom observations. In A. Kelly (Ed.), The missing half. Manchester: Manchester University.

Sandermann, M. (1979). Sex differences in high school course choice and achievements: A cause for concern. Ottawa: Ottawa Board of Education.

Schafer, A.T. & Gray, M. (1981 January). Sex and mathematics. Science, 211(4479), 1.

Schibeci, R.A. (1983). Selecting appropriate attitudinal objectives for school science. Science Education, 67(5), 595-603.

Schwirian, P.M. (1968). On measuring attitudes towards science. Science Education, 52, 172-179.

Science Council of Canada (1982). Who turns the wheel? Proceedings of a Workshop on the Science Education of Women in Canada, Ottawa, Ontario.

Secretary of State (1992). Profile of higher education in Canada. Ottawa: Government of Canada.

Shaw, E.L. & Dean, R.L. (1990, November). Attitudes and achievement between male and female second and fifth grade science students. Paper presented to the Annual Meeting of the Mid-South Educational Research Association, New Orleans, LA.

Sherman, J.A. & Fennema, E. (1978). Distribution of spatial visualization and mathematical problem solving scores. A test of Stafford's X-linked hypothesis. Psychology of Women Quarterly, 3(2), 157-167.

Smail, B., Whyte, J. & Kelly, A. (1982). Girls into science and technology: The first two years. Manchester: GIST, Department of Sociology, University of Manchester.

Smail, B., Whyte, J. & Kelly, A. (1984). Girls into science and technology: Final report. Manchester: GIST, Department of Sociology, University of Manchester.

Smith S.L., (1991). Report of the Commission of Inquiry on Canadian University Education. Ottawa: AUCC.

Spender, D., (1982). Invisible women; the school scandal. London: Writers and Readers Publishing.

Stafford, R.E. (1961). Sex differences in spatial visualization as evidence of sex-linked inheritance. Perceptive and Motor Skills, 13, 428.

Stafford, R.E. (1972). Hereditary and environmental components of quantitative reasoning. Review of Educational Research, 42, 183-201.

Statistics Canada (1992). Community colleges and related post-secondary enrolment and graduates. Ottawa: Ministry of Industry, Science and Technology.

Status of Women, Canada (1989). Participation of girls and women in math, science and technology, Proceedings of a Joint Meeting of Federal/Provincial/Territorial Minorities Responsible for the Status of Women. Toronto, Ontario.

Steinkamp, M.W. (1982). Sex related differences in attitudes toward science: A quantitative synthesis of research. (Report No. 220285). Columbus, OH: Eric Clearing House for Educational Documents.

Steinkamp, M.W. & Maehr, M. (1983). Affect, ability, and science achievement: A quantitative synthesis of correlational research. Review of Educational Research, 53(3) 369-396.

Superior Council of Education, Quebec (1984a). Women in the educational system: Lets put an end to the Cinderella complex. Educouncil, 3, 1.

Superior Council of Education, Quebec (1984b). The status of women in the education system: a double perspective. Quebec: Advice to the Minister of Education.

Tarquinio, S. (1992). Factors influencing women's selection ot science college majors. Ph.D. Thesis, McGill University.

Thivierge, N (1983). L'enseignement ménager, 1880-1970. In Fahmy-Eid, N. & Dumont, M.(Eds.), Maîtresses de maison, maîtresses d'école. Montréal: Boréal Express.

Tobin, K. & Garnett, J. (1987). Gender related differences in science activities. Science Education, 17(1), 91-103.

Torrance, E. (1963). Changing reactions of preadolescent girls to tasks requiring creative scientific thinking. Journal of Genetic Psychology, 102, 217-223.

Tuana, N. (1989) Feminism and science. Bloomington: Indiana University Press.

Turner, H. (1983). Factors influencing persistence/achievement in the sciences and health professions by black high school and college women. Atlanta: Center for Research on Women in Science, Morris Brown College.

Uhl, N. & MacKinnon, A. M. (1992). Students. In A. D. Gregor and G. Jasmin (Eds.), Higher education in Canada. Ottawa: Department of Secretary of State.

Vochell, D. & Lobonc, L. (1981). Sex role stereotyping by high school females in science. Journal of Research in Science Teaching, 18, 209-219.

Waring, D. (1982). Cognitive style and developing science attitudes in the classroom. Journal of Research in Science Teaching, 18, 73-77.

Weber, D. (1977). Sex differences in mental abilities, hemispheric lateralization and rate of physical growth in adolescence. Journal of Developmental Psychology, 13, 29-38.

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

Wiggan, L. (1982). The invisible filter: A report on math avoidance, math anxiety and career choice. Toronto: Mathematics Department, Toronto Board of Education.

Willms, D. & Jacobsen, S. (1990). Growth in mathematical skills during the intermediate years: Sex differences and school effects. International Journal of Educational Research, 14, 157-174.

Wilson, W.R. (1979). Feeling more than we can know: Exposure effects without learning. Journal of Personality and Social Psychology, 43, 811-821.

Witkin, J. (1948). The effect of training and of structural cues on performance in three tests of space orientation. (Report No. 80). Washington: Division of Research, Civil Aeronautics Association.

Women in Science, Hopefully (1988). Strategies: Intervention techniques to retain wo men in mathematics and science studies. Toronto: WISH.

Zeidler, D.L. (1984). Thirty studies involving the Scientific Attitude Inventory: What confidence can we have in this instrument? Journal of Research in Science Teaching, 21, 341-342.

Zern, D.S. (1983). The relationship of certain group-oriented and individualistically oriented child-rearing dimensions to cultural complexity in a cross-cultural sample. Genetic Psychology. Monograph, 108, 3-20.

Zuckerman, J.R. (1991). The outer circle: Women in the scientific community. New York: Norton.

Appendix A: Student interest questionnaire

APPENDIX A

The Student Interest Instrument

CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

QUESTIONNAIRE

The Chemistry Department is trying to find out what students at Champlain are interested in learning about. Some of these topics could be included in Chemistry 101, 201, Organic Chemistry or our new Environmental Chemistry course.

Please put a tick in the box that best approximates to your interest in the topic.

1. The Smelting of Aluminum

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

2. How Fluoride Toothpaste Protects Teeth

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

3. Dating of Archeological Remains

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

4. Causes of Algae Growth in Lakes and Streams

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

5. The Causes of Acid Rain

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

6. The Nature of the Electron

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

7. How the Burning of Fossil Fuels Causes Climatic Change

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

8. Linear Accelerators

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

9. The Chemistry of Pesticides

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

10. The Chemistry of DNA

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

11. Why Ice Floats on Water

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

12. Why Diamonds Sparkle

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

13. The Chemistry of Beer Making

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

14. Why Graphite Can Be Used As A Lubricant

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

15. The Manufacture of Antibiotics

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

16. The Plastics Industry

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

17. Pigments Used in Artists' Paints

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

18. How Ammonia Is Manufactured

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

19. How Lead Effects Human Health

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

20. How CFCs Destroy the Ozone Layer

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

21. Why Atoms Join Together

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

22. How Fertilizer is Manufactured

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

23. How A Silicon Chip Works

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

24. Minerals of Quebec

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

25. How A Lead Battery Works

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

26. How Oil Is Refined

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

27. How Metals Are Purified

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

28. The Chemistry of Rocket Fuels

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

29. The Use of Radioactive Elements in Medicine

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

30. The Principles of Welding

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

31. How Catalytic Converters Work

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

32. New, Ultra Strong Materials Than Can Be Used for Tennis Racquets, Skis or Electric Guitars

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

33. Ways of Cleaning Up Oil Spills

1 [1] I'd like to know more

2 [2] Not sure

3 [3] Not interested

Now I would like to ask you some questions about yourself.

34. Which chemistry class are you currently enrolled in?

111 ☐ 101 ☐ 201 ☐ 202 ☐

35. Sex: Male ☐ Female ☐

36. Overall high school average

91 - 100 ☐

81 - 90 ☐

71 - 80 ☐

61 - 70 ☐

Appendix B: Letter to Canadian universities seeking women chemists

APPENDIX B

Champlain

CHAMPLAIN REGIONAL COLLEGE
ST. LAMBERT - LONGUEUIL CAMPUS
900 Riverside Drive
St. Lambert, Quebec
J4P 3P2
Tel.: (514) 672-7360

August 3,

The Chairman
The Chemistry Department
University of Calgary
2500 University Drive NW
Calgary, Alberta
T2N 1N4

Dear Sir/Madam,

I am preparing a manual to be used in two college level courses in Chemistry in a Quebec CEGEP. I would like to incorporate some information on research done by Canadian women chemists that is relevant to the course material.

Could you give me some information about research that has been done at your University by women faculty members in physical or inorganic chemistry. If you have a list of publications of women who have made a significant contribution to knowledge in physical or inorganic chemistry this would be very helpful.

Thanking you in advance for your cooperation.

Yours truly,

Catherine Gillbert

CG/mcg

-AMPLAIN REGIONAL COLLEGE
ST LAMBERT - LONGUEUIL CAMPUS
900 Riverside Drive
St Lambert, Quebec
J4P 3P2
Tel. (514) 672-7360

le 10 septembre

Université de Sherbrooke,
Département de chimie,
Cité universitaire,
Boulevard Université,
Sherbrooke, Québec,
J1K 2R1

Madame, Monsieur,

Je suis à préparer un manuel destiné à l'enseignement de la chimie, à deux niveaux différents, dans l'un des cégeps du Québec. Je souhaite pouvoir y faire mention du travail des chercheuses canadiennes dans le domaine.

Auriez-vous l'obligeance de me faire parvenir tout renseignement pertinent relatif à la recherche faite, en chimie physique ou en chimie inorganique, par l'une ou l'autre des femmes de la Faculté? Si vous disposez d'une liste des ouvrages ou articles marquants publiés dans ces deux domaines par des femmes, je vous serais très reconnaissante de me la faire tenir.

Veuillez agréer, Madame, Monsieur, avec mes remerciements anticipés, l'expression de toute ma considération.

Catherine Gillbert

CG/ge

Appendix C: Profiles of women chemists

PENELOPE CODDING

PENELOPE W. CODDING

Penelope Codding is a professor of chemistry at the University of Calgary. She graduated from Michigan State University with a Ph.D. in 1971. The goal of her research is to understand how drugs work, in order to help in the design of new and more useful drugs. One of the techniques she uses to determine the structure of a drug is x-ray crystallography.

She is following a long line of women who have been successful in this field. The list includes Dorothy Hodgkin, who received a Nobel prize in chemistry for the elucidation of the structure of vitamin B_{12} using x-ray crystallography.

Diffraction of electromagnetic radiation including light and x-rays occurs when beams of "light" are scattered from a regular array of points or lines, in which the spacing between the components are comparable to the wavelength of the light. You will learn more about this in your Physics 301 course. The distance between atoms in a crystalline solid is similar to the wavelength of x-rays about 0,10 nm to 0,50 nm and so this is a useful way to determine the structure of molecules.

At present Penelope is working on drugs that act on the central nervous system. She studies the spatial relations of atoms within drugs which are known to act in the same manner at the same receptor sites, the points on the cell that the drug attaches itself to. These structures are compared to similar, but inactive, molecules. This helps us to better understand the way drugs work within the body and thence design new ones with the same action but fewer side effects.

GERALDINE KENNEY-WALLACE

Geraldine Kenney-Wallace is the current chairperson of the Science Council of Canada. This prestigious organization advises the Federal Government on Science Policy.

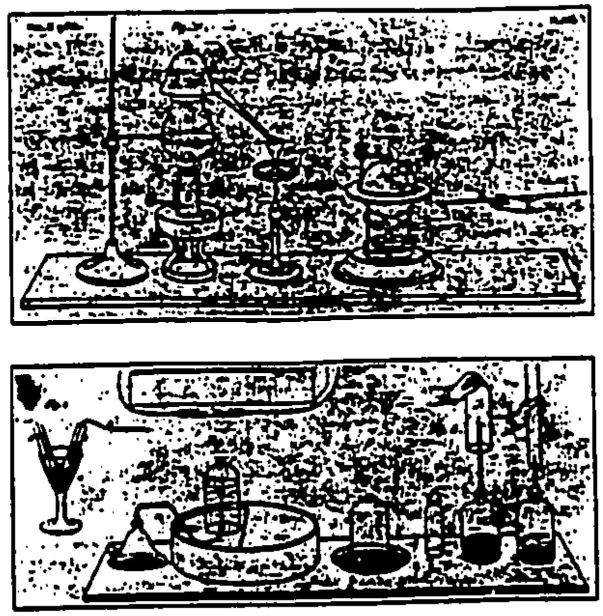
Geraldine was born in England and studied Chemistry at Oxford University. She then came to Canada and received her Ph.D. from the University of British Columbia. She has held appointments at the École Polytechnique in Paris, and at Yale and Stamford Universities in the United States. Before being appointed to the Science Council she was a chemistry professor at the University of Toronto.

She has published many research papers in both fundamental and industrial research. She has a worldwide reputation as a laser scientist but she is most interested in the areas of information technology, biotechnology and optoelectronics, rapidly growing fields that are at the forefront of modern technology.

Geraldine believes strongly in the importance of basic research. She feels that Canada must spend mor^ money on research and development in order to stay competitive in a gl . economy.

JANE MARCET

JANE MARCET, 1769–1858



ILLUSTRATIONS OF APPARATUS FROM "CONVERSATIONS ON CHEMISTRY" BY JANE MARCET, LONDON, 1817. DRAWN BY THE AUTHOR AND ENGRAVED BY LOWRY

Jane Marcet, a British woman born in 1769, can be considered as one of the most successful writers of a chemistry textbook ever. She wrote the most popular chemistry book in the first half of the 19th century and the book had 16 British editions, 15 American editions and 3 French editions.

Her book, "Conversations in Chemistry" is written in the form of a conversation between a Mrs. B and two girls, Emily and Caroline. Emily is serious and hard working, while Caroline is unenthusiastic about the subject except when there are exciting or dangerous experiments to be formed. It is probably this style, which makes the book amusing and extremely readable, that led to its popularity. The great scientist Michael Faraday tells us in a letter he wrote to a friend, that his interest in chemistry began when he picked up the book while working as a book-binder assistant.

She made sure that each new invention was included in the latest edition of the book. She thus became the first person to report on the discovery of the Group I alkali metals, by Sir Humphry Davy.

Mrs. Bryan: Before we part, I must introduce to your acquaintance the curious metals which Sir Humphry Davy has recently discovered. The history of these extraordinary bodies is yet so much in its infancy that I shall confine myself to a very short account of them; it is more important to point out to you the vast, and apparently inexhaustible, field of research which has been thrown open to our view by Sir Humphry Davy's memorable discoveries, than to enter into a minute account of particular bodies or experiments.

Caroline: But I have heard that these discoveries, however splendid and extraordinary, are not very likely to prove of any great benefit to the world, as they are rather objects of curiosity than of use.

Mrs. Bryan: Such may be the illiberal conclusions of the ignorant and narrow minded; but those who can duly estimate the advantages of enlarging the sphere of science, must be convinced that the acquisition of every new fact, however unconnected it may at first appear with practical utility, must ultimately prove beneficial to mankind.

Caroline: What a satisfaction Sir Humphry Davy must have felt, when by an effort of genius he succeeded in bringing to light, and actually giving existence to these curious bodies, which without him might perhaps have ever remained concealed from our view.

She was also interested in the practical use the chemical discoveries could be put to, as we see in this conversation.

Caroline: Mrs. B. - in those beautiful lights, called gas-lights, which are now to be seen in so many streets ... I can perceive no wick at al'. How are these lights managed?

Mrs. Bryan: In this mode of lighting the gas is conveyed to the extremity of a tube, where it is kindled and burns as long as the supply continues. There is, therefore, no occasion for a wick...

Emily: But how is this gas produced in such large quantities?

Mrs. Bryan: It is obtained from coal, by distillation...

Emily: What an admirable contrivance. Do you not think, Mrs. B. - that it will soon be universally adopted?

Mrs. Bryan: Most probably; for the purpose of lighting streets, offices, and public places, for it far surpasses any former invention; but in regard to the interior of private houses, this mode of lighting has not yet been sufficiently tried to know whether it will be found generally desirable, either with respect to economy or convenience. It may, however, be considered as one of the happiest applications of chemistry to the comforts of life...

Perhaps if chemistry textbooks were still written in this style, today's students would find chemistry a more fascinating and useful subject.

HARRIET BROOKS

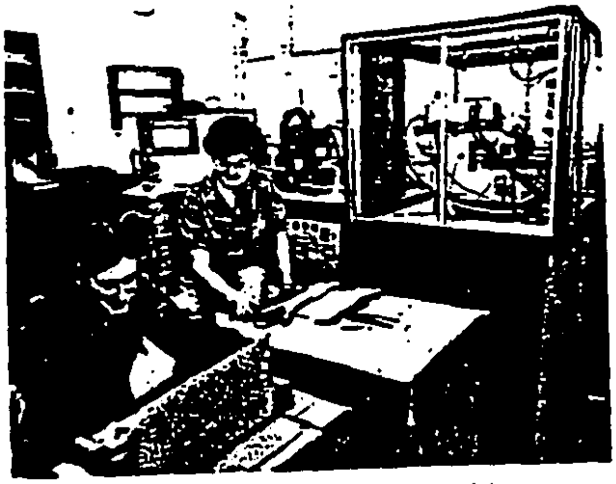
Harriet Brooks, a talented physicist and mathematician, did much of her work at McGill University where she was an assistant to Ernest Rutherford, known to us through his concept, referred to as the "Rutherford atom". He considered Harriet to be a talented researcher and expressed his disappointment when she gave up her career in favour of marriage.

She was one of the first women hired by Royal Victoria College, the women's college at McGill founded in 1899, which for the first time, gave women a residence within the university. Harriet taught mathematics and physics to the young women in her charge.

While working for Rutherford, she discovered the recoil of the radioactive atom.

She continued her research in Cambridge, England under J.J. Thomson, the discoverer of the electron, and then under Marie Curie, the discoverer of radioactivity at the Sorbonne.

SUZANNE FORTIER



Dr Fortier, Miss Marie Fraser, a graduate student and the Crystallographic Machine

Like Penelope Codding, Suzanne Fortier works in the field of x-ray crystallography. Suzanne was educated in a convent in St. Timothée, a small village in south western Quebec. From there she attended CEGEP in Valleyfield. While there, she met a professor from McGill who invited her to visit his crystallography laboratory. Here she found a branch of chemistry that did not involve bad smells or dirty hands and she decided that this would be her career field.

After graduating from McGill with a PhD in chemistry in 1976, she worked in a research laboratory in Buffalo, New York, until, in 1982, she had the opportunity to return to Canada as a professor of chemistry at Queens University in Kingston. She was the first woman to be hired in chemistry in a tenure-track position.

Suzanne uses the techniques of x-ray crystallography, not only to determine the arrangement of atoms within protein molecules, but also to obtain a picture of electron densities within chemical bonds.

TRUIS SMITH-PALMER

Truis Smith-Palmer is a professor at St. Francis Xavier University in Antigonish, Nova Scotia. She is married and has one child and at the time of writing, there is a second one on the way. She was born in New Zealand and attended Aukland University, where she earned her B.Sc. in chemistry. From there she went to Harvard for a year, and then worked for two years at the National Research Council (NRC) laboratories in Ottawa. She teaches analytical chemistry. One of her areas of research is acid rain in Nova Scotia.

Antigonish is a rural community with no local heavy industry. Additional acidity in the air can be assumed to come from the industrialized areas of the eastern United States and Canada, which are upwind of Antigonish. By measuring the amount of sulfuric acid in the air and comparing this to the total amount of sulfate ions she can determine how much of the acid has been neutralized before it reaches Nova Scotia. Neutralization is thought to occur by ammonia in the air produced in urban areas as an industrial pollutant and in rural areas from fertilizer. Since southwest winds, the prevailing summer winds in Nova Scotia, bring the air from the U.S. eastern seaboard up over the ocean, it has little chance of being neutralized and thus makes Nova Scotia particularly vulnerable.

MARY ANN WHITE

Mary Ann White (34) has been a professor of chemistry at Dalhousie University in Halifax, Nova Scotia, since 1983. She is married and has two young children; her son David is in primary school and her daughter Alice attends a local day care center. She is very busy with a young family and a demanding career, but she thoroughly enjoys her life and would not have it otherwise. She has travelled as a result of her work; she has spent two years doing research at Oxford University.

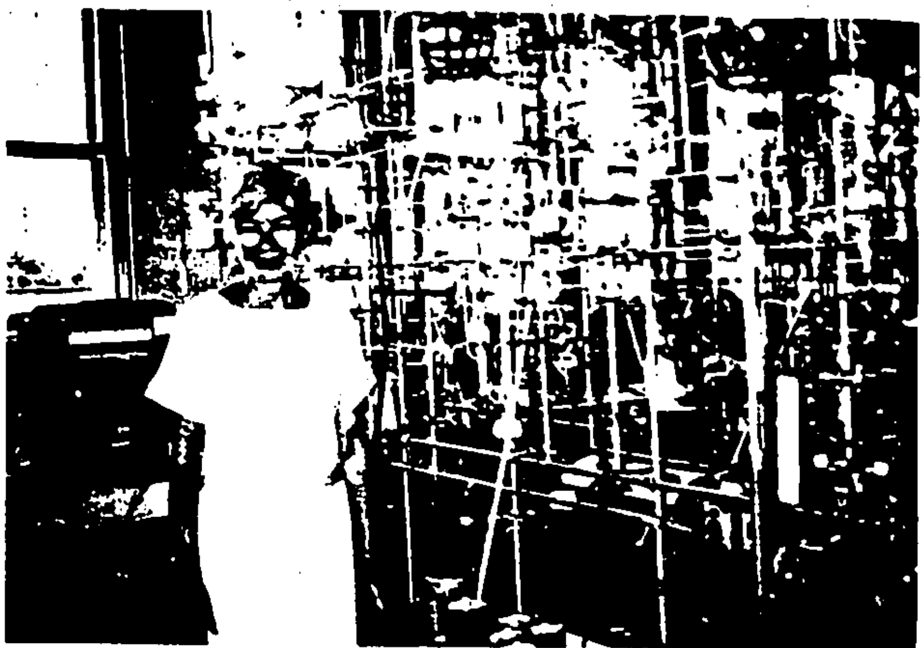
Her research is in the thermodynamics of solids and she teaches a course and gives frequent seminars in this field.

One aspect of Mary's work involves the investigation of solid materials that can store large amounts of energy as they change from one crystallic form to another. The chemical compounds are the same in both forms, it is just the arrangement of the molecules within the crystal lattice that is different.

These substances can be used as an efficient form of heat storage in buildings heated by solar energy. They take up much less space than water or rocks for the same amount of storage capacity. They change form as they absorb heat and revert to the original form as the heat is released. In studying these materials, Mary wishes to know exactly how much heat they will absorb and whether they remain efficient after going through the cycle thousands and thousands of times.

She used an interesting method of investigating the dispersive forces in long chain molecules of carbon and hydrogen. She prepared an ion of the form (RNH_3^+) where R is a long chain alkyl group. One end of the ion is held to the crystal lattice through hydrogen bonding through the NH_3 atoms at the end of the ion. At a certain temperature the alkyl group will "melt" within the lattice, i.e. it will no longer be held rigid but will "wiggle" around while held at one end, i.e. it is acting as it would act in the liquid state even though it is trapped in a solid crystal lattice. Mary calls this two-dimensional melting and the heat absorbed by the crystal as this process occurs tells us about the energy needed to give the alkyl group freedom of movement. Similar types of processes occur within animal or plant cells. Understanding this type of process in a specially constructed crystal is the first step towards understanding a similar process in the complex world of cell bio-chemistry.

MARGARET BACK



Margaret Back is a professor at the University of Ottawa where she has been doing research and teaching for the past 20 years. She has two grown up children, a daughter and a son, and her main interests outside of her work are outdoor activities, such as hiking and canoeing, but she also enjoys music.

Her research has been primarily in the field of reaction kinetics. One of the reactions that has interested her is the oxidation of carbon monoxide (CO) by oxygen gas (O_2).

$$2\,CO + O_2 \rightarrow 2\,CO_2$$

These gases form an explosive mixture in the presence of water. An explosion is usually the result of a branching chain reaction where more than one of the chain initiating species, in this case the OH radical, is formed from one species resulting from the chain, in this case the O atom. Thus, the overall mechanism is:

$$\begin{array}{rl} CO + OH \rightarrow CO_2 + H & \text{Step 1} \\ H + O_2 \rightarrow OH + O & \text{Step 2} \\ CO + O_2 \rightarrow CO_2 + O & \text{Overall} \end{array}$$

and the chain branching reaction is:

$$O + H_2O \rightarrow 2\ OH$$

Thus, each O atom formed above forms 2OH radicals that are available to start another chain. Since these reactions are an important part of the process of the burning of coal in coal fired generating stations, the understanding of this chemistry could eventually result in the more efficient use of an important natural resource.

Appendix D: Profiles of women chemical engineers

Profile of Women Chemical Engineers

CECILLE MILLIGAN

Cecille Milligan has been working for Dow Chemical for the past seven years. At present she is a sales representative in Toronto selling styrofoam and other construction materials. She enjoys her work very much, particularly the variety, no two days are ever alike, she says she likes the fact that she is totally responsible for all the accounts in her territory.

Cecille joined Dow Chemical in 1981 after graduating with a Bachelor of Science in Engineering from Queens University. She was a project engineer in Dow's Sarnia plant where she worked on plastic-lined pipe. She then moved to Toronto where she worked in technical services. She was responsible for a latex product that is added to concrete to improve its resistance to corrosives.

Cecille has one child, a boy. She no longer lives with his father but they have joint custody. He lives with his father during the week, because her job requires her to travel a great deal, and he spends the weekends with Cecille.

JENNIFER HADREVI

Jennifer Hadrevi is a chemist working in sales for Shell Canada. She is responsible for the sale of rubber used in adhesives, footwear and asphalt and exposy used in coatings, adhesives and floor coverings. Her territory covers a large part of southern Ontario. She spends five days a week on the road visiting the customers in her territory.

Jennifer very much enjoys her work. She knows that she is breaking new ground for women, selling in a technical area, and suspects that she is tested more than her male counterparts. She says that customers will ask her technical questions to "keep her on her toes". However, she feels equal to this challenge and often finds it exhilarating.

Jennifer is ambitious and hopes one day to be a business manager. In this position she would be responsible for a group of products, making decisions on all aspects of the business, including production quotas, pricing and marketing strategies. She realizes that it is important to plan one's career if she is to be successful. She feels that it is necessary to have experience in all aspects of the chemical business. Certainly Jennifer has had diverse experience with Shell since graduating from McMaster University in chemistry in 1982.

Her first job was as a refinery laboratory chemist in Sarnia. In this quality control lab all the raw materials, intermediates and final products of the refinery are tested. The most important instrument used for this purpose is the gas chromatograph. Jennifer was responsible for devising new and better methods of testing materials, she was also responsible for trouble-shooting the instruments in the laboratory when there were problems.

CATHERINE MALSEED

Catherine Malseed is a Quality Assurance manager for the Health and Beauty Care division of Procter and Gamble, Inc., a manufacturer of consumer goods such as laundry products, foods, paper products and pharmaceuticals. As part of her work, she has designed a new laboratory for the testing of pharmaceuticals and she will manage the lab after its completion. She is also responsible for ensuring that new products are of high quality and comply with government regulations before they go into full scale production. Cathy finds this aspect of the job very interesting and challenging because she has a great deal of responsibility and works with people in very different areas, including marketing, research, manufacturing and distribution.

Her first assignment with Procter and Gamble was in the food branch, where she worked as a process engineer. Her work involved quality control and finding ways to increase the efficiency of the process. She enjoyed this work because it was challenging, it involved the application of scientific principles to real world situations, and also because she worked as a member of a team.

Cathy studied chemical engineering in the co-op program at the University of Waterloo. She feels that co-op programs are especially valuable to women who wish to work in non-traditional fields, since it allows them to experience the work place while still studying. Incidentally she was able to earn enough money to support herself while studying.

Cathy has been married for three years to a chemical engineer. They do not have children yet, but they are in their plans for the future. Cathy hopes to continue her career after the babies are born. Her husband is very

Appendix E: Attitude measuring instrument Versions 1 and 2

APPENDIX E

Attitude Measuring Instrument

Version 1 (Pilot Study, Pre Test)

QUESTIONNAIRE

Please answer every question on this questionnaire. Please give only one answer to each question unless it tells you otherwise. Please read the questions carefully and answer by putting a check (✓) mark in the box that most nearly corresponds to your situation or opinion. Thank you for your help.

First I would like to ask you some questions about your opinion of the chemical industry and the effects of its actions on the environment?

1. The problem of the pollution of the environment by chemicals is a serious problem for mankind.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

2. It is wrong to do research into chemical weapons such as poison gas.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

3. The number of chemicals added to our food should be of concern to people.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

4. Jobs created by the chemical industry play a vital role in our economy.

1strongly agree [1] 2 agree [2] 3 disagree [4] 4strongly disagree [5] 5dont know [3]

5. Chemicals that have been banned in Canada because they are harmful to the environment should not be sold to Third World countries.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

6. Are you aware of any problems with toxic chemicals in the Montreal area.

Yes ☐ No ☐

If you anwered yes to this question please specify the problem.

____

7. Chemicals in the environment in the Montreal region have had a bad effect on the health of people living here.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

8. At sometime in the future chemicals in the environment will affect your health.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

9. What specific benefits can you think of that the chemical industry has brought to mankind ?

----

10. What are the problems with chemicals that worry you the most

----

----

11. What do you feel are the best words to describe the chemical industry?

----

12. What do you think are the best words to desribe chemistry ?

Now I would like to ask you some questions about studying chemistry in school.

13. Considering all the courses you are taking in school this semester is chemistry

the hardest 5

one of the hardest 4

about the same as other courses 3

one of the easiest 2

the easiest 1

14. The textbook you in chemistry is

the most difficult book I use 5

one of the most difficult books I use 4

about the same as other textbooks 3

easier than most books 2

the easiest book I use 1

15. Chemistry tests in the cegep are

the hardest tests I take 5

harder than those in most other courses 4

about the same as in other courses 3

easier than those in most other courses 2

the easiest tests I take 1

16. How many women chemistry teachers have you had in high school?

none 0

one 1

two 2

more than two 3

17. How many women physics teachers have you had in high school?

none 0

one 1

two 2

more than two 3

18. If you make a mistake in your work in class or in the laboratory , what is the most frequent reaction of A male students, B female students C amle teachers D female teachers.

Choose among the following types of reaction

1. They help you to correct the mistake.
2. They encourage you to correct the mistake
3. They appear to be indifferent
4. They make fun of your mistake
5. They criticize the mistake

A The reaction of the male students ☐

B The reaction of female students ☐

C The reaction of male teachers ☐

D The reaction of female teachers ☐

19. In the opposite sense, if you do well in a test or if you get good results in a lab , what is the most frequent reaction of A male students, B female students, C male physics and chemistry teachers, D female physics and chemistry teachers

Choose among the following reaction to your success
1. They congratulate you on yur success
2. They encourage you to try even harder
3. They appear to be indifferent
4,. They make fun of your success 5. They put you down on account of your success

A The reaction of the male students ☐

B The reaction of female students ☐

C The reaction of male teachers ☐

D The reaction of female teachers ☐

20. The environment of physics and chemistry labs is often stressful.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

21. Female students at Champlain are treated as equals by their male peers.

1strongly agree [1] 2 agree [2] 3 disagree [4] 4strongly disagree [5] 5dont know [3]

Now I would like to ask you some questions about your opinions on what it would be like to work as an engineer.

22. Jobs in engineering are usually well paid.

1strongly agree [1] 2 agree [2] 3 disagree [4] 4strongly disagree [5] 5dont know [3]

23. There is a good future with good job prospects in engineering.

1strongly agree [1] 2 agree [2] 3 disagree [4] 4strongly disagree [5] 5dont know [3]

24. Both now and in the future engineers have a good chance of promotion.

1strongly agree [1]   2 agree [2]   3 disagree [4]   4strongly disagree [5]   5dont know [3]

25. A woman engineer will usually be treated as an equal by her male co-workers.

1strongly agree [1]   2 agree [2]   3 disagree [4]   4strongly disagree [5]   5dont know [3]

26. Many women engineers feel stress from working in a predominantly male environment.

1strongly agree [5]   2 agree [4]   3 disagree [2]   4strongly disagree [1]   5dont know [3]

Now I would like to know what you think it would be like to study engineering in a University.

27. A woman engineering student will have to perform better than a male student to obtain the same mark.

1strongly agree [5]   2 agree [4]   3 disagree [2]   4strongly disagree [1]   5dont know [3]

28. Women engineering students are treated as equals by the male students

1strongly agree [1]   2 agree [2]   3 disagree [4]   4strongly disagree [5]   5dont know [3]

29. Women engineering students would be under more stress than men students.

1strongly agree [5]   2 agree [4]   3 disagree [2]   4strongly disagree [1]   5dont know [3]

Now I would like to know about scientists and engineers that you know personally.

30. Do you know personally a woman scientist or engineer?

Yes [ ]   No [ ]

Describe her life style for me please.

If you know personally any scientists or engineers, either male or female, please answer the next 2 questions. If not please go on to question 33.

31. Most scientist and engineers that I know personally are interesting people.

1strongly agree [1] 2 agree [2] 3 disagree [4] 4strongly disagree [5] 5dont know [3]

32. Most scientists and engineers that I know have interesting and rewarding jobs.

strongly agree [1] agree [2] dont know [4] disagree [5] strongly disagree [3]

Finally I would like to ask you a few questions about yourself.

33. What is your sex?

Male ☐ Female ☐

34. How old are you ?____

35. What is your mothers primary occupation ?

paid work ☐

studying ☐

caring for the house ☐

36. Fathers occupation or latest occupation

engineer ☐

scientist ☐

manager ☐

teacher ☐

health worker ☐

other(please specify) ---------------

37. Mothers occupation or latest occupation

engineer ☐

scientist ☐

manager ☐

teacher ☐

health worker ☐

other(please specify)-______________

38. What have been your most rewarding hobbies during the last ten years.

____

39. Do you ever help repair or repair any of the following ? (You may choose as many as you wish).

car ☐ motor bike ☐ bicycle ☐ household appliance ☐ motor ☐

other(please specify)__________

Please imagine you are 30 years old . I would like to know how you see your life style?

40. Do you imagine your main occupation will be

studying ☐

working fulltime ☐

working parttime ☐

at home ☐

41. How many children will you have?

none ☐

one ☐

more than one ☐

42. If you are working , what will be your field of work?

43. If you are working what will your position be in the organization in which you are employed?___________

Attitude Measuring Instrument

Version 2 (Pilot Study, Post Test)

QUESTIONNAIRE
Thank you very much for helping me with my research. This will be my last request of you.

Please answer every question on this questionnaire. Please give only one answer to each question unless it tells you otherwise. Please read the questions carefully and answer by putting a check ( ) mark in the box that most nearly corresponds to your situation or opinion. Thank you for your help.

First I would like to ask you some questions about your opinion of the chemical industry and the effects of its actions on the environment?

1. The problem of the pollution of the environment by chemicals is a serious problem for mankind.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

2. It is wrong to do research into chemical weapons such as poison gas.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

3. The number of chemicals added to our food should be of concern to people.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

4. Jobs created by the chemical industry play a vital role in our economy.

1strongly agree [1] 2 agree [2] 3 disagree [4] 4strongly disagree [5] 5dont know [3]

5. Chemicals that have been banned in Canada because they are harmful to the environment should not be sold to Third World countries.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

6. Are you aware of any problems with toxic chemicals in the Montreal area.

Yes ☐ No ☐

If you anwered yes to this question please specify the problem.

____

7. Chemicals in the environment in the Montreal region have had a bad effect on the health of people living here.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

8. At sometime in the future chemicals in the environment will affect your health.

1strongly agree [5] 2 agree [4] 3 disagree [2] 4strongly disagree [1] 5dont know [3]

9. What specific benefits can you think of that the chemical industry has brought to mankind ?

----

10. What are the problems with chemicals that worry you the most

----

----

11. What do you feel are the best words to describe the chemical industry?

----

12. What do you think are the best words to desribe chemistry ?

Some people missed the last page the last time I gave you this questionnaire. I hope you don't mind if I ask you to fill it out again

37. Mothers occupation or latest occupation

engineer ☐ 1

scientist ☐

manager ☐

teacher ☐

health worker ☐

other (please specify) - ______________

38. What have been your most rewarding hobbies during the last ten years.

____

39. Do you ever help repair or repair any of the following ? (You may choose as many as you wish).

car ☐ motor bike ☐ bicycle ☐ household appliance ☐ motor ☐

other (please specify) __________

Please imagine you are 30 years old . I would like to know how you see your life style?

40. Do you imagine your main occupation will be

studying ☐

working fulltime ☑

working parttime ☐

at home ☐

41. How many children will you have?

none ☐

one ☐

more than one ☐

42. If you are working , what will be your field of work? ______.

43. If you are working what will your position be in the organization in which you are employed? ____________________

Appendix F: An example of a visual-spatial exercise

APPENDIX F

WEEK 1

NAME

SHAPE: SYSTEM 1 #12,3

SHAPE:SYSTEM 1 #15,3

NAME
STYRO M

NAME
STYROFOAM

SHAPE :SYSTEM 1 #2,3.

SHAPE

NAME
STYROFOAM

NAME
STYROFOAM

D

Appendix G: Material provided to the instructors

Champlain

CHAMPLAIN REGIONAL COLLEGE
ST. LAMBERT-LONGUEUIL CAMPUS
900 Riverside Drive
St. Lambert, Quebec
J4P 3P2
Tel.: (514) 672-7360

Materials for the Instructors

MEMO

TO: M. MCCLORY
J. PHILIPP

FROM: C. GILLBERT

RE: **INSTRUCTORS' INSTRUCTIONS RE CHEM 101 RESEARCH PROJECT**

DATE: January 22, 1990

1. It is very important that the students have no idea that the experiment is being carried out. The results have no validity if they have any knowledge of what is happening.

2. We need to decide the best days for the two visitors.

3. Try to incorporate the profiles of the chemists in the lab manual as:

   a) **Marcet** - First day when you are telling them about the textbook. I usually read the excerpt from the textbook.

   b) **Harriet Brooks** - Atomic theory, emphasize McGill connection and buried on Mont Royal, if you like.

   c) **Penelope Codding**) Shapes of molecules.
   Suzanne Fortier) X-ray diffraction.

   Penelope uses knowledge of the shapes of organic molecules to design medical drugs with specific properties and fewer side effects.

   d) **Truis Smith Palmer** - Acid rain - determination of the source of sulfate ions in rain water in Nova Scotia.

   e) **Mary Ann White** - Measurement of the strength of dispersive forces.

   f) **Margaret Back** - Kinetics - The Oxidation of Carbon.

4. **Additional Materials**:

Slides are in Tina's cupboards. Videos are in my office.

a) Nuclear medicine - slides and notes - Atomic Theory

b) Molecular shapes - perfumes - slides & notes - Bonding

c) Greenhouse effect - video tape VHS - show on classroom monitor - 15 minutes - Descriptive Chemistry

d) Acid rain - video tape VHS - 15 minutes - Descriptive Chemistry

e) Jewels - Macro molecules - slides & notes - Intermolecular Forces

f) Ozone layer - video VHS - Kinetics

I need to circulate the questionnaire at the beginning as well as the end of the semester, since this semester there is not a random selection process. I will give you some copies this week.

Thanks.

ge
MEMO13.RES

CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

NOTES TO ACCOMPANY SLIDES ON GEMS

1. Structure of diamond and graphite.
Diamond is the hard crystal with one of the highest refractive indeces .. sparkles.

2. Diamonds found bedded in rocks where they formed under very high pressure.

3. In the rough, they are not very attractive.

4. Because of their high value, miners must be searched.

5. Cullinan diamond, the biggest ever discovered, after cleaving.

6. Same diamond after polishing.

7. Hope diamond after setting.

8. Diamonds also have industrial uses. Industrial diamonds are made synthetically by heating carbon to 1400°C at pressures of 1 million lbs./square in. This simulates conditions 160 km below the surface of the earth. Here we see a dentist's drill under a microscope with diamond chips.

9. Rubies are the second most valuable stone. They are aluminum oxide, the macro molecular powder in the classification lab, with trace amounts of chromium salts to give the red colour. Sapphires are also alumina with traces of Fe or Ti.

10. Emeralds are BeAl silicate.

11. These show the comparison of a synthetic and natural ruby, emerald and opal - silica under a microscope. The synthetics are above, you can see the imperfections are different in each case, although chemically and in their crystal structure, they are identical. Jewellers will always be able to tell the real thing so they cost 100 to 1000k as much as the synthetic.

12. Ivory, a form of bone is a macro molecule of calcium phosphate.

13. Amber is resin from ancient trees, similar in structure to a plastic.

14. Jade is two minerals. Jadeite the more valuable is from Burma NaAl silicate and comes in many colours. This jade ring is worth 32,000$.

15. And nephrite, not so hard, coloured with Fe_2O_3 and more abundant. These pieces are made of New Zealand nephrite.

CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

NOTES TO ACCOMPANY SLIDES ON MOLECULAR SHAPES

1. The sense of smell is at the heart of memory and emotion. It is the sense that most frequently triggers memory taking us back to a place and time in the past. It kindles our appetites and allows us to enjoy food and drink. The flavours of our food other than sour, salt, sweet and bitter, are all detected in our nose. That is why you lose your sense of taste when you have a cold.

2. Odors are caused by volatile molecules. They enter your nose, are carried up the nostrils to two chambers behind the bridge of the nose and close to the brain. Here the molecules bind to receptors or tiny hairlike cilia at the ends of olfactory nerves or neurons. These neurons send the message to the brain. The sense of smell has a privileged position in the brain. The receptors are close to the brain and are connected to the limbic region of the brain that controls our body chemistry - our metabolism, insulin levels, stress, repulsion, arousal, sex, etc. For example, when young women, not on the pill, live together in a dormitory, their menstrual cycles tend to synchronize, the message being sent by molecules called pheromones present in their sweat. A woman who has irregular periods often becomes more regular the more she is around a man - again the link as the pheromones present in his sweat.

3. Olfactory neurons unlike other brain cells replace themselves when damaged - a beneficial evolutionary adaptation for animals. Smell is the most important sense for animals, it allows them to find food and a mate. This sow is being artifically inseminated. She will stand quietly if she smells the artificial odor of a boar and feels his weight on her back.

4. An oscilloscope records a strong nervous system response by a male American cockroach to a female pheromone and almost no response from her. Artificial pheromones are used as non-toxic bait to trap harmful insects.

5. It is the shape of a molecule rather than its chemical properties that determines its smell. On the left we see water and ethanol and on the right hydrogen sulphide and ethyl mercaptan. The chemicals on the right are foul smelling. According to the Guinness Book of Records, ethyl mercaptan is the foulest smelling substance in the world.

6. It is the SH group that dictates olfactory response. This mercaptan is not so bad as it is much less volatile - higher molecular weight.

7. The molecule at the top of the slide has an SH group but it has a pleasant odor because of its overall shape.

8. The molecule with an oxygen atom rather than an S atom smells very similar.

9. In fact all these molecules fit into a spherical receptor and have the camphor smell that you know in Vicks Vapour Rub.

10. The essence of animal communication relies on odors produced by skin, glands, faces and urine. Cats and dogs mark their territory by urinating. Your cat marks you with odor from his facial and rump glands when he rubs your leg. This cheetah is spraying a rock to mark his territory.

11. And this Thomson gazelle is claiming his territory with a secretion from under his eye.

12. Odors from plants and soils along the river allow salmon to migrate upstream. If young salmon are imprinted with a strong smelling chemical in the hatchery, they can be attracted to sport fishing areas with the same chemical.

13. Dogs can be trained to recognize many scents from drugs to termites.

14. Ventilating a smoker's office requires three times the circulation as a non-smoker's office. The smell in this room is being measured by odor judges, the nose is still the best odor measuring instrument we have.

15. Development of pleasing odors for many consumer products is one of the jobs done by industrial chemists.

16. This young doctor is learning to diagnose disease and poisons using smell.

17. This instrument which is analysing all the odors - molecules given off by this woman's body, might become a powerful medical diagnostic tool in the future.

ge
INFO03.101

CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

CHEMISTRY 101

NOTES TO ACCOMPANY SLIDES ON NUCLEAR MEDICINE

1. Radioactive tracers are extremely useful in medical research and diagnosis. One of the commonest nucleides used is Tc 99m. Technetium is an element that does not occur naturally. It is made from fission products within a nuclear reactor. It has a short half life and is chemically inert in the body so it is excreted with other waste products.

2. Mo-99 (from a CANDU reactor) with a long half life is kept at the hospital and the Tc 99m is elected from the generator as needed. The rays emitted by the Tc 99m are recorded by an x-ray camera.

3. This slide shows a typical series of pictures taken by the x-ray camera of a patient's liver. The times represent minutes after ingestion. Note the sample has reached the gall bladder by 18 minutes and is beginning to leave by 32 minutes. This is normal so this patient does not have a gall bladder problem and another solution for the stomach aches must be found.

4. We have all heard of treating cancer with Co60 but Canada is exporting new cancer treatment equipment called the Therac 25. The machine is a small linear accelerator used for accelerating a beam of electrons. The fast moving electrons can then be used directly to treat surface cancers or the high energy electrons can be impacted on metals to produce x-radiation which can be used to treat internal cancers. The advantages over Co60 are:

   1. Do not need to keep ordering new supplies of Co60.
   2. The target beam can be better controlled.
   3. The x-radiation can be adapted to the location of the cancer and how much tissue must be penetrated by the x-rays.

5. Perhaps the most interesting new technique on the market is the PET scan, positron emission tomography. A positron, a positive electron is annihilated on collision with an electron and two photons are produced that go off in opposite directions. In this technique the patient takes in a positron source O_{15} either in the air they breathe or in an injection of glucose (sugar) $C_6H_{12}O_6$. The radioactive oxygen then goes to the part of the brain that is working to give that area energy. A series of detectors placed around the head locates the x-photons emitted and calculates the location of the active area.

6. All these pictures are taken at the Montreal Neurological Institute in the Royal Vic. This picture shows a normal brain above and below we can see the brain of a patient suffering from epilepsy. Note the arrow points to the region starved of oxygen. This area was removed surgically and the patient was cured.

7. This series shows the use of the PET to locate a brain tumor.

    1. A normal brain.

    2&3. Blue mass is tumor.

    4&5. Show the same tumor using a glucose source of positrons. Notice that some glucose is absorbed and metabolized by the tumor.

    6. The most effective drug for treating brain tumors is BCNU. This too has some O_{15} in the molecule and so its concentration in the tumor can be monitored and adjusted.

8. Here we see a brain tumor identified by the PET scan being surgically removed.

9. Perhaps the most fascinating research in this area is to understand the working of the brain. We now know that an expert in classical music uses a different part of the brain to listen to a symphony than does a musical amateur. Here above, we see a brain at rest, and below, a brain controlling rhythmic tapping by the fingers of the left hand.

ge
INFO01.101

Appendix H: Attitude measuring instrument, Version 3

APPENDIX H

Attitude Measuring Instrument
Version 3 (Pre Test)
CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

QUESTIONNAIRE

Please do not write your name on this paper. Please answer every question on this questionnaire. Please give only one answer to each question. Please read the questions carefully and answer by putting a check (✓) mark in the box that most nearly corresponds to your situation or opinion. Thank you for your help.

1. Student number ______________________

2. Is this your first time taking Chem 101? Yes ☐ No ☐

3. If ~~yes~~ no, was an engineer invited to your 101 Chemistry class last semester? Yes ☐ No ☐

First I would like to ask you some questions about your opinion of the chemical industry.

4. Jobs created by the chemical industry play a vital role in the Canadian economy.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

5. There are many interesting jobs available in the chemical industry.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

6. Jobs in chemical engineering are usually well paid.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

7. The chemical industry offers many chances of promotion.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

8. Chemical pollutants are a serious health hazard.

   1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

9. Chemical pollutants are a serious environmental threat.

   1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

10. The chemical industry has a vital role to play in solving environmental problems.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

11. The chemical industry is modifying its practices to take into accoun environmental concerns.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

12. Chemical technology has significantly enhanced our quality of life.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

13. A woman engineer will usually be treated as an equal by her male co-workers.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

14. Many women engineers feel stress from working in a predominantly male environment.

1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

15. Women engineering students are under more stress than men engineering students.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

.6. Most scientists and engineers are interesting, caring people.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

17. Most scientists and engineers have interesting and rewarding jobs.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

Now I would like to have some information about you.

18. Sex: Male ☐ Female ☐

19. Age: 16-21 ☐ Over 21 ☐

20. Who is your teacher for Chemistry 101 this semester? ____________________

21. Are you considering a career in physics or chemistry? Yes ☐ No ☐

22. Are you considering a career in engineering? Yes ☐ No ☐

23. Are you considering a career in the medical, health or biological sciences? Yes ☐ No ☐

Appendix I: Attitude measuring instrument, Version 4

APPENDIX 1

Attitude Measuring Instrument
Version 4 (Post Test Experimental Group)
CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

QUESTIONNAIRE

Please do not write your name on this paper. Please answer every question on this questionnaire. Please give only one answer to each question. Please read the questions carefully and answer by putting a check (√) mark in the box that most nearly corresponds to your situation or opinion. Thank you for your help.

1. Student number ______________________________

First I would like to ask you some questions about your opinion of the chemical industry.

2. Jobs created by the chemical industry play a vital role in the Canadian economy.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

3. There are many interesting jobs available in the chemical industry.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

4. Jobs in chemical engineering are usually well paid.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

5. The chemical industry offers many chances of promotion.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

6. Chemical pollutants are a serious health hazard.

   1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

7. Chemical pollutants are a serious environmental threat.

   1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

8. The chemical industry has a vital role to play in solving environmental problems.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

9. The chemical industry is modifying its practices to take into account environmental concerns.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

10. Chemical technology has significantly enhanced our quality of life.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

11. A woman engineer will usually be treated as an equal by her male co-workers.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

12. Many women engineers feel stress from working in a predominantly male environment.

1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

13. Women engineering students are under more stress than men engineering students.

1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

14. Most scientists and engineers are interesting, caring people.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

15. Most scientists and engineers have interesting and rewarding jobs.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

Now I would like to have some information about you.

16. Sex: Male ☐ Female ☐

17. Who is your teacher for Chemistry 101 this semester? ____________________

18. Are you considering a career in physics or chemistry? Yes ☐ No ☐

19. Are you considering a career in engineering? Yes ☐ No ☐

20. Are you considering a career in the medical, health or biological sciences? Yes ☐ No ☐

21. The course content of Chemistry 101 is interesting.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

22. The chemical engineers that visited the class were interesting.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

23. The information on the environment incorporated into the course was interesting.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

24. I read most of the information on women chemists in the objectives.

Yes ☐ No ☐

Appendix J: Attitude measuring instrument, Version 5

APPENDIX J

Attitude Measuring Instrument

Version 5 (Post Test Control Group)

CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

QUESTIONNAIRE

Please do not write your name on this paper. Please answer every question on this questionnaire. Please give only one answer to each question. Please read the questions carefully and answer by putting a check (√) mark in the box that most nearly corresponds to your situation or opinion. Thank you for your help.

1. Student number ______________________________

First I would like to ask you some questions about your opinion of the chemical industry.

2. Jobs created by the chemical industry play a vital role in the Canadian economy.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

3. There are many interesting jobs available in the chemical industry.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

4. Jobs in chemical engineering are usually well paid.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

5. The chemical industry offers many chances of promotion.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

6. Chemical pollutants are a serious health hazard.

   1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

7. Chemical pollutants are a serious environmental threat.

   1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

8. The chemical industry has a vital role to play in solving environmental problems.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

9. The chemical industry is modifying its practices to take into account environmental concerns.

   1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

10. Chemical technology has significantly enhanced our quality of life.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

11. A woman engineer will usually be treated as an equal by her male co-workers.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

12. Many women engineers feel stress from working in a predominantly male environment.

1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

13. Women engineering students are under more stress than men engineering students.

1 strongly agree [5] 2 agree [4] 3 disagree [2] 4 strongly disagree [1] 5 don't know [3]

14. Most scientists and engineers are interesting, caring people.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

15. Most scientists and engineers have interesting and rewarding jobs.

1 strongly agree [1] 2 agree [2] 3 disagree [4] 4 strongly disagree [5] 5 don't know [3]

Now I would like to have some information about you.

16. Sex: Male ☐ Female ☐

17. Who is your teacher for Chemistry 101 this semester? ____________________

18. Are you considering a career in physics or chemistry? Yes ☐ No ☐

19. Are you considering a career in engineering? Yes ☐ No ☐

20. Are you considering a career in the medical, health or biological sciences? Yes ☐ No ☐

21. The course content of Chemistry 101 is interesting.

1 strongly agree ☐ 2 agree ☐ 3 disagree ☐ 4 strongly disagree ☐ 5 don't know ☐

Appendix K: Protocol for the interview with instructors

APPENDIX K

Interviews with teachers

M E M O

Please answer the following questions:

A. Did you use the following in your class and how could each be improved?

1. Nuclear Medicine Slides

2. Acid Rain Video

3. Greenhouse Video

4. Jewels and Gems Slides

5. Smells

B. Which of the two speakers did you think held the interest of the class?

Petro Canada (first)

Dow (second)

C. I had problems with the questionnaire. If we use the radio-activity lab people had not shown the material. Any suggestions? How about in the final? It should not be administered by the teacher.

D. Did you use the profiles in the lab manual? How?

E. Any other comments?

CG/ge
MEMO12.EIJ

Appendix L: Results of survey of student interests

Appendix L
Mean scores on Student Interest Questionnaire

	Subject area	Mean males	mean females
1	Smelting of aluminum	2.6	2.3
2	How fluoride toothpaste protects teeth	1.5	1.8
3	Dating of archeological remains	1.4	1.6
4	Causes of algae growth in lakes and streams	1.3	1.6
5	Causes of acid rain	1.2	1.3
6	Nature of the electron	2.2	1.7
7	Burning of fossil fuels causes climatic change	1.4	1.6
8	Linear accelerators	2.5	1.8
9	Chemistry of pesticides	1.7	2.1
10	Chemistry of DNA	1.3	1.5
11	Why ice floats on water	1.4	2.1
12	Why diamonds sparkle	1.2	1.9
13	Chemistry of beer making	1.4	1.4
14	Why graphite can be used as a lubricant	1.9	1.6
15	Manufacture of antibiotics	1.4	1.5
16	Plastics industry	2.0	1.7
17	Pigments used in artists paints	2.0	2.4
18	How ammonia is manufactured	2.2	2.3
19	How lead effects human health	1.2	1.6
20	How CFC's destroy the ozone layer	1,2	1,4
21	How atoms join together	2,1	1,7
22	How fertilizer is manufactured	2.4	2.1
23	How a silicon chip works	2.0	1.4
24	Minerals of Quebec	2,4	2,4
25	How a lead battery works	1.9	1.8
26	How oil is refined	1.9	1.8
27	How metals are purified	1.9	1.6

27	How metals are purified	1.9	1.6
28	The chemistry of rocket fuels	1.9	1.4
29	Use of radioactive elements in medicine	1.0	1.4
30	Principles of welding	2.3	2.2
31	How catalytic converters work	2.1	1.9
32	Ultra strong materials	1.6	1.3
33	Cleaning oil spills	1.3	1.4