MAKING CHEMISTRY

MORE FEMALE-FRIENDLY

Catherine Gillbert

Dépôt légal - 2e trimestre 1992
Bibliothèque nationale du Québec
ISBN 2-9801273-7-X

MAKING CHEMISTRY MORE FEMALE FRIENDLY

Catherine Gillbert

Cette recherche a été subventionnée par la Direction générale de l'enseignement collégial dans le cadre du Programme d'aide à la recherche sur l'enseignement et l'apprentissage.

On peut obtenir des exemplaires supplémentaires de ce rapport de recherche en s'adressant au

Bureau d'Administration
Champlain Regional College
900 Riverside Drive
St. Lambert, Qc J4P 3P2

(514) 672-7360

S.V.P. inclure un chèque ou un mandat-poste à l'ordre de Champlain Regional College au montant de 10$ par exemplaire demandé.

ACKNOWLEDGEMENTS

I would like to think thank the members of the Chemistry Department at Champlain College for their participation in this project; they are Robert Bichler, Ella Hus, Rouben Ishayek, Michael McClory, Jarmilla Phillipp and Isaac Zia.

Catherine Gillbert

Catherine Gillbert

ABSTRACT

The purpose of the study was to see if it is possible to change the attitude of female students at Champlain College towards chemistry by modifying the curriculum in Chemistry 101. Some attitude change was found and some female students decided to consider a career in engineering after exposure to the modified curriculum.

TABLE OF CONTENTS

1. INTRODUCTION

In the past several years we have seen increased concern in Canada, and particularly in Quebec, expressed by women's organizations, governments, educators and industry about the lack of participation of women in the physical sciences and engineering. If we look at the literature of the first half of the last decade we see the concern was focused on economic considerations. Several reports were published that pointed to the need for Canada to stay in the forefront in the development of modern technology if Canadians wished to maintain their high standard of living. The argument continues that we must attract more of our superior intellects into these fields and this requires the recruitment of many more women into the profession. (As examples of reports with this focus see Science Council of Canada (1982), Conseil de la Science et de la Technologie (1986) and Claire Gagnon (1989). The second economic issue is the disparity between the earning power of males and females. The fact that women work primarily in the service and care giving sectors is given as one of the important reasons for this disparity. (For an example of this type of analysis see Conseil du Statut de la Femme, 1985).

Recent literature, however, has concentrated on two other issues, the notion of fairness and the special contribution that women can make to science and technology.

This idea of fairness goes beyond the question on economic equity; it includes the idea of women having equal power in decisions that affect the political and cultural future of our nation. In a report by the Status of Women on the participation of women in science and math we find 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).

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 reiterated this theme in the Massey lecture series for the 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)

Obviously the increased interest in the participation of women in science and engineering has led to attempts to understand the factors that influence girls in their choice of careers and consequently to establish the nature of the barriers that prevent their participation in these fields. Only, if this knowledge is available, can society make the necessary changes that will allow more women into these professions.

Obviously choosing a career is a complex process and the final choice results from the interaction of many factors, both internal and external to the girl herself. Although the process is by no means completely understood, Gagné and Poirier (1990) give us some important insights into the decision making process. Some of the important variables are her 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 important such as level of support from parents, teachers and friends (Neville, Gibbins and Codding, 1988), academic achievement (Ethingnon, 1988) and the motivation level to master a new skill (Farmer, 1985). 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 non traditional career.

There has been much literature in the past five years dealing with these barriers. The Ministry of Education, Quebec (1988) gives an overview of the research in this area and more recently we have seen the establishment of the Canadian Committee for Women in Engineering which, funded by the Federal Government, has been touring the country asking concerned citizens what can be done to change the situation. Recommendations from this committee have been presented to the various levels of government, industry and the engineering societies.

1.1 The Barriers

Some of the obstacles that are constantly mentioned in this context are the following:

1.1.1 Girl's Lack of Self-Confidence

Much work has been done on girls' math phobia which results in their avoiding careers in science (Mura 1982, 1985). Research carried out in Quebec supports data from the United States. A study indicated that girls in Quebec high schools have a lower perception of their ability in math than do boys despite the fact that they perform better in math courses (Mura, Cloutier, Kimball 1985). A recent nationwide poll of American elementary and high school students funded by the American Association of University Women (1991) discovered the incredible drop in self-esteem that girls experience during their high school years. The survey finds a strong relationship between performance in math and science and adolescent self-esteem for both boys and girls. However, as girls learn "they are not good at these subjects their sense of self-worth deteriorates". 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 math and science, a girl's level of self-esteem and confidence in choosing a challenging career are causally related.

1.1.2 The Image of Science

Kelly (1978) believes 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.

Science has the image of being difficult and this myth is encouraged by many teachers. If we add to this the idea that their is a talent for doing science that some people just don't have, then we can see how easily girls can be discouraged. Research shows us that it is study habits not "talent" that separate those who succeed in science at cegep from those who do not.

A third 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 gift supposedly more often found in females, and yet this is rarely mentioned. A recent publication by DGEC (1990) gives an excellent account of the myths in chemistry and ways of "debunking" these myths.

1.1.3 The Search For a Caring Profession

Girls more often than boys express the desire to work in a field that will help others; they seem to be less concerned about status and salary and more concerned with personal satisfaction. (Gilligan, 1984; Gagné & Poirier, 1991). Science and technology on the other hand, has received a great deal of bad press over the past few years. Science has been blamed for pollution, environmental catastrophes and many health problems and there is some evidence that this deters girls from entering science. (Gagné & Poirier, 1990).

1.1.4 The Lack of Role Models

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 towards girls' more negative attitudes to science. Bandura (1977) underlines the importance of learning by observation. Crabbe (1985) develops the ideas of Bandura in the context of girls in secondary schools and the consequence for girls of the lack of appropriate role models. She reminds 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, follow the traditional female roles or continually attempt to reconcile the dual roles of their professional and female goals.

Lee (1984) in a survey of the literature of factors affecting the choice of a nontraditional career states that there is conflicting evidence concerning the importance of role models and that more research should be done in this area. However, educational authorities clearly feel this is an important factor since, in the United States, several slide-tape shows about the work of women scientists have been developed and a visiting scientist program has been established. The success of these programs in developing positive attitudes to science in girls has not been measured.

1.1.5 The Learning Styles of Girls and Boys

In the classic study by Benbow and Stanley (1980), psychological differences between males and females that have been demonstrated in many different pieces of research are presented. These include males' higher level of aggressiveness or competitiveness, males' superior mathematical ability and females' greater verbal ability. These differences manifest themselves in classroom behaviour, not only in achievement as measured by grades, but in classroom behaviour. Male students respond better to lectures followed by question and answer. Perhaps this is because they are more self-confident and respond to a competitive environment, where the student asking an intelligent question is the center of attention and has high status in the class. However, females prefer cooperative learning. Males are more likely to respond to theory based on pure reason, whereas females prefer application to real world problems along with the theory. Omerod (1981) suggests that this might be one reason why girls prefer biology since in this science we generally start with empirical data and description of the visible world and teach theory only in more advanced courses.

1.2 The Role of the Educational System in Overcoming the Barriers

Teachers' attitudes and their perception of their specialization and their attitude towards gender stereotyping is an important factor determining the atmosphere of the classroom and, to some extent, affects the attitude of students towards the subject matter.

An understanding of the behavioral differences between males and females, the difference in their world views and their differences in preferred learning styles should be an important part of teacher training and professional development programmes. Attitude change in adults, however, is difficult and there is little information in the literature to tell us whether it is possible to change teachers' attitudes and behaviour.

The educational system certainly has a role to play in changing the image of science for students, particularly for female students. However, probably many teachers, too, believe the culturally determined myths about science, so, once again, we need to see a change in teacher attitudes before we will see a change in student beliefs.

There are other ways in which the classroom can be used to help females overcome the barriers to careers in science and engineering.

The lack of role models can to some extent be addressed by bringing women engineers into the classroom. The lack of information about what it is like to work as an engineer can be remedied at the same time. The lack of relevance of the material can be corrected by the use of appropriate examples and, at the same time, the humanitarian aspects of science can be emphasized.

1.3 Some of the Projects Attempted in Canada to Lower the Barriers

1.3.1 Université Laval

A massive program is underway at Université Laval to 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. The process involves working with high schools and colleges to provide more information about engineering, using displays, publications, visits and participation in workshops. In order to prevent female students from dropping out of engineering, female engineers are available as resource people; a course on women in science was organized; more scholarships are provided to women students and research was carried out to determine why women students change out of engineering programs. Finally, women graduates are helped to find a compatible environment when they are looking for their first job.

1.3.2 University of Calgary

The University of Calgary has organized summer courses for high school girls to give them a chance to work in the laboratories and see, first hand, what the engineering programme involves.

1.3.3 The National Research Council

Many companies are offering scholarships to women engineering students. Of these the NRC scholarships are the most valuable and involve the promise of summer jobs in its research facilities.

1.3.4 Association of Professional Engineers of Ontario

This group has put together a list of women engineers who are prepared to visit high schools and act as role models.

1.3.5 Vanier College

An experiment was carried out at Vanier College to investigate the impact of alternative pedagogy in the physical sciences and in mathematics. The strategies included more personal, verbal feedback from the teacher, encouragement of journal writing and the establishment of an environment that was conducive to the formation of partnerships for group learning. (Davis, Steiger and Tennenhouse, 1989; Davis, Steiger and Tennenhouse, 1990)

2. BACKGROUND FOR THE PRESENT STUDY

2.1 Science in the Cegeps

About 45% of those registered in the general science program in Quebec cegeps are females. Contrary to popular belief, the success rate of women in science courses in the cegeps is higher than that of the male students (86.5% compared to 81.1%). We would expect, therefore, that women would be well-represented in the pure and applied programs in Quebec's universities (Government of Quebec, 1984).

This, however, is not the case. In 1983 only about 35% of those registered in pure science programs at university were women and the number dropped to less than 20% in the applied sciences. Women, however, occupy a predominance of places in the biological and health sciences programs in Quebec universities. There is also evidence that of those students studying science at Canadian universities, a lower percentage of women have the intention of continuing in a scientific career (Neville 1988).

It is the author's opinion that certain factors operating within the cegeps contribute to these low percentages, by inhibiting the interest of female students in the pure and applied sciences.

2.2 Chemistry at Champlain

Chemistry 101, the first college level course offered at Champlain is given in both the fall and winter semesters. All students complete the same labs, the courses have common learning objectives and the students take a common final exam. Most students enrolled in Chemistry 101 in Fall 1989 were first semester students who had arrived at the college with a substantial background in chemistry either 70% in Chemistry 552 or 80% in Chemistry 452. The remainder were students who had failed a chemistry course at least once or who had changed into the science program. 2nd year students could be recognized by their student number.

Fewer sections are offered in the winter semester. These students fall into two groups: those who started in Chemistry 111, a high school equivalent course and those who took Chemistry 101 in the Fall semester and either abandoned or failed.

2.3 The Pilot Study

A pilot project was carried out in 87-88 at Champlain. The work is reported in Women-Friendly Chemistry by Catherine Gillbert. The goal of the project was to increase the interest of girls in the physical sciences in an attempt to make a career in the physical or applied sciences more appealing. The GIST study of Manchester Education Authority was used as a model (See Appendix 1).

A questionnaire was prepared to measure the attitude of the students towards chemistry. The questionnaire was validated at a second anglophone college using first semester science students. Questions were selected where the response of males and females were significantly different or which specifically questioned attitudes about the place of women in the applied sciences. Material was inserted in the course which was believed to be of interest to female students. Women engineers were invited to talk to the class and profiles of women chemists working in fields related to the course were inserted in the laboratory manual.

The questionnaire was administered at the beginning and end of the course to see if there was a significant change in attitudes.

The results were somewhat inconclusive. Firstly, the sample size was very small, only 12 female students completed the course; secondly, there was a bias built into the experiment since the teacher carrying out the intervention was also the researcher.

3. OBJECTIVES OF THE PRESENT STUDY

To develop a version of Chemistry 101 at Champlain Regional College that can be used in other cegeps and will realize the following objectives:

To increase the interest of female students in the physical sciences in order that:

1. the rate of program change for female students from the general science program is diminished; and

2. that a larger percentage of female students choose to enroll in programs at the university level in the pure or applied sciences.

4. HYPOTHESES

1. That the attitude towards the chemical industry of female students in the physical sciences can be changed by the insertion of additional material into the Chemistry 101 curriculum, by selecting appropriate examples to explain the subject matter, and by providing role models for the students.

2. That the rate of program change of female students from the general science program at Champlain College can be decreased by curriculum intervention.

3. That the use of feminist pedagogy will not have a negative impact on the attitude of male students.

4. That a larger percentage of female students will choose to attend university in the physical or applied sciences as a result of the intervention.

5. METHODOLOGY

It is apparent that many of the barriers to women entering physical science and engineering programs at the university are either caused by the educational system or could be lowered by education; we did not attempt in this study to address all of them. No direct attempt was made to change the attitudes of the teachers, although we can assume that participation in the project indicates an awareness of the problem and that some attitude change would result from involvement in the project.

In this experiment we attempted to make chemistry more relevant to all the students with particular emphasis on environmental issues. We showed some of the ways chemistry has improved our lives and we brought female role models into the classroom who could tell the students what it was like to be an engineer.

Groups were assigned as experimental or control based on teacher preference. Apart from the additions listed below, both groups followed the same course, used the same textbook, did the same labs and took the same final exam.

5.1 Interventions in the Curriculum

5.1.1 Role Models

The lack of role models for women in the physical and applied science was addressed by inserting in the lab manuals of the experimental group the profiles of women chemists prepared during the pilot project (See Appendix 2). Two women chemical engineers were invited to visit the classes of the experimental groups.

5.1.2 Information About Engineering as a Profession

The women engineers who visited the classes were asked to tell the class about their experiences at university both as students and as women and the type of summer work they did; their experiences in the chemical industry including the type of work they did, the promotions they had received, the different plants they had worked in. One of the chemical engineers worked for Dow Chemical at its Boucherville plant, which has advanced environmental safegrounds, information was given to the students about this.

5.1.3 The Relevance of Chemistry

An audio-visual presentation was prepared for each unit of the Chemistry 101 course. The presentation applied the course content to subjects believed to be of interest to women. (See Appendix 3 for a complete description of the additional material.)

5.1.4 The Human Aspects of Chemistry

In each of the presentations an attempt was made to reflect a positive attitude. For example, in the segment on acid rain, emphasis was placed on chemical solutions to the problem as well as its causes.

5.2. Assignment of Groups

Teachers volunteered to instruct an experimental group and the remaining groups became the control. An attempt was made to balance by sex.

Teacher	Experimental or Control	Number of Males Who Completed the Course	Number of Females Who Completed the Course
Fall Semester			
Male A	Experimental	18	13
Male B	Control	11	13
Female A	Experimental	15	16
Female B	Control	16	17
Winter Semester			
Male C	Experimental	14	10
Male A	Control	24	8
Female B	Experimental	9	13

Table 5.1 Experimental Design

Two teachers (Male A and Female B) taught both an experimental and a control group (see Table 5.1).

5.3 Training of Teachers

Teachers were asked not to tell their students that we were conducting an experiment. The teachers told the students that the purpose of the questionnaires was to give us feedback on the courses. The teachers were encouraged to introduce the visitors simply as engineers; no emphasis was placed on their gender. The teachers were asked to ensure that the engineers talked about their jobs and their experiences at university during their presentation.

5.4 Instrument for Measuring Students' Attitudes

Questions developed in the pilot project were used with slight changes so that we could reject students who were repeating the course. (See Appendix 4) Questionnaires were distributed at the beginning and end of each semester to both male and female students. Those at the beginning were used to assure that there was a random distribution of students' attitudes in the two groups and to allow us to detect changes in individual students.

5.5 Instrument for Measuring the Response of the Teachers in the Experimental Group

Questionnaires were completed by teachers of the experimental groups. They were asked how they had incorporated the extra material. The questionnaires were intended to gauge affective response and attitudinal orientation of teachers towards the project. (See Appendix 5)

5.6 Estimation of Rate of Program Change

Data on the rate of program change was obtained from college records.

5.7 Data Analysis

Data from student questionnaires were analyzed using STATPACK, a statistical package developed by McGill University. The teachers' responses were analyzed using content analysis techniques.

6. RESULTS

6.1 Results That Test Hypotheses

6.1.1 Results That Support Hypothesis #1: That the attitudes of female students towards chemistry and the chemical industry can be influenced by the curriculum.

6.1.1.1 Question Where the Response Appears To Be Dependent On the Teacher

The course content of chemistry 101 is interesting.

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

When analysing the responses for female students, the average score was lower for the experimental group, but the difference was not significant. However, for teacher Male A and teacher Female B there was a significant difference between their experimental and control groups. In both cases the female students in the experimental group found the course more interesting.

Teacher	Number	Group	Mean	SD	t	p
Male A	13 8	Experimental Control	1.923 3.000	0.641 1.414	2.401	.027
Female B	13 10	Experimental Control	2.077 3.000	0.641 0.816	3.043	.006

Table 6.1 Responses of female students to question on the course content

6.1.1.2 Question Where Analysis is Based on the Entire Group of Female Students

Female students in the experimental and control groups showed significant differences in their answers to the following four questions: questions #2, #3, #11, #15. The results are summarized in Table 6.2.

Question #2:

Jobs in the chemical industry are important to the Canadian economy.

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

Group	Number	Mean	SD	t	p
Experimental Control	54 40	1.759 2.450	0.751 1.131	3.556	0.001

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

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

Group	Number	Mean	SD	t	p
Experimental Control	54 40	2.185 2.750	0.870 1.149	2.713	0.008

Question #11:
A woman engineer will usually be treated as an equal by her male co-workers.

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

Group	Number	Mean	SD	t	p
Experimental Control	54 40	2.519 3.300	1.112 1.203	3.255	0.002

Question #15:
Most scientists and engineers have interesting and rewarding jobs.

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

Group	Number	Mean	SD	t	p
Experimental Control	54 40	1.704 2.525	0.571 1.176	4.474	0.000

Table 6.2 Responses of female students to selected questions

There was no significant difference between the responses of females in the experimental and control groups for all other questions that assessed the attitude of the students towards science and engineering .

6.1.2. Results that test hypothesis #2: that the rate of programme change for female science students can be reduced by curriculum intervention.

Table 6.3 shows the program change rate for students in the year prior to the intervention, the year of the intervention and the year after the intervention.

6.1.3 Results that test hypothesis #3: that feminist pedagogy will not have a negative impact on male students.

There was no evidence that the curriculum intervention had negative effects on male students. The question designed to test the attitude towards chemistry showed no significant change in the attitudes of male students either from pre test to post test or in experimental and control groups. The attitudes of male students (see Section 6.2.2) towards the visiting engineers was very positive.

6.1.4 Results that test hypothesis #4: that the intervention will increase the number of female students intending to study physical or applied science at university

The method of testing a student's intention of continuing her studies in engineering was determined by the answer to the question: "Are you considering a career in engineering"? It is important to remember that intention to act is not always a good predictor of action. Results indicate that, for students who completed the course, the number of female students

Semester	Females: Initial Number of Students	Females: Number Changed Program	Females: % Program Change	Males: Initial Number of Students	Males: Number Changed Program	Males: % Program Change
Fall 88	68	14	21	67	13	19
Fall 89 Experimental	30	3	10	39	7	18
Fall 89 Control	39	9	23	38	8	21
Fall 90	45	5	11	56	4	7
Winter 89	26	6	23	55	18	33
Winter 90 Experimental	25	4	16	24	8	33
Winter 90 Control	11	4	36	20	1	5
Winter 91	44	12	27	54	16	30

Table 6.3. A comparison of the rates of program change for science students showing data for the year prior to the intervention and the year following the intervention.

interested in a career in engineering increased and that the increase was more noticeable in the experimental group than the control group. On the contrary, some males who completed the course had been turned away from engineering but there was no obvious trend. The results are summarized in Table 6.4.

EXPERIMENTAL							
Semester	Teacher	Initial # Females*	Final # Females		Initial # Males*	Final # Males	
Fall	Male A Female A	2 4	5 7	+3 +3	11 13	11 12	0 -1
Winter	Male C Female B	4 4	5 6	+1 +2	13 6	12 6	-1 0

CONTROL							
Semester	Teacher	Initial # Females*	Final # Females		Initial # Males*	Final # Males	
Fall	Male B Female B	6 6	6 6	0 0	7 11	7 11	0 0
Winter	Male A	4	3	-1	17	17	0

* Only students who completed the course are considered.

Table 6.4 Table showing the change in interest in engineering as a career for both male and female students with and without intervention.

6.2 Other Results

6.2.1 Teacher Responses

The teachers responsible for the experimental groups were all positive about the experience. They found the additional material was interesting and could be fitted easily into the course. None of the teachers had a problem completing the curriculum despite the addition of the extra material. All of them would be prepared to make changes permanently, if it were shown to be beneficial, and they felt that we should look at doing the same thing for our other chemistry courses. One teacher noted that he enjoyed using the slide presentations as he found that they encouraged student questions and discussion. Another commented that the visits of the engineers brought a "*taste*" of the real world into the classroom.

All the teachers agree that it is important to have more women engineers but they do not necessarily see the problem the same way. Male teachers see the problem that science is difficult logical and a lot of work, and finding students, either male or female, who can handle the program is a problem. It is probable that these teachers reinforce the myth of science being difficult and arduous in their classes. The female teachers, however, responded as if the problem was with society, i.e. men. That when men accept women as being intelligent and career minded, girls will no longer be deterred from the field.

6.2.2 Student Responses to Visits of Women Engineers

	Males	Females
Very interesting	28%	18%
Interesting	48%	65%
Don't know	12%	4%
Not interesting	12%	9%
Very negative	0%	4%

We can see that the visits were popular with both male and female students, with close to 80% in both groups indicating they found the visits interesting. No student seemed to notice or certainly no student commented on the fact they were women. This would indicate that, to some extent, women engineers are being accepted as normal. The males in the class asked far more questions about courses and job opportunities, so we can assume that this type of interaction is also beneficial for male students.

6.2.3 Students Responses to the Profiles in the Lab Manuals

Perhaps because the material was not tested, only 30% of both male and female students 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.

6.2.4 Student Responses to Information on the Environment in the Course

	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%

67% of the male students and 83% of the female students stated that they found the material on the environment interesting. Perhaps this was part of the reason for the interest in the course content of female students.

7. CONCLUSIONS

7.1 Hypothesis #1:

that the course content of 101 is more interesting to female students if topics that are expected to be of interest to females, i.e. topics related to health, the environment and beauty are included in the course. This hypothesis is accepted. The attitude of female students towards the chemical industry can be modified by including in the course material that puts the chemical industry in a positive light and giving the students the chance to interact with female engineers, an experience which they admitted to finding interesting. They also found the information on the environment, provided in the course, interesting.

7.2 Hypothesis #2:

that the rate of program change of female students from the general science program at Champlain College can be decreased by curriculum intervention. The results were encouraging. The rate of program change for the experimental group was much less than that of the control group in both semesters. Since two teachers were involved with both the experimental and the control group and since these students also took a physics course at the same time, their experience in physics would almost certainly influence their decision to change programs. The students would also have taken a mathematics course in the same semester. Their decision to change programs is less likely to be influenced by their experience in math, since, if they change into the Commerce program, they will still be required to take mathematics courses. Long term trends are less clear as we have little data. Since the percentage of students entering the Science program at the level of Chemistry 101 and not being required to take Chemistry 111 first is declining, we might expect to see a diminishing rate of program change in the Fall semester as only the better prepared students are in the course.

7.3 Hypothesis #3:

that the use of feminist pedagogy will not have a negative impact on the attitude of male students. There was no evidence that the curriculum intervention had any impact, either positive or negative on male students. Male students did however find the visit of the female engineers to the class more interesting than did the females. This is possibly because more of the males are interested in becoming engineers.

7.4 Hypothesis #4:

that a larger percentage of female students will choose to attend university in the physical or applied sciences as a result of the intervention. Between one and three females in each of the experimental groups changed their position from no interest to a career in engineering to an openness to consider the possibility. Insufficient data is available to know if this is simply due to the exposure to a college education. However, since the control groups did not show the same trend, we do have some indication that the change of career plan can, at least in part, be attributed to the intervention.

7.5 Teacher Responses

The teachers involved in the project found the experience positive. They enjoyed having engineers visit their classes and the teachers that used the audio-visual material provided, thought it was useful.

8. RECOMMENDATIONS

1. DGEC should provide professional development opportunities to college science teachers that will raise their awareness of the interests of female students, their concern about working in a male-dominated career, and their negative view of industry.

2. DGEC should encourage the colleges to make use of female engineers in Quebec, by inviting them to meet female science students.

3. DGEC should fund research to prepare audio visual material that is appropriate to college education and that focuses on subjects that are of primary interest to females.

BIBLIOGRAPHY

American Association of University Women (1991), Shortchanging Girls, Shortchanging America. Washington AAWW

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

Benbow, C.E. and Stanley, J. (1981) Sex Differences in Mathematical Ability: Fact or Artifact? Science 210, 1262-1264

Conseil du statut de la femme (1985). La situation économique des Québécoises. Québec: Gouvernement du Québec.

Conseil de la Science et de la technologie (1986) Avis: la participation des femmes en science et technologie au Québec (Document 86:06), Québec: Gouvernement du Québec.

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

Davis, F., Steiger, A. and 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 revue-ménage.

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

Ethington, C.A., Lee, M.W. (1988) Women 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.

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

Gagné, E. and Poirier, P. (1990) Le Choix de Carrière de la Femme dans une Perspective Systémique, Les presses de l'Université d'Ottawa: Ottawa.

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

Gillbert, C. (1988) Women-Friendly Chemistry, St. Lambert: Champlain College

Gilligan, C. (1984) In a Different Voice.

Hanen, M. (1990) Women in Science and Technology: The Why Matters as Much as the How, Affaires Universitaires, Juin-Juillet, 48.

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

Lee, L. (1984) Etude des facteurs limitant l'orientation des adolescentes dans les programmes de formations non-traditionnelles. Québec: Ministère de l'Education

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

Mura, R. (1982) Women and Mathematics. Proceedings of the Annual Meeting of the Canadian Mathematics Society.

Mura, R. (1985) Filles et garçons face à la mathématique: égalité de chaque congrès de APAME, Three Rivers. Reprinted in September 1985, Instantes Mathématiques.

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

Neville, N., Gibbons, R. and Codding, P.W. The career goals of female science students in Canada. The Canadian Journal of Higher Education, 18, 31-48.

Omerod, 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.

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

Smail, B., Whyte, J., and Kelly, A. (1982) Girls into Science and Technology: Final Report, Manchester: GIST, Department of Sociology, University of Manchester.

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

Whyte, J., Deem, R., Kant, F. and Cruickshank, M. (1985) Girl Friendly Schooling. London: Methuen.

APPENDIX 1

THE GIST EXPERIMENT

The most comprehensive experiment to change attitudes towards science is the Girls Into Science and Technology (GIST) program undertaken by the Manchester Education Authority. (Smail and Whyte, 1982; Whyte, Deem, Kant and Cruickshank, 1985). The goal of the program was to close the achievement and attitude gap between girls and boys in science and therefore 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 eight comprehensive schools belonging to the Manchester Educational Authority, with two schools as the control group. The choice of schools was determined by certain practical considerations. There was no selection process as such (Whyte, Deem, Kant and Cruickshank, 1985). In the control group attitudes were measured but no intervention took place.

In the planning portion of the program, studies were carried out to find the students' interests. The following intervention strategies were developed with the help of the teachers involved.

1. Aspects of the course which proved to be more interesting to boys were replaced by modules of more equal interest to both sexes.

2. Several women scientists were trained to respond to the interests of girls concerning their careers and family life and a visiting scientist's 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. The 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.

At least in one case an experiment to change girls' attitudes towards science has met with limited success.

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.

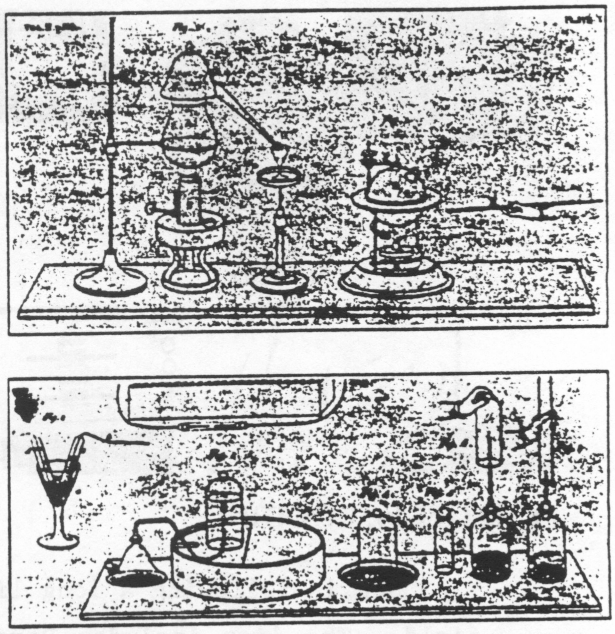
She is following a long line of women who have been successful in this field. The list includes Dorothy Hodgkin, who received a Nobel prize in chemistry for the elucidation of the structure of vitamin B_{12} using x-ray crystallography.

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.

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.

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.

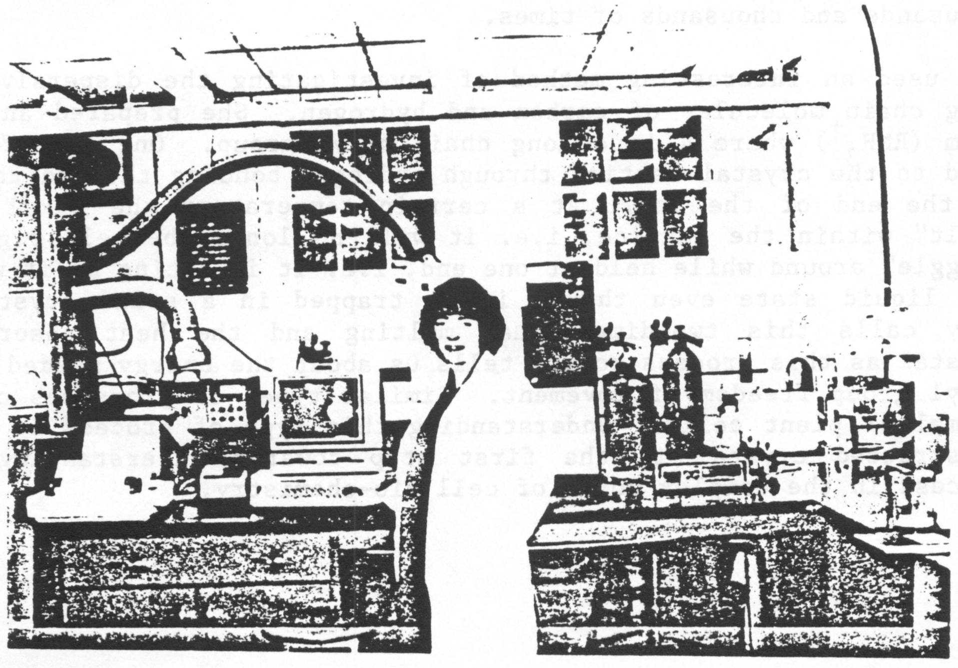
After graduating from McGill with a PhD in chemistry in 1976, she worked in a research laboratory in Buffalo, New York, until, in 1982, she had the opportunity to return to Canada as a professor of chemistry at Queens University in Kingston. She was the first woman to be hired in chemistry in a tenure-track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

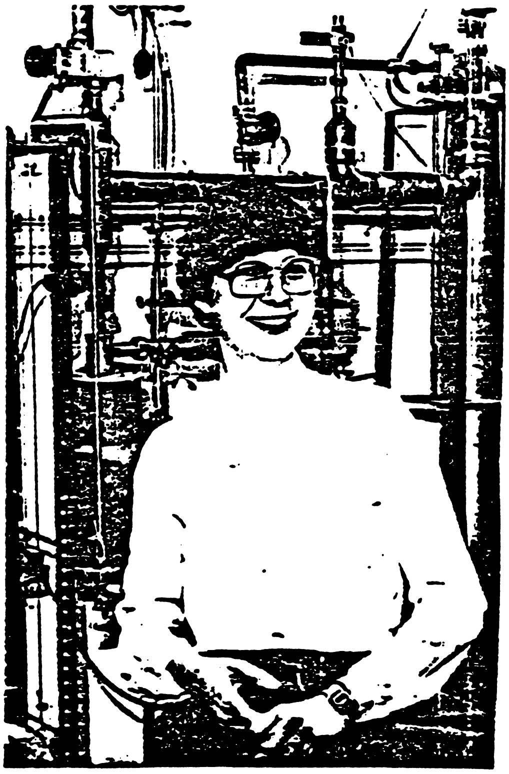
TRUIS SMITH-PALMER

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.

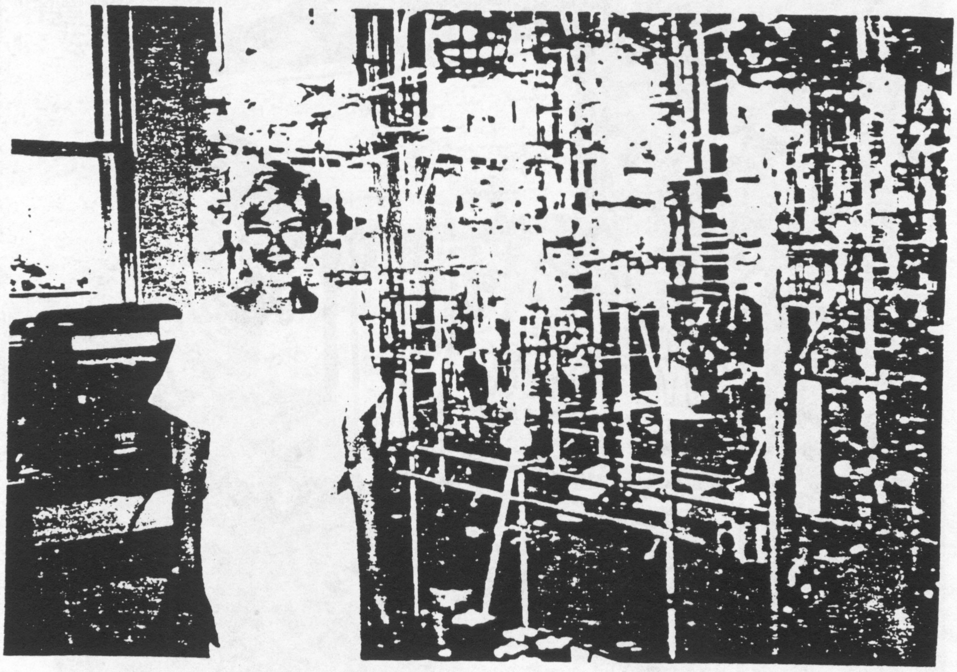
CECILLE MILLIGAN

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.

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:

$$CO + OH \rightarrow CO_2 + H \quad \text{Step 1}$$
$$H + O_2 \rightarrow OH + O \quad \text{Step 2}$$
$$CO + O_2 \rightarrow CO_2 + O \quad \text{Overall}$$

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 3

AUDIO VISUAL MATERIAL PREPARED FOR THE COURSE

UNIT	RESOURCE
Unit 1: Atomic Theory	Slides and background on nuclear medicine especially PET scan.
Unit 2: Bonding and Molecular Geometry	Slides and background material showing the relationship between smell and molecular shape.
Unit 3: Descriptive Chemistry	Video on acid rain. Video on the greenhouse effect.
Unit 4: Intermolecular Forces	Slides and background on gems.
Unit 5: Kinetics	Video and explanation on the destruction of the ozone layer.

A:\DOC02.CG

CHAMPLAIN REGIONAL COLLEGE
St. Lambert-Longueuil Campus

APPENDIX 4

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, 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 ☐ 2 agree ☐ 3 disagree ☐ 4 strongly disagree ☐ 5 don't know ☐

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

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

6. Jobs in chemical engineering are usually well paid.

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

7. The chemical industry offers many chances of promotion.

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

8. Chemical pollutants are a serious health hazard.

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

9. Chemical pollutants are a serious environmental threat.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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 ☐

FORM02A.QUE

APPENDIX 5

Champlain

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

M E M O

TO:

FROM: CATHERINE

DATE: December 18, 1989

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 radioactivity lab people had not shown the material. Any suggestions? How about in the final? It should <u>not</u> be administered by the teacher.

D. Did you use the profiles in the lab manual? How?

E. Any other comments?

CG/ge
MEMO12.EIJ