

**THE SOCIAL CONSTRUCTION OF FEMALE ENGINEERS:
A QUALITATIVE CASE STUDY OF
ENGINEERING EDUCATION**

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by
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ABSTRACT

This research is a case study of three important phases of engineering education: the social factors influencing young women and men in choosing engineering as a profession, what causes students to discontinue their studies, and the students' educational, social and cultural experiences during their education. The study is within the framework of feminist standpoint epistemology and uses both qualitative and quantitative methods, giving the study both depth and breadth. The data derive from a demographic survey of one first-year cohort in an engineering college, from non-participant observations in first, third, and fourth-year engineering classes, but primarily from in-depth, tape-recorded interviews with male and female students at the first and fourth year levels of study and with students who transferred to other disciplines. Data collection took place between September, 1996 and April, 1998.

Major findings point to a chilly climate in the college of engineering where a masculine culture tends to exclude the female students from equal and equitable educational experiences. This culture, which in addition to exclusionary features includes a heavy workload with little time left for outside activities, was a major reason for attrition from the engineering program. There are also indications of an environment where male harassment of female students cause significant discomfort to women. However, women's attempts to voice their objection to such treatment are met with further exaggeration of the problem. The women are also labelled as troublemakers, poor sports, poor team-players, and lacking a sense of humour.

The college exploited a committee of female students as volunteers in its recruitment strategy. This committee earned high praise from the administrative level, having raised the ratio of first-year female students from 5% to 22% at the same time as the college increased enrollment limit from 300 to 410 students. However, it had low prestige among the students.

This research is significant in its use of feminist theory and methodology and using a qualitative method that allows the students own words and voices to express their day-to-day, lived experiences in the college.

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CHAPTER ONE
SURVEYING IN SEARCH OF A CONSTRUCTION SITE
(Introduction and Research Objectives)

In the afternoon of December 6, 1989 shots rang out in the classrooms and hallways of L'École Polytechnique in Montreal, P.Q. When the shooting ceased 14 young women, 13 engineering students and one employee, lay dead while an additional nine women and four men were wounded. Their assassin, who then turned the gun on himself, was a self-proclaimed hater of women in general and feminists in particular. The Massacre in Montreal was the worst mass-murder in Canadian history. This horrifying event became the catalyst for a heightened public awareness of violence against women in general, and it created an interest in the conditions for women in predominantly male occupations or professions, in this case, female engineering students.

Since the early 1980s, the low enrollment of women in engineering has become an increasingly public issue, and governments, universities and the engineering profession itself have made efforts to both recruit and retain female students. As one step toward encouraging women into engineering, Northern Telecommunications (Nortel) and the Natural Science and Engineering Research Council of Canada (NSERC) established a National Chair for Women in Engineering (WIE) at the University of New Brunswick, Fredericton, in May 1989. The Chair holder, Monique Frize, P.Eng., Ph.D., OC., immediately constituted the Canadian Committee of Women in Engineering (CCWE) to study and implement strategies for recruitment and to combat attrition. Similarly, the Equal Opportunities Commission and the Engineering Council in Great Britain launched WISE (Women into Science and Engineering) in 1984 to promote increased enrollment as an equality program for women (Henwood, 1996).

More women are now seeking an engineering education, in general as well as at the University of Saskatchewan (U of S). Female enrollment in first-year and total four years has increased from a low of 4.8% and 6.3% in 1987/88 to 22% and 23% respectively in 1998/99.

First year female registration peaked in 1994/95 at 24% of the cohort. It has since decreased and stalled at approximately 21 - 22% (University Studies Group, 1992, 1994, 1999). Total student population in the College of Engineering in 1996/97 (the year of data collection for this study) was 1,156, of whom 242, or 21.8% were women. However, women are still poorly represented in engineering compared to female enrollment in many other previously male colleges at the U of S (University Studies Group, 1993; 1999). (See Appendix E)

A recurring problem in engineering education, at the U of S as elsewhere, is the high rate of attrition. Although statistics show that the total attrition from engineering education has always been high, it is higher for female than for male students. The first-year attrition rate for women has varied between 32% and 46% during the years between 1984/85 and 1992/93 and, according to the Dean of Engineering at that time, female withdrawal from the program appeared unrelated to the women's academic performance as measured by grades. The loss of first-year male students during the same period ranged from 23% to 41% (University Studies Group, 1992, 1994, 1999).

Because engineering is perceived as "a field where professional identity is associated with being male" (Dryburgh, 1999:674), there is reason to believe that a masculine culture is reflected also in engineering education. The purpose of my research is to investigate women's experiences in engineering programs through a case study of women's engineering education at the University of Saskatchewan in Saskatoon from a theoretical perspective of the feminist standpoint and using feminist research methodology. The research questions also investigated whether or not there is a masculine culture in the engineering college. If so, it is possible that the study of engineering will entail different educational and social experiences for female and male students. Through surveys, interviews and observation I expected to find answers to the questions:

1. *Which social factors or forces influence and motivate young women and men to choose engineering as a career?*
2. *Is any particular field of engineering especially attractive to women?*
3. *The attrition rate in the College is higher for female than for male students and not related to academic ability. Why do the students voluntarily withdraw from engineering education?*
4. *In light of the persistent and high attrition rate for women, what kind of educational, social, and cultural influences do women experience during their tenure as students? Or, in lay terms, what is it really like to be a woman as a student in a College of Engineering?*

The focus of my research is the population of female students in the College of Engineering at the University of Saskatchewan. My major concerns are the reasons why some women withdraw from the program when academic ability is not an issue, and the lived experiences of those who complete their engineering studies.

Background and Strategies in Engineering Education

Changing social attitudes during the past few decades have seen a decreasing birth rate, an increased divorce rate, a steady increase of women in the paid labour force, and a growing number of dual-income couples and families. However, statistics show that women's income, on average, is only 65 to 70% of the average for men.

The average earnings of employed women are still substantially lower than those of men. In 1997, women working full-time, full-year had average earnings of just under \$31,000, or 73% of their male counterparts' earnings. However, the average earnings of these women is up from 68% in 1990 and around 64% in the early 1980s (Statistics Canada, 2000).

Therefore, in order to better provide for their families, many women are seeking higher paid employment in fields that have traditionally been considered male. Engineering is such a field, offering interesting, challenging and financially rewarding employment opportunities.

Both history and statistics indicate that, except for a small number of 'exceptional' women, the engineering profession has been overwhelmingly, almost exclusively, a male domain. Until recently, women's participation in engineering was below ten per cent in Canada. In 1985/86 women made up only 6.3 % of the students in the College of Engineering at the U of S (University Studies Group, 1992). Since the mid-1980s, governments and industry have encouraged women to seek education and employment in non-traditional fields and professions. For example, the federal government introduced the Canada Scholarships (now defunct) to promote science and technology education. The scholarships were intended to be divided equally between male and female students. Because women's participation in science and technology had been considerably lower than men's, it appeared to some male students that a disproportionate number of the scholarships was awarded to women. Additionally, in 1989, the Canadian Engineering Memorial Foundation established a scholarship fund to commemorate the victims of the Montreal Massacre.

However, the social forces that encourage women into science and technology go

deeper than mere socialization, recruitment, and encouragement. When Dr. Monique Frize accepted the Women in Engineering (WIE) Chair,¹ she consulted her mentor, Dr. Ursula Franklin, eminent physicist, humanist, and Professor Emerita at the University of Toronto, for directions for the chair. Franklin responded: "It's more than just numbers, you know" (Frize, 1994, personal communication). *More Than Just Numbers* subsequently became a slogan for the Chair and the title of the 1992 Canadian Committee of Women in Engineering (CCWE) report and the 1995 update conference. The motto implies that social and professional attitudes, such as reluctance toward women in the workforce in general and non-traditional occupations in particular, can be major barriers to women's full participation in the engineering profession. The *More Than Just Numbers* slogan thus suggests that women's under-representation in science and technology/engineering is multidimensional.

Positioning the Researcher

My position as a feminist researcher is the result of several intersecting and parallel events that started in 1985 when I enrolled as a part-time student at the U of S. The decision to return to a university education became the source of enjoyment, pleasure, aggravation, frustration and many other emotions. To my surprise, it was fun to return to a formal educational setting. I also discovered a difference between the way I, as a so-called 'mature' student, approached the courses, and the attitudes of my much younger classmates. I was doing well in my courses, and that boosted my self-image. As a stay-at-home mother and farm wife I had felt somewhat inferior, to my sons because they thought I was old-fashioned and to my husband because I had grown up in a large, foreign city and not on a Saskatchewan farm.

In my third year of part-time studies a letter from the Office of the Dean of Arts and Science encouraged me to seek an honours degree, which I then earned in 1991, after six years of studies. But those years were at times emotionally draining. The death of my mother, the 'empty nest' syndrome when my sons left home for university pursuits, divorce from, and the

¹ The National Chair has since been divided into five regional chairs sponsored jointly by NSERC and industry. The five chairs are: British Columbia and the Yukon (NSERC/IBM) located at the University of British Columbia; Prairie Region (NSERC/Petro-Canada) at the University of Calgary; Ontario (NSERC/Nortel) at Ottawa and Carleton Universities; Quebec (NSERC/Alcan) at Laval University and Atlantic Provinces (NSERC/Petro-Canada) at Memorial University. Dr. Frize now holds the Ontario Chair.

subsequent death of, my husband, and a move to the city from the town where I had spent a major part of my life, all contributed to crisis situations. Thanks to my educational goal and the friends I made in and outside the university I look back on those years with joy and satisfaction. With a seemingly insatiable need to keep studying, I entered graduate studies and wrote my M.A. thesis on the university experiences of mature female students.

During my undergraduate studies I had been introduced to feminist studies and feminist theory. Although all the 'classic' feminist theories had elements that appealed to me, I was most influenced by the socialist feminist perspective, and particularly feminist standpoint epistemology. As Dorothy Smith (1987; 1988b) explains the feminist standpoint, it allows a researcher to involve herself in the situations of her research. The standpoint also allows her to bring with her the 'baggage' she has accumulated during her life. Thus, while doing my research with mature female students, I had a special affinity for them because I was one myself and understood many of the issues and barriers mature women faced in university settings.

The experiences with mature women encouraged me to look ahead to other student populations that might face barriers and difficulties in the masculine university environment. At that time, my older son was enrolled in the College of Engineering. While he was studying engineering he lived at home, and we often ate our evening meal together. During these meal times we compared our different fields of study and our lives as students. Mine was mostly involved with female students in the social sciences, his was with men in applied science in the College of Engineering. Juxtaposing the experiences of a mature female engineering student I had interviewed for my M.A. with my own and those of my son, I realized that my next project would be engineering education for women. What makes women want to study engineering? Why do so many academically talented women voluntarily give it up? How do they cope in a very masculine culture and environment during their tenure as students? These, then, became the questions I wanted to answer.

The qualitative, case-study approach to the research provides a richly textured look at the students' educational experiences. Only confidential dialogue could reveal many of the nuances of their lived experiences. During the interviews, the students spoke openly and freely, mainly because I was an outsider and not a representative of the college. Yet I had some of the insights of an insider, as the mother of an engineer who had gone through the same program as my respondents.

The voluntary nature of the study participants may have had an influence on the results because the respondents had taken personal interest in my study and welcomed the opportunity to talk about their experiences. My own attributes as a mature woman and mother of a male engineer and as a student, likely had some bearing on the research. As a woman, familiar with feminist theory and methods, I believe I can understand, and perhaps draw out, some issues that the students may not have considered on their own, such as harassment and power dynamics. I believe the engineering students accepted me as a woman and a student at their own level of power, although I was, of course, in control of the project.

Organization of the Dissertation

In the following chapters I will attempt to 'construct' female engineers through their education as if it were a physical structure, that is, treating engineering education as the 'construction' of professionals who practice within 'The House of Engineering.' In this introductory chapter I have 'surveyed the landscape' of possible research problems. I have established a 'construction site' that has sprung from my own interests, experiences, education and family.

Chapter Two reviews literature on engineering education for women and establishes a theoretical framework for the data analysis. I see the chapter as 'excavating the building site' as I pore over the literature and theoretical perspectives that elucidate the study. The chapter includes discussions of feminist issues of the roles and numbers of women in engineering as well as explanations for women's under-representation in engineering. It also brings to light the many issues that impinge upon the academic environment where women increasingly enter areas of study that have previously been reserved mainly for male students. Gender issues in education, such as sex discrimination and a 'chilly climate' for women are of the utmost importance to the analysis.

Chapter Three discusses the methodology and methods I have used to gain information from my informants. This process can be compared to 'drawing the blueprint' for the 'structure' I am about to build. The chapter provides a general discussion of feminist epistemology and research methodology and how these differ from traditional, androcentric research methodology. The chapter will discuss how I have operationalized my research within the context of feminist research strategies.

In chapters four through seven I will present the data as they emerged from the various methods and components of the research. Chapter Four examines the 'building material,' that is to say, the students who seek an engineering education (being 'manufactured' into engineers) and the factors and social forces that encourage or discourage young women and men to study engineering. The chapter compares the demographic characteristics of the 1996/97 first-year cohort of engineering students to the general provincial population, based on the 1996 census. The chapter also discusses how these particular students were encouraged to study engineering and how students decide on their engineering specialization. It provides information on which departments the male and female students favour at this university.

Unfortunately, the 'plumbing' in the 'house of engineering' is defective. The 'pipeline' leading to the engineering degree is 'leaking' as students, especially female students, voluntarily withdraw from their education in spite of having the skills and academic expertise to continue. In the literature, this phenomenon is called "The Leaky Pipeline" from grade school to a Ph.D. degree, university appointments and senior management in industry. Why do proportionately more female than male students leave their engineering education? Is the problem the engineering profession *per se*, the course load required to complete the requirements for graduation, or are there other issues that interfere with the students' aspirations? What do they do when they leave engineering and enter the 'corridor of educational opportunities?' These issues are discussed in Chapter Five.

Chapter Six explores the culture in engineering education through the students' educational and social experiences while they are being 'constructed' as engineers during the years of their education. The chapter examines the actual learning environment in the classrooms and engineering courses as well as day-to-day interactions with faculty and fellow students. Students relate some of their classroom experiences in which the culture of the profession and the college emerges as masculine, which at times is both non-inclusive and uninviting to many. The specialties they choose, the courses they elect, and other college activities build their skills and confidence in preparation for becoming full-fledged engineers. As the students move through the years, they are polished and fine-tuned, both educationally and socially, in readiness for 'commissioning' as engineers at graduation.

In Chapter Seven I examine and analyze the extra-curricular activities in which the students chose to be involved. A gendered division of labour became evident as the male

students held most of the executive positions within the Students' Society while the female students had become the organizers of the outreach and recruitment strategies of the college. In these student organizations, the future engineers become 'organized;' the men prepare for the prestigious corporate world, the women develop skills important to the care-taking effort that is considered "women's work" and, as such, is undervalued.

The concluding Chapter Eight will discuss the implications of the research findings presented in the preceding chapters, both for future students and for the College of Engineering. The chapter is the 'commissioning' of the completed 'construction project,' that is, the students earn their B.E. at graduation. (In the engineering world, the commissioning takes place at the completion of the project, when the responsibility transfers from the construction team to the project owners). The chapter will suggest some strategies to improve the environment in the College of Engineering, as well as make recommendations for further study.

CHAPTER TWO EXCAVATING THE BUILDING SITE

(Review of the Literature)

Since the 1980s, the issue of women's low participation in science and engineering has become an area of general interest. When Monique Frize, P.Eng., Ph.D., O.C., then the holder of the national NSERC/Nortel chair for Women in Engineering, addressed the Seventh International Conference on Gender and Science and Technology (GASAT 7), Waterloo University, August 1993, she stressed the need for, and the importance of, more sociological research on women in engineering. Despite the increasing visibility of female engineering students in public and political arenas, women are still under-represented in engineering, and there is little sociological literature on the variables influencing this situation. In this chapter I examine three separate bodies of literature relevant to women's participation in engineering and science programs. One of these areas is the recruitment, attrition and retention of female students in higher science and engineering education. A second area, gender issues, includes gendered socialization, "doing gender," equal opportunities for women, the idea that education for women is in a deficit position, as well as issues of masculinity, sexism and harassment. The latter is generally known as the "chilly climate" for women. The third area of the literature shapes the framework for my understanding of these bodies of literature, grounded in the literature on feminist theoretical perspectives. The major theoretical framework is the feminist standpoint, which allows the researcher to use her life experiences to elucidate the insights and lived realities of the research participants.

RECRUITMENT, ATTRITION AND RETENTION

Because of the low rate of participation of women in engineering and the sciences, the main focus has been to increase their numbers, starting at the introductory level of education. Two major issues influenced the drive to increase the involvement of women in these fields:

ensuring a steady supply of a qualified workforce in science and technology fields, and the growing demand for equal employment opportunities for women. As an example of the first issue, and pointing to a declining birth rate at the time (LeBold, 1983; Frehill, 1997), Bowen (1988) stated that there were fewer American students in the eligible age groups available for engineering education. Therefore, he was concerned that a decreasing interest in engineering would soon cause serious faculty shortages, which would eventually influence the workplace. Noting that about 75% of engineering degrees were awarded to white males, Bowen recommended urgent steps to recruit women and minorities to the profession. However, he found that these students were the most difficult to retain in the programs. Therefore, Bowen (1988) suggested that recruitment of engineering students must start in kindergarten because of the many years it would take to successfully complete the engineering education needed for the various levels of specialized university degrees. He had also observed that European and Asian countries had outdistanced the USA in numbers of engineers per capita and stressed that not enough American-born engineering graduates proceeded to the Ph.D. level to become eligible and available to fill faculty shortages, which would soon become evident.

The issue of recruiting and increasing the numbers of women was also important in Great Britain, where Kim Thomas (1990) reported that the government saw women as an untapped resource that could be encouraged into science and engineering, preferably into the areas of the physical sciences and engineering, where the shortages were most acute, rather than in biology or medicine, where women were already making inroads. In Canada, Finnie et al. (2001:1) warn that the country needs “a substantial growth in the number of engineers” to maintain our position in technology. Because women are reluctant to enter these fields, it is necessary to investigate the reasons why and to make efforts to attract women to these areas. The goal must be getting “women technically—and attitudinally—equipped for and into the science and engineering workforce” (Fox, 1998:209). The use of women as such a reserve army to fill employment shortages became an incentive for industry to consider women’s equal opportunities with men in the workplace (Henwood, 1996).

The launch of the WISE (Women into Science and Engineering) approach in Great Britain in 1984 appealed to industry because it would alleviate the worker shortage that was a problem at the time. However, the program was also an effort to encourage equal opportunity

for women in those disciplines. Flis Henwood (1996) argues that its success was limited because the 'WISE discourse' had a too narrow focus on women's choices as constraining. The discourse focused primarily on information, both printed and practical, for girls who might be intimidated by the presence of boys. Henwood (1996:200) cites three major assumptions of the program as concerning (1) "women's access to relevant information," (2) "the importance of images of science and technology for women's choices," and (3) "women's relationship to masculinity and femininity." Henwood's empirical research did not support these assumptions as proper explanations for the conflicts and contradictions women face in their occupational choices. She found the discourse contradictory in that engineering was work for men, but women could do it, too. Both women who sought traditional and non-traditional careers supported equal opportunity, but were acutely aware that gender difference made it easy to equate 'different' with 'less,' and that gendered power relations were not easily changed.

Recruitment

A major strategy in the recruitment of women into engineering is to make high school girls¹ aware of the opportunities engineering offers. But Eleanor Baum (1989) pointed out that high school counsellors did not encourage women to seek a career in engineering because they considered engineering, in general, to be a field for men. Therefore, the profession would need to promote itself with the help of engineering schools, industry and government. Baum's major concern was that high school teachers and counsellors did not know enough about the educational requirements for engineering or what engineers actually did, causing barriers for recruitment of women into the profession. In response to a decline in general literacy at all levels of education, including at the teachers' level, some engineering schools decided to raise their SAT requirements for entry in order to increase student quality (LeBold, 1983). Raising the SAT requirements would, however, jeopardize equity and be counterproductive, as the higher requirements would exclude from engineering schools 68% of all female and 50% of all male college-bound youth, as well as 84% of female and 59% of male African-American

¹ The literature refers to students in elementary and secondary education as 'girls' and 'boys' and students in post-secondary education as 'women' and 'men.' I will follow that convention.

students. Instead of SAT scores, Daniels (1988) suggested that high school grades in science and mathematics courses would better predict success in engineering education. LeBold (1983) recommended improved teaching and education in these courses to alleviate problems. If the goal was to reach demographic gender parity in engineering education, recruitment needed “sweeping social and educational changes” (Daniels, 1988:766). Therefore, other major existing barriers to women’s recruitment must be identified.

Daniels (1988) stated that while the proportion of female engineering students in the USA had increased from 2.3% in 1972 to 16% in 1985, it was beginning to show decline. While some schools had 20-25% female participation, that was only half way to demographic gender parity. Part of the problem was that girls and boys were encouraged differently and were given different career information in high school. Moreover, girls were subjected to peer pressure and stereotyping that discouraged participation in the courses required for engineering education. Girls who liked mathematics and science were ridiculed by their male classmates and therefore might not pursue these courses. There was also a perception that engineering was “thing-oriented” (Daniels, 1988:766) rather than people-oriented, a stereotype Daniels believed to be inaccurate.

The ‘thing’ versus ‘people’ orientation could be an example of gendered socialization, which militates against girls’ and women’s participation in certain career fields. Etzkowitz et al. (1994) cite gender socialization as a major barrier to women’s comfort in science and engineering, and they found such barriers to women’s career path throughout the academic career ladder. Therefore, Etzkowitz et al. (1994:2) argued that the general assumption of barriers only at the beginning of women’s education, i.e., a “threshold effect” upon entry, and a gender specific “glass ceiling” at the end, is false. For example, male faculty are often unwilling to consider women’s skills on equal terms with men’s. Courses are taught from a taken-for-granted male model and structured to negate much private life. Advising patterns do not consider that women are socialized to be nurturing while men are expected to be competitive, so that socialized responsibilities regarding marriage and children affect women and men differently and become impediments to women’s career aspirations, thus making careers in science and engineering unsuited to women’s lives (Etzkowitz et al., 1994; see also Connell, 2000).

Most important in recruitment is using a variety of approaches and to follow up to keep in touch with students who expressed some interest. To improve and increase recruitment of women to engineering, Daniels (1988) suggested that personal contact with students was more productive and cost-effective than using mass media campaigns. To achieve the personal contact she suggested some strategies that had been successful at her own institution, such as community career days, where teams of women engineers would present information in the students' own communities. There should also be summer programs, career conferences and career days on campus for those who wanted the information to be presented in its natural university setting. Contact with parents, teachers and counsellors would create a social support network, which is essential for young women who choose engineering. As another important aspect of recruitment Daniels stressed the presence of "real people" role models (p.767) who could explain both the positive and the negative sides of engineering and give the students a realistic impression of the profession. Unfortunately, with the existing paucity of women in the field, the problem was to find enough of these "real people" to act as role models in engineering faculties or as mentors (Baum, 1989; Daniels, 1988).

Attrition

However, recruitment in itself is no panacea, as the attrition rate in engineering and science bears out. While Pascal and Kanowitch (1979) did not analyse students' reasons for attrition, they recommended that research would benefit from adopting uniform categories for student withdrawal. They suggested categories of 'no shows' who did not register after being accepted in a particular school; 'withdrawers' who exited the program without completing the term; and 'non-returners' who successfully completed a term but failed to register for the next term. Pascal and Kanowitch argued that there could be widely differing reasons why these groups dropped out of any post-secondary education.

It appears that women tend to withdraw from science and engineering education sooner than men do (Donaldson and Dixon, 1995). The women's "drift" from these fields is of concern to faculty and administrators, as well as to society. Donaldson and Dixon suggest that women value discussion because it builds relationships and constructs meaning, which they do not find in science and technology. Women therefore choose "courses where they feel more

included, interested and important” (Donaldson and Dixon, 1995:30). Although there have been many studies on recruitment, attrition and retention of female engineering or science students in Canada, Australia and the United States (Baignée, 1993; Beal and Noel, 1980; Brainard, 1993; Cukier, 1993; Cummings, 1993; Dench, 1993; Donaldson and Dixon, 1995; Frize, 1993, 1996; Learmont and Lindley, 1993; Sheahan and White, 1990), only a few have asked students directly for their own reasons for withdrawal. In her study, Alison Baignée (1993) surveyed engineering students at two Canadian universities (Ottawa and Manitoba) and found that the major barrier to completing the program for both women and men was the heavy workload. In addition, the difficulty of the work was a major issue, as was the proliferation of outside responsibilities, such as part time work to finance their studies because there was a general lack of financial support for students. However, Baignée’s survey offered only a limited number of choices rather than an open-ended question regarding the barriers that might lead to withdrawal. It would be more beneficial to address individual women directly about their real experiences in engineering, which Henwood (1996) states is lacking in the WISE program. However, the printed materials do prioritize examining the effects of hostility or prejudicial attitudes in male dominated fields.

Through questioning individual students directly, Sheahan (Sheahan and White, 1990²) had found that withdrawal was a combination of many factors, especially difficult mathematics and science courses and a heavy workload. The students thought that mathematics and science appeared too “sterile” (p. 1019) and that the courses lacked connection to the real world. As a result of the heavy workload, students felt exhausted and isolated and decided to leave. White (Sheahan and White, 1990) was critical of this approach to engineering education that gives rise to high attrition rates, saying that the seemingly deliberate effort to weed out even exceptional students was an example of poor administration and that the result was a loss both to engineering and to the nation. Although the weeding-out had been a decades-long process, White believed that there was no reason for that practice to continue. He argued that the answer to attrition was retention and quoted a colleague as saying “a prerequisite for improving

² In this paper, Sheahan had discussed science and engineering education with several undergraduate students. Before returning to her position at the National Science Foundation in the USA, she discussed the students’ issues with White, an engineer and then the acting deputy director of the NSF.

retention is a desire to retain" (p. 1021).

Retention

Daniels (1988) pointed out that the issue of too few women in engineering did not end with recruitment: the next step was retention, for which she suggested strategies that had been successful at her university, for example, seminars for first-year students where role-model alumnae discussed issues such as assertiveness, test anxiety, self-esteem and student life. A film or video of women engineers at work would illustrate what the profession could offer. A retention or recruitment officer, who would be trained in human resource management, would be an asset to any school. Such a position could advise students on available resources and have some discretionary funding to develop necessary programs. However, most important in the process of recruitment and retention is the co-operation between administration and faculty in the creation of an environment that would be supportive for all concerned (see also Baum, 1989).

Role modelling has been identified as a good way to carve out a career. Because of the dearth of female faculty, the lack of female role models may be exacerbating the problems for women in science and engineering. Etzkowitz et al. (1994:14) argue that male students can easily identify with male faculty advisors, who often do not know how to properly advise female students, especially at the graduate level. In contrast, women have difficulty identifying with the male culture in science and engineering and may therefore drop out because there are no women to explain the necessary steps to take to proceed beyond the first degree.

As a minority, women often feel isolated in engineering, both in education and in the workforce. Henwood (1996) finds the WISE solution to the all-male working environment particularly problematic. The program suggests that women themselves must learn to cope with the environment as it is, (that is, 'grin and bear it') and thus preserve the status quo rather than insisting that the environment needs changing. Others believe that engineering schools must work to lessen the isolation by giving women opportunities for some research experience that could encourage them to continue to graduate schools. Engineering schools must emphasize the proper treatment of all students, but especially female and other minority students, and impress the rules for proper treatment upon foreign-trained faculty from countries

where women are not held in high esteem. Married female graduate students must also be considered equally for financial support. Many of these strategies have proved to be successful at several engineering schools (Davis and Hollenshead, 1993; Skidmore et al., 1993; Ryerson Polytechnic University, 1994; University of New Brunswick, 1995; University of Waterloo, n.d).

Lack of financial support was a major issue in Baignée's (1993) attrition survey. Fox (1998) also stressed that financial support and participation in research are essential for women's success in science and engineering. One of the graduate programs in Fox' survey was particularly adamant to provide "academic support" to the enrolled students. As in Etzkowitz et al. (1994), the faculty advisors were keys to the program's success.

In terms of retention, White (Sheahan and White, 1990) argued the need to rethink both engineering education and the value of good teaching. He emphasized that it was imperative to place the very best teachers in the introductory courses and to insist on a high level of proficiency in the English language, not only for foreign-born faculty but for American-born faculty as well. To improve retention, White stated emphatically that he was "prepared to recommend that universities admit precisely the number of freshmen they want to graduate. That would put the burden on the university to help the student succeed" (p.1021). However, the most important strategy to keep female students is to treat them with respect and provide a safe, welcoming learning environment (Eisenhart and Finkel, 1998; Fox, 1998; Stalker and Prentice, 1998) with the ultimate goal of such programs some day becoming redundant (Fox, 1998).

Program Evaluation

Because the increase in female participation in engineering colleges has coincided with the introduction of recruitment programs aimed at high school girls, it is reasonable to believe that there is a causal effect. First, the promotional programs expose high school students both to the engineering profession and to women in the profession as well as to the requirements for entry. Second, more women are entering university programs in general and now constitute at least half of the undergraduate population in most institutions. Some institutions have begun evaluating their recruitment and retention programs and have found them successful, at least as

to student satisfaction with the programs and reaching out to prospective students (Lodge, 1998).

A WISEST³ (Women in Scholarship, Engineering, Science and Technology) program had been important to the participants' choice of career selection, especially in those cases where the program had included a research component. Evaluation also pointed out that balancing work and studying was becoming increasingly difficult for many students (Tovell et al., 1998). A minimal survey evaluation at the U of S College of Engineering has also found that a number of students now entering the college have had contact with one or more aspects of the college's recruitment strategies (College of Engineering, 2000). Another evaluation of retention programs has found that various types of mentoring, both individually and in groups, have been beneficial to female students' persistence and success in science and engineering. Both peer and parental support as well as networking increased academic success, particularly for women (Schultz, Main and Huebner, 1998).

FACTORS ASSOCIATED WITH RECRUITMENT, ATTRITION AND RETENTION

The literature on recruitment, retention and attrition has identified gender socialization as a key deterrent for women entering engineering (Connell, 2000; Etkowitz et al., 1994; Frehill, 1997b). Understanding the concepts underlying gender socialization and how they relate to women's career choices is important in understanding women's lack of interest in engineering. In addition, the More than just Numbers report by the Canadian Committee of Women in Engineering (CCWE, 1992) identified other factors that impeded women's success in science and technology, such as a dearth of role models and encouragement for women, and a general lack of gender sensitivity and equity issues. The report recommended better support systems for women students as well as an action plan to increase female mathematics and science teachers as well as engineering faculty (Also cited in Dececchi et al, 1998).

However, the accumulated evidence suggests that socialization is not an adequate

³ Other institutions may call it WEST (Dryburgh, 1999) or WISE programs for the students while in university. There is no such program at the U of S.

explanation for recruitment, attrition and retention. Rather than focusing on the learned behaviours and norms associated with femininity (which are presumably internalized), the literature points to socio-cultural and structural barriers, which are deeply imbedded in gender relations. Connell (2000) and Etzkowitz et al (1994) demonstrate that education in general, and engineering education in particular, is actively involved in constructing particular forms of gender.

Gender Socialization

Socialization, also called enculturation, is defined as “the process in which the culture of a society is transmitted to its children; the modification from infancy of an individual’s behavior to conform with the demands of social life” (Jary and Jary, 1991:452-3). Without such socialization, societies cannot reproduce themselves and assure that the values and practices of the particular society are preserved.

An important aspect of the socialization process is gender socialization whereby females and males are inculcated with the social expectations of the women and the men in their society. Within a patriarchal society, “the metaphors of gender constructed the male as the norm and the female as deviant; the male as whole and powerful; the female as unfinished, physically mutilated and emotionally dependent” (Lerner, 1993:3). Accordingly, young males are encouraged to become active, assertive and demanding while young females are taught to be passive, acquiescing and nurturing. This emphasis on gendered behaviour carries over into career choices for adult members of the society. In Western society, the division of labour has normalized the public sphere, that is, the paid labour force and politics, as a male domain while the private sphere of caring for home, husband, and children became women’s responsibility.

One of the significant breakthroughs in feminist analysis of women’s oppression was the distinction between sex and gender. ‘Sex’ refers to the biological ‘male’ and ‘female,’ while ‘gender’ denotes the socialized ‘masculine’ and ‘feminine.’ Gender ideology refers to the manner in which the sexes are socialized within any society in general, while gender identity is the expression of how male and female individuals accept these ideologies for themselves. Such identities may change between situations. Gender ascription refers to how individuals within a given society are expected to behave because of their sex. “Gender, then, denotes

multidimensional and changing understanding of what it means to be a man or a woman within particular social settings” (Schiebinger, 1999:16).

The most important sources of primary socialization are the family and the educational process where children learn about the gendered division of labour in society.

The sexual division of labor, which has allotted to women the major responsibility for domestic services and nurturance of children has freed men from the cumbersome details of daily survival activities, while it disproportionately has burdened women with them (Lerner, 1993:11).

This burden has long prevented women in general from seeking education and work in professions other than those considered suitable for women, such as nursing, teaching, sales and service, collectively dubbed “the pink ghetto.” Within a patriarchal society, prestigious occupations, including engineering, were considered male domain (Eitzen and Baca Zinn, 1994). That more women now claim a place in these professions has caused considerable discomfort in this male enclave (Connell, 2000; Etzkowitz et al., 1994).

Role models and social support are important sources of encouragement for young women’s career choices and for success in engineering education. Although individual women have for years studied engineering, as witnessed by the fact that there are female engineering professors teaching in the universities, they have been the exception rather than the rule. For example, the history of women in science and engineering at MIT goes back to the 1870s, when women were not admitted except as special cases (Bix, 2000). However, once admitted, professors could refuse the women access to their courses. Services for women, such as dormitory space and washrooms, were also in short supply. Admission standards for the early female students were higher than for the men, yet a woman had to show “that for all her brains, she is a woman” (Bix, 2000:29). The formation of the Association of Women Students (AWS) in 1939 made possible orientation events for new co-eds, who were otherwise excluded from the male bonding rituals of the freshman initiations. The AWS much later became a forum for women’s and feminist activities by hosting monthly colloquia on women’s issues of interest. However, as role models for future cohorts of female students, the women attending these seminars risked being identified as troublemakers.

Although women now have easier access to most engineering schools, there is a lingering reluctance for women to choose education in technology, in spite of WISE’s best

intentions in Great Britain (Henwood, 1996; Finnie et al, 2001)). In Henwood's sample of female students in a traditionally female Personal Assistant program, some of the respondents had been reluctant to try a non-traditional line of work, citing lack of interest, and fearing that they were not good enough in a field where they perceived a stressful task of "proving themselves" to their male classmates. The female respondents in a software engineering program, on the other hand, realized they had to be twice as competent to be considered equal to the men.

The literature, as well as anecdotal information, indicates that women who choose engineering as a career have support for such choice in their immediate family or close circle of friends (Geppert, 1995; McIlwee and Robinson, 1992).⁴ Some women may withdraw because they find it difficult to be a small minority in labs and classrooms, but when a critical mass of female students is achieved, it assists in forming support groups that help the women complete their studies (Carter and Kirkup, 1990; McIlwee and Robinson, 1992). In addition to family support, hands-on "tinkering" experience is important for choosing a career in engineering, especially for men. Boys and young men are assumed to acquire such experience and interest in cars and machinery through their socialization, while girls are assumed to lack interest in such activities (Carter and Kirkup, 1990; McIlwee and Robinson, 1992). Moreover, due to gender socialization and the construction of science as a masculine activity with imbedded strength, rigor, skills and rationality, science should be reserved for men (Keller, 1990; Noble, 1992; Shepherd, 1993). Girls then see mathematics and science as 'male' activities and often avoid them (Baum, 1989), thereby excluding themselves from engineering education.

Although some women have succeeded in becoming engineers, the women's under-representation has come to be seen as a 'problem' in Western industrialized countries. The major explanation for women's reluctance to enter the engineering profession is what has been commonly known as 'the deficit model,' where women are thought deficient in the requisite

⁴ In 1993 I interviewed a woman who had always known that she wanted to be an engineer, having had the opportunity for hands-on "tinkering" with her engineer father (Anderson, 1994). The College of Engineering also has records of a Saskatchewan couple, who had seen seven of their nine children, including one of two daughters, graduate as engineers. When the youngest son graduated, the parents received a plaque.

skills for entering engineering education.

The Deficit Model of Women's Education

Research in the 1960s into educational opportunities (e.g., Coleman 1966 and Porter 1965, cited in Gaskell and McLaren, 1991) found that family background predicted educational success and adult jobs and that children from poor families showed low achievement in school. Under the term of the deficit model of education, success in school became an issue of equal opportunity for all students. Feminists then argued that girls, in general, were educationally disadvantaged and lacked some of the skills needed to succeed and that the deficit was particularly evident in mathematics and science. In addition, psychological research, especially by Horner (1968), proposed that high-achieving college women suffered "fear of success," suggesting a conflict between achievement and femininity (cited in Gaskell and McLaren, 1991:119-120).

The deficit model assumes that women do not major in science and technology in universities because they are deficient in high school mathematics and sciences. It assumes that women do not have the same mathematics and spatial skills as men, which in turn is frequently exclude women from entering these fields. In the 1970s, the deficit model saw women's low participation in science "from the top down" as the result of discriminatory issues, such as lack of educational equity, originating at the administrative level of education and blocking women's opportunities for success and promotions (Schiebinger, 1999:54). In the late 1980s, the focus shifted from a deficit model to a "pipeline model" with the emphasis on educational discrepancies "from the bottom up," that is, from the students' level (Schiebinger, 1999:54). The pipeline model, to be discussed as "leaking" in Chapter Five, suggested that girls and young women needed more remedial training and encouragement to counteract the gaps in their science and mathematics education and to increase the girls' performances. It argued that if enough girls could be encouraged to take more science courses, there would be more qualified women in the science and engineering employment pool. The model was perceived as less discriminatory than the deficit model because, if the girls or women did not study these areas, it would not be for lack of equity, but as a case of their own "self-(de)selection" (Schiebinger, 1999:54). In other words, the onus was on female students themselves to

acquire proficiency in these subjects in order to succeed in science and technology.

As a result of the reconfiguration from deficit model to pipeline model, the public issue became one of designing strategies for encouraging girls and women to choose to study sciences. One such strategy has been the establishment of special scholarships for women in science and engineering (Davis and Hollenshead, 1993; Canadian Engineering Memorial Foundation, 1995), based on a degree of excellence rather than economic need. The federal government's Canada Scholarships were important because the awards were equally divided between men and women and were therefore a major incentive and source of funding for gifted female students.

The Canada Scholarships Program is designed to help your country succeed tomorrow. . . . At least half of all Canada scholarships are being awarded to academically outstanding women. The intent is to encourage greater female participation in scientific and engineering fields, particularly those where representation by women has been lowest (Pamphlet, Canada, n.d).

The program was launched in 1988 with a projected life of five years and was extended to 1995/96, when Industry Canada discontinued the scholarships (Government of Canada, n.d). The program offered three-year renewable \$2,500.00 scholarships to undergraduate students in science and engineering, contingent upon the recipients maintaining a grade average above 80 per cent. The scholarships were discontinued just as female enrollment in engineering was showing noticeable increase (Simon Fraser University, 1995). A program evaluation found that the required average grade was difficult to maintain; as well, high-achieving women tended to transfer to university programs that were not eligible for the Canada Scholarship Program (Gilbert and Pomfret, 1995).

Yet another strategy to offset the deficit model is mentoring programs designed to boost women's self-confidence and expertise in mathematics and science. The Marian Sarah Parker Scholars program at the University of Michigan, jointly funded by the university and the National Science Foundation in the United States, is a combination of several strategies (Davis and Hollenshead, 1993). The program encourages female students to seek graduate studies in engineering by funding the last two undergraduate years. By doing so, the program aims at keeping women in engineering. At the same time, it features Ms. Parker, the first female engineering graduate at that university as well as other role models, and provides mentorship

throughout the program.

Strategies such as role models and mentoring for women assume that it is women who need to be changed to adapt to science and technology engineering (McIlwee and Robinson, 1992). While Ellis (1986) emphasizes, as role models *par excellence*, female engineers who are also wives and mothers and who are considered outstanding by their peers, the fact remains that these women are exceptional superwomen who may discourage, rather than encourage, possible average women engineering students. Such high standards may become a deterrent and be seen as unattainable for the average woman.

The deficit model, and later the pipeline model, with its focus on the individual female students themselves, placed the responsibility for access to science and engineering programs on girls and women who had been considered disadvantaged and deficient in their education while it ignored social issues and educational structure. The onus was on the girls and women to take advantage of remedial courses and thereby ease their access to engineering schools (Schiebinger, 1999). The model essentially “blamed the victims” by stressing what was wrong with them rather than making changes to the educational system with its built-in gender bias and stereotyping (Connell, 2000; Gaskell and McLaren, 1991).

However, the deficit model of women’s education not only does not explain the low number of women who seek an engineering education, but it also does not explain the disproportionate attrition of female students from such education. Instead, it is possible that the structure of primary and secondary education discourages girls from seeking a ‘non-traditional’ career path in post-secondary education. At the same time, women who do choose engineering do so because of their primary socialization, the availability of role models such as engineers in the family, and social support.

The “Chilly Climate”

A supportive environment is of utmost importance for optimal achievement in any field and situation. In her survey of eleven graduate programs in science and engineering, Fox (1998:210) found only one program that had as its goal “improving the academic climate for women and thus improving the odds of women continuing as scientists.” In contrast, the literature has ample documentation that women who choose a career in science and

engineering may face a number of barriers in a hostile environment, what has been called a “chilly climate” for women in engineering.

Bernice Sandler and Roberta Hall coined the concept of a “chilly climate” for girls and women in 1982 (Stalker and Prentice, 1998) as authors of a report on the status and education of women for the Association of American Colleges. It refers to the marginalization of women and the day-to-day environment in the educational institution, which is less supportive of the women than of the men who work, teach or study within it. The chilly climate demonstrates that sexual harassment renders educational campuses dangerous for women (Stalker and Prentice, 1998) and refers to a number of subtle forms of gender discrimination and unequal treatment of girls/women and boys/men in the classroom (Wood, 1994).

Girls’ and women’s educational experiences both in high school and engineering colleges are of the utmost importance if they are to complete their education. In 1994, Sadker and Sadker documented how girls, throughout the elementary and secondary educational system, are treated unfairly: Girls get less attention from teachers than boys do. Textbooks are biased and stereotyped (also Connell, 2000) and do not reflect girls’ lives or experiences. Fewer resources, e.g., remedial help and funding for sports, are allocated to girls than to boys. Boys tend to appropriate available computers. In science labs girls become ‘recorders’ while boys perform the experiments. Girls are praised for neatness, while boys are praised for their answers. Girls usually get a short ‘right’ or ‘wrong’ comment when they answer questions, while boys are helped to find the right answer or encouraged to elaborate. Girls are chastised for interrupting or calling out unsolicited answers while boys suffer no such consequences or receive praise. Girls are encouraged to become ‘ladies’ and take ‘softer’ social science courses instead of mathematics and science. Girls who do study mathematics and science often suffer ridicule in class, both from classmates and, even worse, from their teachers. As a result, female students’ self-esteem suffers, while male students’ self-confidence is inflated (Sadker and Sadker, 1994). Men tend to overestimate and exaggerate their abilities and project a “strutting behavior;” in contrast, women tend to be more modest and often display an “impostor syndrome” in downplaying their skills and successes (Schiebinger, 1999).

Little has changed since the Sadkers conducted their research, as presented in a television program on the CBS television network’s magazine *Sunday Morning* (March 14,

1999). The segment referred to a report by the National Science Foundation (USA), which indicated that only 12% of Ph.D.s in engineering are awarded to women, a fact that creates a dearth of role models and candidates for university positions. The report further stated that women are not inferior to men in science and engineering; on the contrary, women have higher GPAs than the men. According to the program, the reason for the numerically poor showing of women in science and engineering is that the educational system in science does not work well for girls. For example, boys still tend to monopolize computers and other equipment. As a consequence of the unequal distribution of women in science, one California community had recently, as a pilot project, opened a Middle School for girls only. Girls interviewed for the program indicated that the school was “great” and that they did not miss a co-educational environment. In another project, girls had separate science lab sessions. A female engineering student in the program stated that the sheer numbers of male students did not intimidate her; however, she preferred to take her seat in the front row of the classroom where her presence was noticed, and where she did not have to look at the “sea of male students’ backs.” These three strategies, the single-sex school, the single-sex labs and the effort to be noticed were perceived as affirmative actions for making a more equitable playing field for women in science and engineering. In addition to emphasis on encouragement and role modeling, there were strategies in curriculum transformation (CBS-TV, 1999).

Teachers may be partly responsible for girls’ rejection of science and mathematics courses (Mendoza and Johnson, 2000). More or less subtle signs from teachers steer the girls away from informal technology and science activities such as repairing their own bicycles, taking an interest in the mechanics of the automobile, or attending science fairs, thereby sending the message that these fields or activities are not for them. Mendoza and Johnson’s (2000:22) report recommends that teachers’ gender equity skills must be improved in order to “create a culture that nurtures the full range of girls’ dreams.” For example,

Every time a teacher defers to a boy for computer assistance . . . we are telling our daughters that computers aren’t for them. We are sowing seeds of doubt (Mendoza and Johnson, 2000:23. Attributed to Roberta Fugner, n.d.)

The trend that starts in elementary and high school settings continues in universities where women are getting short shrift. Levenson (1990) refers to videotaped research showing how professors knew the names of male students and paid more attention to them than to

female students, often ignoring the women's questions and suggestions altogether. Dagg and Thompson's (1988) exposé of women's mis-education in universities paints a bleak picture with frightening tales of bias against women, of misogyny, of harassment and of gender inequality. For example, some male professors still believed that women should not be educated because they would just marry or become pregnant. Some faculty still used sexist language even when university policy stated otherwise. Some joked about sexism, used sexist jokes, and called all women 'girls,' regardless of age--and that was when they recognized women at all (Dagg and Thompson, 1988).

The University of Saskatchewan's (U of S) President's Advisory Committee report (1993) pointed out many of the same inequalities for women that Dagg and Thompson identified. While critical of many inequality issues, the 1993 report nevertheless acknowledged that there was hope for change. However, when blatantly overt inequalities are reduced or eliminated, subtle, covert sexism may still remain; that issue is much more difficult to erase (Benokraitis, 1997), and its presence in the academy as well as the workplace still relegates women to 'women's work.' In contrast to blatant harassment or sexism, subtle sexist behaviour is more difficult to define, document and diffuse because it is less visible and obvious, yet as hurtful and harmful as blatant sexism. It is often camouflaged as jokes or teasing and manifests itself in differential treatment of gendered individuals. Within this socially constructed climate of structural and systemic inequality, girls and women are disadvantaged, and their skills and contributions are often trivialized (Benokraitis, 1997).

Jacqueline Stalker and Susan Prentice (1998) describe how the chilly climate creates numerous micro-inequities for campus women. Their categories coincide with Nijole Benokraitis' (1997) excellent definitions and examples of the various levels of discrimination. In general: "*Sex discrimination* refers to the unequal and harmful treatment of people because of their sex" (Benokraitis, 1997:7, all italics in the text). In *blatant sex discrimination*, this behaviour is intentional, visible (overt) and easily documented, while *covert sex discrimination* refers to "the unequal and harmful treatment of women that is hidden, purposeful, and often, maliciously motivated." Benokraitis (pp.14-24) identifies nine sub-categories of *subtle sex discrimination*, which will be elaborated as they appear in the data analysis. Subtle sex discrimination is not as noticeable because people tend to internalize subtle sexist behavior as

'normal,' or 'natural.' It may be unintentional, or it may be manipulative, and some people do not consider it harmful (p. 11).

The climate in science and engineering education is especially chilly. Women may hear comments like "you'll have to face the facts--there's no room for women in the world of engineering. The demands for strength, rigor, and precision are simply more than any woman can muster" (Hawkesworth, 1990:59). Some engineering schools have resisted hiring female faculty in the past and would rather hire men from other countries than Canadian women when there are not enough Canadian male applicants for positions (Dagg and Thompson, 1988)⁵. Dagg and Thompson, among others, question the ethics of recruiting and encouraging women into engineering and science when qualified graduates are denied employment, and when employed, they suffer inequalities and discrimination (Levenson, 1990). The prospects for changing the chilly climate in science and engineering with the help of larger numbers of female faculty are not encouraging if qualified Canadian women have difficulty finding university employment. A critical mass of female professors in engineering could modify the long-standing, masculine culture in engineering education.

Masculine Engineering Culture

Culture is generally viewed as the total way of life within a particular society and includes the language, accepted behaviours, values and technologies for living within the territorial borders of a society (Brinkerhoff and White, 1991). Ursula Franklin considered technology as "ways of doing something," a system involving organization, procedures and symbols, and not only artefacts and gadgets. From her definition of technology, Franklin (1992: 12; 15) derived her definition of culture as "a set of socially accepted practices and values," which differs from one society (or group) to another. In other words, Franklin sees culture as entailing different technologies, or different ways of doing something. Following Franklin, I conclude that it is legitimate to consider the strategies and approaches of the

⁵ Dagg and Thompson (1988:22) cite an incident at the University of Calgary, which in the 1980s refused to hire a woman as professor in engineering. The Queen's Bench Court of Alberta found that the university "had violated principles of fundamental justice in its hiring process." They also cite "an Ontario university" that had never hired any of its own female graduates as professor in its Faculty of Science.

engineering profession as culture. As well, if we consider territorial borders not only in geographical terms but also as intellectual and professional boundaries, we can argue that engineering *per se* is a community, with its own professional “engineering culture.”

Although there now are more women in engineering, it has a history as a male-dominated profession (Frehill, 1997) with the resulting masculine culture in both engineering colleges (Whittaker, 1994) and the workplace. In preparation for the workplace, women learn in engineering colleges to adapt to the masculinity of the engineering culture (Dryburgh, 1999), which is both perceived and experienced as hostile to women (Henwood, 1996). Therefore, a number of feminists have argued that male values are represented in such a way that many women feel unwelcome and inferior despite their academic proficiency (Franklin, 1992; CCWE report, 1992). Henwood (1996) similarly found that non-traditional students had made their choice of work in spite of such hostility, while the traditional students had made their choice because of it. Henwood’s research confirmed that the engineering culture is, indeed, masculine. Because it is associated with men and male power, it also has higher status than other workplace cultures (Henwood, 1998).

McIlwee and Robinson (1992:21) posit that the masculine culture in engineering is characterized by three basic components: 1) an ideology that stresses technology; 2) organizational power is required for success; and 3) technology and organizational power interact in a form that is closely tied to male gender roles. “To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking, and acting male” (see also Stalker and Prentice, 1998).

Furthermore, there is also a masculinist culture in universities in general:

By this we mean a set of practices that men themselves do not necessarily identify as sexist but that has been built up over the centuries as men have taken for granted that those who count in the university are males, that the business of the university is men’s business, and that the significant working relationships are relationships among men (Drakich et al., 1991, cited in Stewart, 1994:221).

Women, both as students, faculty and employees in a university setting, and particularly in engineering education, are expected to embrace this type of environment. Among the characteristics of engineering education, Tonso (cited in Eisenhart and Finkel, 1998:121) found engineering courses to be “greedy,” that is to say that they monopolized so much of students’

time that there was little time for social relations. Tonso also found that the female students in her research enjoyed group work and on-site inspections and visits to their project. The women particularly enjoyed the social interaction while discussing the project among each other and with the site workers. In contrast, the male students found that aspect of the project too time consuming. The men preferred solitary, individual work, especially perusing technical documents in the library, stating that the library provided more factual information and was more easily accessible and less stressful (Eisenhart and Finkel, 1998).⁶

While interviewing engineering faculty at MIT for her study of engineering and engineering education, Hacker (1990) found an established hierarchy of engineering specializations: the greater the specialization's need for the human element, such as interaction with people, the lower it was on the hierarchical scale. She discovered that civil engineering had a low status because it was considered to be far too involved in physical, social and political affairs. In contrast, electrical engineering had the highest status and was considered the "cleanest, hardest, most scientific" area because of its closeness to pure, abstract science (Hacker, 1990:117). Thus, some engineering sub-specialties which include interpersonal, social interaction and communication are constructed as feminine and are devalued, while other specialties, where abstract, rational thinking is a valued skill, are constructed as masculine in science and engineering.

Privileging of the abstract has its origins in the nineteenth century when women were believed to be unable to do science because they lacked the masculine trait of analytical ability (Shepherd, 1993:xiii). However, Shepherd found that present women scientists are in a no-win situation: science is now leaning in a more intuitive direction, and women are accused of being too rational to make intuitive and creative leaps. Patriarchal attitudes have excluded women from science by making science, and knowledge in general, alien and hostile to women (Shepherd, 1993).

Such attitude is also evident in Noble's (1992) concept of science as a sacred and cloistered activity. Noble made an interesting connection between science and the Latin Church, which except for cloistered nuns, was a "world without women." While science in the

⁶ That is not to say that women disliked library research.

beginning was anti-clerical and challenged the epistemological status of religion, it welcomed women's participation. However, as science developed and became more powerful, it adopted clerical ideas (for example, that marriage interfered with science) that again excluded women. By giving science status as a sacred activity which required clerical guardianship, the clerics of the Middle Ages—and later Western patriarchal culture—found a new way in which women were denied access to and involvement in the creation of knowledge (Noble, 1992).

Cole and Fiorentine (1992, cited in Schiebinger, 1999:59) rejected the assumption of unequal opportunities for women in science and engineering. Instead, they introduced the concept of a professional “persistence gap” between men and women and suggested that, although it was acceptable for women to enter high-status occupations, women failed because they did not identify properly with the professions. Cole and Fiorentine argued that men try harder than women to persist, succeed and identify with their professions, while women could always “rely on the socially sanctioned safety net of marriage” (Schiebinger, 1999:59). Thus, Cole and Fiorentine saw marriage and family as an escape hatch for unsuccessful professional women, rather than seeing the masculine culture of science and engineering as a structural barrier for married women. Consequently, Londa Schiebinger (1999) suggests that one reason why women leave science and engineering is the different cultural expectations for males and females in our society.

Other elements of engineering culture include androcentrism and gender stereotyping in texts and examples, lack of equality in laboratory participation, and trivialization of women's experiences by faculty and male students (Carter and Kirkup, 1990; Connell, 2000; McIlwee and Robinson, 1992; Sadker and Sadker, 1994). In general, the prevalent expectations of behaviour according to male gender roles do not contribute to educational well-being for women. Such behaviour is alienating and unwelcoming to women and may be a major explanation for the high attrition rate for female engineering students. Franklin (1993:15) therefore admonishes educators to consider that “If it's not appropriate for women, it's not appropriate.”

Because women have proven adept at understanding engineering concepts, Franklin (1992) argues that male students subject their female classmates to jealousy and resentment. Franklin also believes that women's interactive skills and preference for holistic work are major

reasons why women do not select science and technology. She suggests that women are most likely to succeed if they quickly become “one of the boys” (Franklin, 1992:104), or deny their gender, as Geppert (1995) laments. Similarly:

Our communication technologies are invented by men who don't like to talk to people. Our offices are designed by men who prefer isolation. . . . The human being has been left out; the female part of us is missing and we miss it. If that doesn't explain why we need more women engineers, nothing will (Jan Zimmerman, cited in Schmitz, 1994:122).

In addition to the masculine environment within education and the workplace, female engineers face the same problems as other female professionals in balancing work demands and family life (Carter and Kirkup, 1990; McIlwee and Robinson, 1992; Ranson, 1998; 2000). In the science and engineering workplace, women encounter a “glass ceiling,” a top rung on the employment ladder considerably below that of men (Carter and Kirkup, 1990; Etzkowitz et al., 1994; McIlwee and Robinson, 1992; Toohey and Whittaker, 1993). This glass ceiling is a gender barrier that prevents women from advancing into top positions in the workplace (Etzkowitz et al., 1994). Many women engineers have realized that “having it all”—successful marriage, well-adjusted children, and a full-time job—is almost impossible. Many would prefer part-time work to accommodate family life but are afraid “employers would expect full-time results from part-time commitment” (Toohey and Whittaker, 1993:33).

A number of writers such as Cockburn (1988), Cockburn and Ormond (1993), Hacker (1990), and Wajcman (1991) have argued that just as people are gendered, so also is the engineering workplace where women tend to be channelled into stereotypical work classifications within the engineering profession (Carter and Kirkup, 1990; Cockburn and Ormond, 1993). For example, research and development (R and D) and design are considered male spheres while more women work in production and sales (McIlwee and Robinson, 1992). McIlwee and Robinson also found that it was easier for female engineers in the United States to succeed and advance in companies that depended on government contracts, which were subject to federal equity and equality laws (e.g. the defence industry). Women in private industry, on the other hand, often found themselves in dead-end jobs, overlooked for promotions, and not considered as management. Female engineers tended to be clustered together in carrels, mistaken for secretaries, and often referred to by their appearance, while the

men were referred to by their skills. In private industry, women with children were reluctant to accept positions that involved travel, even if they were offered (Carter and Kirkup, 1990; Toohey and Whittaker, 1993).

Present economic conditions have changed social expectations and attitudes about women's role in the productive sphere just as women themselves have changed their expectations of personal fulfilment through productive labour. While engineering has been a male-dominated profession, changing social attitudes about women's work and a greater female participation in engineering could facilitate changes in the engineering profession. Some writers insist that existing androcentric curricula and programs need revision. Women must influence science and technology *per se* to change from male ideas of progress to incorporate women's ideas of compassion and co-operation. To achieve such change there must be radical changes in science and engineering education (Hacker, 1990; Shuster and Van Dyne, 1984; Van Dyne and Shuster, 1985). Others call for a radical approach to the transformation of engineering, overturning the epistemological assumptions of masculine and positivist science and replacing them with feminist values (Geppert, 1995). From the above literature it appears that, from elementary school and throughout their working lives, women in such non-traditional occupations as engineering find themselves to be in "second-class" positions, hardly "a good place to be" (Carter and Kirkup, 1990).

The literature examining the recruitment, attrition and retention of women in engineering reveals that gender structures women's career choices in engineering ranging from familial support to early educational experiences which prepare women for an engineering education to the culture of engineering schools and the workplace. This review of the literature reveals that gender relations permeate every aspect of the existing social order and that they are multidimensional and ongoing. Gender, then, is not an attribute that one possesses but rather a concept that is socially constructed.

Socialization revisited: "Doing Gender"

A number of feminist theorists have argued the importance of gender construction and have emphasized the relational nature and processes of gender. In a previous section, I have defined socialization as a process wherein the norms and values of an existing value system are

transferred from one generation to the next. In most cases, this transfer acts like inscriptions on a *tabula rasa* where the 'blank page' is the passive recipient of information. However, the transfer is not necessarily a simple or simplistic process. Thus, expanding on socialization theory, Candace West and Don Zimmerman (1991[1987]) have coined the concept of "doing gender." The concept "involves a complex of socially guided perceptual, interactional, and micropolitical activities that cast particular pursuits as expressions of masculine and feminine 'natures'" (West and Zimmerman, 1991:14). The key word is 'interactional,' the active, relational negotiations individuals perform. Accordingly, gender acquisition is not a matter of the once in a lifetime socialization process, but a process that requires numerous re-evaluations and renegotiations during the lifetime.

In "doing gender," West and Zimmermann (1991) describe and analyze how women and men do what they do *qua* women and men according to a perceived natural, biological division, which is not natural at all. "Doing gender" also includes how individuals manage these roles in a public forum. In other words, gendered individuals negotiate culturally accepted expectations in such a way that they reproduce gender appropriate behaviour associated with masculinity and femininity. As a result, the construction of gendered identities appears natural. While the concept of negotiation highlights the active role, or agency, of the individual, these negotiations are structured by hierarchies of power, which shape and constrain individual behaviour, values and aspirations. For many, it is difficult to imagine 'doing gender' in other ways. However, in this process it is also possible to 'pass' as a member of the opposite gender by learning from other sources, like observations or manuals, the accepted and expected "doing" of that opposite gender. This way of

doing gender consists of managing such occasions so that, whatever the particulars, the outcome is seen and seeable in context as gender appropriate or purposefully gender-inappropriate, that is, *accountable* (West and Zimmerman, 1991:22).

In their work, West and Zimmerman refer to Garfinkel's 1967 study of a boy who began presenting himself as female in his late teens and later underwent sex reassignment surgery and other procedures for successfully 'passing' as a woman. This case illustrates that gender is not tied to biology. They also relate the dilemmas that face those who dare to cross the boundaries between the biological sexes and cultural genders. One example, particularly appropriate to my research, is the case of a young female engineer, who as a designer of

airplanes skillfully negotiated the expectations of male airplane designers to partake in the maiden flight of the aircraft, then to host a stag dinner for the usually male workers on the project. As flying the plane was considered a male task, she was urged not to fly and thus behave like 'a lady' rather than an engineer. She solved her dilemma by flying the plane as an engineer, then hosting the party for the workers, as the designer, like a male designer would have. However, after the meal and the obligatory toasts, she acted "like a lady" and left the otherwise stag party (West and Zimmerman, 1991:26). In other words, this woman showed that it was possible to be both an engineer and a woman.

Lisa Frehill (1997b:225) argues that engineering education exemplifies "the process by which occupational gender characteristics are maintained." Because women, on average, take fewer of the physics and mathematics courses required for admission, Frehill suggests that certain women are effectively excluded from entering, as well as transferring into engineering from other disciplines, leaving the profession and its education overwhelmingly masculine. Thus, engineering education 'does gender' the only way it knows how: by reproducing and perpetuating its masculine attitudes.

According to West and Zimmerman (1991) "doing gender" appears almost as a natural act. If appropriately done, it sustains, reproduces and legitimates gender categories. The concept includes social structure while at the same time exercising elements of both agency and social control. However, both social structure and control are subject to social change. During the time that has lapsed since the article was first published in 1987, the boundaries between the genders have become blurred, especially, I believe, as they relate to the gendered division of labour. The labour market and the balancing of work and family have experienced changes, and the present generation of young men and women are performing tasks, for example in child rearing, that would have boggled the minds of previous generations, especially the adult males of those generations. What is considered acceptable gendered behaviour is changing for both women and men. The concept of masculinity, in particular, is changing, although there are pockets where the machismo male image still prevails.

Issues in Masculinity

In the English-speaking world, popular ideology believes masculinity "to be a natural

consequence of male biology. Men behave the way they do because of testosterone, or big muscles, or a male brain. Accordingly, masculinity is fixed” (Connell, 2000:57). However, recent research, especially by Robert W. Connell, has challenged this view. Connell (2000) has argued that although masculinity refers to men, it is not determined by male biology, and that masculinity, like femininity, is socially constructed. That is, masculinity is produced through cultural, social and economic practices. As a result, one cannot speak of a singular, universal form of masculinity. Instead, Connell found that there are constructions of multiple masculinities, which vary historically, cross-culturally, and by race, class, age and sexual orientation.

From the definition of patriarchy, which literally translates as the law of the father, Connell (2000) argues that masculinities are hierarchically organized into dominant, subordinate and marginalized forms that reflect particular configurations of race, class and sexual orientation. Connell (2000) uses ‘dominant’ and ‘hegemonic’ masculinities almost synonymously, indicating that the ‘hegemonic’ forms, which are the “culturally authoritative patterns” (p.30), are the most honoured and desired. In his earlier work, Connell defined hegemonic masculinity as “economically successful, racially superior, and visibly heterosexual” (Lorber, 1994:4). Thus, the dominant forms of masculinity are embodied in white, middle class, heterosexual males. As with ‘dominant’ and ‘hegemonic,’ Connell does not clearly distinguish between the ‘subordinate’ and ‘marginalized’ forms of masculinity, but it follows that racialized, working class males are subordinate, while poverty and/or homosexuality are additional marginalizing attributes. As masculinity is culturally constructed, to be masculine in North America generally includes being “strong, ambitious, successful, rational and emotionally controlled” (Wood, 1994:21). Moreover, some men tend to overestimate and exaggerate their abilities and project a “strutting behavior” (Schiebinger, 1999:58).

Some of the research on masculinities has been in response to feminist gender research, which caused a “disturbance in the gender system” (Connell, 2000:3). Although it is a recent field for social research, it has spread quickly and includes conferences and programs for men as well as studies on masculinity (for example, the Scandinavian countries have established a Nordic coordinator for men’s studies). The research falls into two major categories: social psychology and psychoanalysis, and ethnographies, including life histories (Connell, 2000).

Within psychology, theoretical debates of masculinities have attempted to explain masculine gender issues as a problem of men suffering psychological wounds from being deprived of their “deep masculinity” (p.5), which was their heritage of privileged social status within patriarchy. To counteract these wounds, there are several ‘men’s movements’ that promote new-age therapies for emotional healing and male bonding to replace the violent and destructive behaviours that till now have been the common ‘masculine’ response. The effects of these movements have been twofold: (1) the promotion of new men who incorporate aspects of the ‘feminine’ previously denied them and (2) right wing religious evangelism which has promoted a misogynist ‘taking back’ of male authority in family settings⁷ (Connell, 2000).

As examples of the ethnographic research, Connell (2000) includes a number of studies of the social construction of masculinity in various times and particular places, ranging from drinking groups in Australian bars, British industrial management and a rural high school in Texas to body-building in California gymnasias. In his work, Connell wants to depart from the concepts of ‘men’ and ‘masculinities’ and instead discuss and understand gender relations and to establish a workable theory of gender and masculinity. As a method, life-history is useful for studying social processes, for example the commercialization of sports within class and gender relations, as illustrated by Connell’s study of an “iron man.” This particular sport combines marathon requirements in three different disciplines and embodies three ideals of masculinity: strength, stamina and speed. In Connell’s study (2000:69-85), the athlete also displays a high degree of self-centeredness, as his focus is on his sport as a job that he expects will make him a millionaire, to the exclusion of commitment to intimate human relationships as opposed to purely sexual relationships. It is this type of hegemonic masculinity that has been the focus of the sports media, where ‘jocks’ like this ‘iron man’ are worthy of emulation, while the quiet athlete may be ignored (Connell 2000).

Connell’s ideas on gender and masculinity have been adopted by other researchers. A particularly poignant example is the work of Flis Henwood (1998:41), who found “two distinct masculinities” among the male students in a non-traditional program in a college of technology.

⁷ The Promise Keepers organization in the USA is a “soft” version of this movement, while the Taliban rulers of Afghanistan are a “hard” version of militant misogyny.

In a mixed gender class, where all the female students were concentrated, the male students were protective and paternalistic toward their female classmates. In contrast, in an all male group, which at times had classes together with the mixed group, the men were aggressive and hostile toward the female students. One group used their protective role to emphasize how the women were vulnerable; the other group used open sexism to assert their power and to exaggerate the women as different (Henwood, 1998). Both types of masculine behaviour, although different, are examples of “doing gender” (West and Zimmermann, 1991).

For understanding gender, feminism offers a wellspring of sources, and West and Zimmermann’s (1991) concept of “doing gender” is one such source. Connell’s (2000) work parallels West and Zimmermann’s as he focuses on how masculinities are embodied in everyday life and institutionally sustained through active negotiations and social interactions, and which may differ between given social settings. The historical element of gender construction and “doing gender” makes it necessary to examine and redefine masculinities in the twenty-first century.

Redefinition is particularly important in a profession like engineering, which until recently was almost completely male. There is lingering resistance to change among some men who believe that the entry of more women in engineering is certain to influence the value system within a profession where the machismo male image still prevails. Women, like the aeronautical design engineer in West and Zimmermann’s (1991) work, should not involve themselves in such a masculine field (my data will show that there is an element of fear of competition for positions among some men). As West and Zimmermann have argued, “doing gender” is the active negotiation and re-negotiation of internalized gender identities, which change with time and culture. Construction of masculinities, dependent on changing values over time and across cultures, is part of “doing gender.” Education, or the training process, is an important element of socialization into the profession. Redefining masculinity, especially in previously predominantly masculine professions, must start at the entry level to the profession, that is, in the educational process. For the engineering profession, that means the colleges of engineering.

THEORETICAL FRAMEWORK

The framework for analysis of the data in this research is feminist. Feminism means different things to different people; and there are multiple definitions of the movement that started as a political call for women's rights and equality. Because patriarchal societies give priority and preference to the value and validity of what men think, say and do, to the detriment of what women think, say and do, feminism aims to identify the different standards and expectations for men and women which denigrate and oppress women's lives (Lerner, 1993; Smith, 1987; 1988; 1990). Feminism defines a philosophical and political perspective rather than a sex, and is not limited to the oppression and liberation of women (Schiebinger, 1999) but includes all oppressed groups. Feminism, in general, then becomes a strategy for a struggle to end oppression (hooks, 1984), sexist or otherwise.

A fundamental goal of feminist theory is (and ought to be) to analyze gender relations: how gender relations are constituted and experienced and how we think or, equally important, do not think about them. The study of gender relations includes but is not limited to what are often considered the distinctly feminist issues: the situation of women and the analysis of male domination (Flax, 1997:171).

Feminism, or the women's movement, has occurred in three 'waves.' The first wave, beginning in the early 1830s and lasting until the 1920s, was grounded in classical political liberalism and characterized by its focus on women's enfranchisement and civil rights for women (Kemp and Squires, 1997). A defining moment was the first women's right conference, held in 1848 at Seneca Falls, NY (Wood, 1994). The second wave emerged with Betty Friedan's book *The Feminine Mystique* in 1963 and lasted to the 1980s. The focus has variously been on reproductive rights, equal rights to the various levels of education, equality in the workplace, equal pay for work of equal value, and a multiplicity of other issues to better conditions for women (Kemp and Squires, 1997; Wood, 1994). Throughout this period, the distinct feminist theories of liberal, radical, and socialist feminisms emerged, providing different explanations for the sources of women's oppression. With the rise of postmodernism, the categories of the feminist perspectives of the 1960s and 1970s have become less relevant. Although not originally an issue, diversity within feminism is now firmly established (Kemp and Squires, 1997). Within present feminism, the grand theories were abandoned as a result of the growing recognition that the category of 'woman' erased differences among women and

presented middle-class women's experiences as universal. These grand theories have been replaced by more contingent theorizing, which celebrate difference and recognize 'otherness.' While some see such fragmentation of feminism as problematic, others see it as beneficial and as symptomatic of feminist action and endeavours (Kemp and Squires, 1997).

Feminist Standpoint Theory

Because there are many and varying ideas within feminism and a considerable degree of overlap between them, it is difficult to choose one over the others. For this research, I have situated myself within the feminist standpoint approach (Harding, 1991; 1987; Hartsock, 1997; Jaggar, 1988), or the standpoint of women (Smith, 1987; 1990). Broadly speaking, standpoint theory is a method of elucidating the lived experiences and insights of women and has its theoretical antecedents in socialist feminist theory and Marx' historical materialism.

The development of socialist feminist theory in the 1970s has as its central project "the development of a political theory and practice that will synthesize the best insights of radical feminism and of the Marxist tradition and that simultaneously will escape the problems associated with each" (Jaggar, 1988:123). In a departure from traditional Marxism, the socialist feminist perspective argues that women in a gendered society have a particular social or class position giving them "a special epistemological standpoint which makes possible a view of the world that is more reliable and less distorted than that available either to capitalists or to working-class men" (Jaggar, 1988:370). This standpoint of the oppressed is different from the perspective of the ruling class and carries an epistemological advantage of being able to pinpoint issues important to the lives of members of the lower classes. Similarly, women's experiences give them insights into lived realities that differ from men's and can then be identified as the standpoint of women, which differs from a neutral, disinterested and detached "Archimedean" (Jaggar, 1988:370; 378) point for observation.

An important and defining component of socialist feminist standpoint theory is Marx' historical materialism (Hartsock, 1997; Jaggar, 1988). Because socialist feminism bases its epistemology within historical materialism it is able to apply standpoint theory to show how women's daily lives are structured. The standpoint then becomes not neutral but a place of interest from which certain features of women's life may be seen, while other features are

obscured (Jaggar, 1988). Dorothy Smith (1990) argues that the standpoint makes it possible to ask questions about the social relations within our activities. However, inquiry from a feminist standpoint, or standpoint of women, must always begin with women's experience as women see it. Because women are insiders in their own experiences they become the authority on their own existence. In addition, bell hooks (1987:ix) reminds us that

Living as we did—on the edge—we developed a particular way of seeing reality. We looked both from the outside in and from the inside out. We focused our attention on the center as well as on the margin. We understood both. . . . This sense of wholeness, impressed upon our consciousness by the structure of our daily lives, provided us an oppositional world view—a mode of seeing unknown to most of our oppressors, that. . . strengthened our sense of self and our solidarity.

In developing a feminist standpoint, Nancy Hartsock (1997 [1983]) explicated the materialist features of women's lives by calling attention to common threads in female experience. She pointed to women's universal activities through their contribution to subsistence living, childrearing, and most particularly, motherhood. Hartsock found that motherhood expressed the unity of mental and manual labour, as well as the generally sensuous works of women. She argued that unlike men's work, women's work and material life was both productive and reproductive through pregnancy, giving birth and lactation. This fact, she argued, satisfied the material life criterion for a standpoint. By promoting a revaluing of women's lives and contributions, Hartsock (1997:159) also argued that what was once considered labours of love must be "recognized as work whether or not wages are paid." However, Hartsock conceded that abandoning the gendered division of labour in society would require radical and far-reaching changes.

Dorothy Smith further emphasized women's material life through her analysis of "the standpoint of women in our everyday/everynight worlds" (1990:6) of women as problematic. In contrast to hooks' perception of women's dual views, from the outside in and the inside out, as a unifying experience, Smith saw a "bifurcation" of women's consciousness, a blurring of women's materialist private life with their more abstract life and the modes of ruling in the public sphere. Smith (1987:105-106) perceived the standpoint of women within a sociology for women as "methods of thinking" for women "whose grasp of the world *from where she stands* is enlarged thereby." She stated that she did not equate the standpoint of women with a perspective but rather saw it as a method to include the lived and spoken everyday life

experiences of women (1987).

Hartsock, Jaggar and Smith all show how feminist standpoint epistemology elucidates the difference between the positivist, disinterested and detached Archimedean standpoint and a standpoint that is interested, engaged, and connected within the experienced, material world of women. In the material world we find a different validation of male and female activities, experiences, and efforts. In this gender-divided environment, the male and the masculine is privileged while the female and the feminine is devalued and at times denigrated. Moreover, Judith Lorber (1994:7) considers this difference in valuation a gender paradox and asks: "Why are most cultural images of women the way men see them, not the way women see themselves?" In summing up, Hartsock lists five criteria for developing a feminist standpoint:

- (1) Material life, which both structures and limits the understanding of social relations.
- (2) If material life is different for different groups, they will be inversions of each other, and the dominant ruler's view will be partial and perverse.
- (3) The ruling class or gender structures the relations, forces it upon all participants, and cannot be dismissed outright.
- (4) The oppressed group must struggle for its vision, which then becomes an achievement.
- (5) The understanding of the oppressed becomes the standpoint, which exposes the real human relations as inhuman (Hartsock, 1997:153).

As will become evident through the empirical data, the women and men I surveyed, observed and interviewed in this research (1) lived in a material world where gender relations are deeply embedded in the culture and structure of engineering education programs. (2) Through their superior position, the male students reproduced the idea that engineering was a masculine profession, although some admitted that women might be better than men as engineers. (3) Through their behaviour, dominant male students "did gender" by reinforcing on a daily basis that unless the female students worked to 'pass' as men, they could never be their equals. (4) In response, the female students "did gender" by negotiating and practicing three major strategies to achieve their goals of surviving in the masculine world. (5) One strategy was to comply with the male students' demands for adopting a masculine attitude toward their work and their student life. For some women, another coping mechanism meant keeping their thoughts to themselves without complaining. The third option, to protest against the masculine culture and climate, would result in harassment and being labelled as troublemakers. A last strategy was to abandon engineering in favour of other fields that were more welcoming to

women in general, and where there was stronger emphasis on social relations.

Feminist standpoint theory, which takes women's lived experiences as the starting point for theorizing women's oppression and developing a political practice, links well with the concept of "doing gender" (West and Zimmermann, 1991). "Doing gender" and feminist standpoint theory emphasize the local and the particular while recognizing the dynamic and shifting gender relations. Both "doing gender" and the feminist standpoint, or the standpoint of women, provide insight into the micro-politics of gender relations, the ways in which gender inequalities are reproduced on a daily basis, and they suggest possible strategies for intervention. Connell (2000), as well, "does gender" in his assertions that masculinities are changing with time and culture and require constant negotiations, depending on the situation at hand. A standpoint approach becomes evident in Connell's distinction between dominant or hegemonic masculinities and the subordinate or marginalized forms.

As a comparatively recent perspective, feminist theorizing does not have a lengthy history. The proliferation of perspectives within feminism can be confusing, yet it is necessary, simply because there are many oppressions and standpoints (Harding, 1991), just as there are many women and groups or categories of women. Feminist theory is not complete but is always in flux, always seeking better and expanded explanations of women's conditions. For example, Hartsock (1998) has revised and pluralized her standpoint theory, which now coincides with Harding's (1991) multiple standpoints. The feminist standpoints, or the standpoints of women, thus aim to reflect the multiplicity of women's lived and materialist "everyday/everynight life" experiences (Smith, 1987; 1990).

CHAPTER SUMMARY

In this chapter I have reviewed some of the bodies of literature that have relevance to my study of engineering students at the University of Saskatchewan. I reviewed the literature on recruitment, attrition and retention of students in engineering colleges and factors that impacted on engineering students. The gendered socialization of our society is an issue for attracting women to engineering education, and I have reviewed those elements of socialization that address the deficit model of women's education, as well as harassment and sexism, the so-called "chilly climate" for women. However, socialization theory is limited to the absorption

learned behaviours and roles. Instead, important issues in the construction of gender include the construction of femininities and masculinities and how we all practice “doing gender” in our everyday lives and activities through agency and negotiations. I have summarized issues in feminist theory, with a special focus on the feminist standpoint, or the standpoint of women, which informs my theoretical and methodological perspectives. Additional literature will be reviewed and discussed as needed in the chapters that analyze the empirical data on engineering education at this university. In the next chapter I will discuss research methodology and the methods I used in this study, followed by four chapters presenting and discussing the empirical data.

CHAPTER THREE

THE BLUEPRINT

(Methodology)

Choosing the proper method of investigation is one of the first tasks with which the researcher has to contend. However, it often becomes necessary to use more than one method to generate the desired data. For my research, I used the techniques of three different methods: non-participant observation, survey, and in-depth interviews. Because my research concerned human individuals, I submitted each component of the research to the university's Advisory Committee on Ethics in Behavioral Science Research for approval (Appendix A).

In this chapter I first position my feminist approach within social science research methodology. I discuss the traditional, scientific method and its assumptions and outline certain feminist research principles and practices. Finally, I discuss my choice of methods for the current study and how I have applied them in the various components of the research.

POSITIONING THE RESEARCH

Traditional research within the scientific paradigm has tended to be researcher-oriented and focused on problems that were of interest to men. As a result, women's experiences and women's issues have often been excluded from research (Smith, 1988). The male experience has been taken as universal in this androcentric approach, and deviations from the universal standard, i.e., female experiences, taken to be abnormal.¹ In this manner, women's reality has been defined by male standards, which separated women's thinking and opinions from their

¹ For example, without investigating the effects on women, much medical research has assumed that men's development of diseases and conditions, as well as their reactions to treatment would also apply to women. However, it has lately become clear that female cardiac patients, for example, respond differently to treatment than men do. Disease has also shown to develop differently in male and female patients, and that men and women are prone to different conditions and diseases, thus requiring different treatment strategies.

lived experiences. In contrast to the traditional assumption of the researcher's objective, arms length distance from the research problem, Smith recommends starting from the researcher's own experiences and knowledge about the problem. However, taking personal experience and knowledge as the starting point does not automatically mean that the researcher is too familiar with the subject matter, but rather has a privileged understanding of it. In addition, Smith (1990) stresses the importance of where the researcher is situated; the view of an actor will be quite different from that of an observer. These are feminist assumptions that the scientific method rejects.

Paradigm Shifts: From Positivism to Feminism

The traditional model of science, or the scientific method, gained prominence during the 18th century Enlightenment era. With its elements of theory, operationalization and observation it arose as a modern, rational way to gain abstract knowledge about the physical world (Babbie, 1986) by rejecting religion and other traditional explanations such as magic and the spirits (Martin, 1994; Himmelfarb and Richardson, 1982). In what can be considered a major paradigm shift, the scientific method slowly replaced the theological explanations of physical phenomena that had reigned supreme prior to the Enlightenment. The scientific method of physical science also became the paradigm for other sciences.

The scientific method of physical science is a positivist method of gaining knowledge through observation, experimentation, generalization, and verification. It assumes that scientific knowledge is cumulative and generally depends on inductive logic, based on observations, to construct theory. However, deductive logic through mainly statistical testing of the hypotheses that theory elicits is an equally important feature of the method (Theodorsen and Theodorsen, 1979).

Within positivism, the "verification principle" assumes that knowledge, in order to be valid, must be verified by experience, also known as empiricism (Jary and Jary, 1991). That is, empiricism assumes that the only valid information is what "can be observed or 'sensed' in some way under specifiable conditions by people possessing the normal sensory apparatus, intelligence, and skills. . . observable, directly or indirectly through some tangible manifestation. . . . [A]ppeals to authority, tradition, revelation, [or] intuition . . . cannot be used as scientific

evidence” because they are non-empirical ways of knowing (Singleton et al. 1988:31).

Positivism, or positive philosophy, as formulated by Comte, assumes a belief in science. It accepts the idea that one scientific method applies to all areas of study (Ritzer, 1988, 1992), and asserts that only scientific observation is true knowledge (Jary and Jary, 1991). Through positivism, Comte sought laws that governed both the social and the physical world. Knowledge through scientific observations contrasts with idealism, which relies on adherence to moral values, and rationalism, where reason working on its own is capable of producing substantive and reliable knowledge (Martin, 1994).

Critics of the positivist scientific method argue against positivism’s prescriptions for keeping human values out of their work. These critics argue that positivism allows for neither the agency of individual social actors nor any form of social action (Ritzer, 1988, 1992). Feminists as well, through their critical theory approach, find flaws in positivism and the scientific method. Therefore, it became necessary to develop distinct feminist epistemologies.

In his treatise on *The Structure of Scientific Revolutions*, Kuhn (1970) explained how knowledge is accumulated within a paradigm during a period of “normal science.” Kuhn (1970:10) defined normal science as “research firmly based upon one or more past scientific achievements” that specific scientific communities might consider the basis for further practice and discovery in their fields. For Kuhn, a paradigm was a model for scientific research. At times, the paradigm cannot explain errors, or anomalies, that occur in the research. When the accepted model is unable to explain too many of these anomalies, the model will be thrown into a crisis stage, which may result in a scientific revolution. At the end of the revolution, a new paradigm will emerge that may, or may not, better explain research within the field.

In theory and in research, feminists have challenged the male model of social structure and social reality, and some feminists, e.g., Saarinen (1988) and Nielsen (1990), have suggested that a paradigm shift is taking place. Nielsen’s approach to the paradigm shift, from male-stream to feminist, follows Kuhn’s model but with an added factor of ‘Focus on Women’ or ‘Feminist Consciousness,’ which she sees as coming from outside the respective disciplines. This factor intersects the schema during the normal science stage and contributes to the anomalies, crisis, and revolution that by Kuhn’s definition by necessity must occur when a new element is introduced.

Kuhn (1970:176) states that a “paradigm is what the members of a scientific community share, *and*, conversely, a scientific community consists of men [sic] who share a paradigm.” Because women, especially feminist women, share in a different kind of community, it is reasonable to call feminist research a feminist paradigm. Furthermore, not only feminists but also aboriginal researchers have been influenced by Kuhn’s ideas. For example, as an aboriginal female scientist, and member of an aboriginal community, Dyck (1998b) has expanded Kuhn’s framework to include the Plains Indians’ medicine wheel. Dyck suggests that the medicine wheel also enters the cycle during the normal science stage and contributes aboriginal issues to additional anomalies, crises, and revolutions that will possibly lead to a new, aboriginal paradigm.

Through challenging the male model of social structure and reality, feminism and the feminist paradigm have had an impact on public perceptions of social change. Citing Minnich, Saarinen (1988:35) stated that just as Copernicus, in earlier times, shattered geo-centricity and Darwin shattered species-centricity, feminists are shattering andro-centricity in a dangerous, fundamental and exciting way. Saarinen added: “And we are surprised that we are not welcome in the academy?”

Feminist Research Approaches

Until recently, women, women’s interests and women’s concerns were essentially ignored and excluded from scientific research, leading to feminist charges of “bad science” (Harding, 1991). Nielsen (1990:4-5) has described the positivist, scientific method as a way of knowing based on five major, interrelated assumptions, all of which are challenged by feminists:

1. *Objectivity* assumes that the social world, like the natural world, is knowable and that knowledge can be obtained through objective and value-free observations by an independent researcher.
2. *Subject-object separation* assumes that subjective knowledge should not influence the objective truth; i.e., the concerns of the researcher cannot be included.
3. *Empiricism* relies on sensory observations for verification of information. It assumes that the senses give accurate information about human behaviour and that different observers exposed to the same situations will reach the same conclusions.
4. The *cause-and-effect* assumption assumes that the social world is ordered and rational

and that universal laws can be found and developed.

5. *Unity in the sciences*, including the social sciences, is assumed since they share the tools and methods for learning about the world.

Although many feminist scientists use the positivist, scientific method when it is appropriate in their research, it is only one of many tools that feminists use to describe and explain the long ignored world of women. Feminist research generally falls into three major categories: feminist empiricism, standpoint epistemology, and post-modernism, all of which critique the traditional scientific research method (Eichler, 1991; Harding, 1987).

An important and constraining aspect of positivist science is that the investigator must not use her/himself as a source of data (Schwartz and Jacobs, 1979). Feminist research, in contrast, encourages the researcher to become part of the data. Because the assumptions of objectivity and value neutrality have been trademarks of traditional research, feminist research is criticized for being subjective and biased. Moreover, feminist research is often critiqued for methodological flaws and sampling inadequacies. Equity research, including issues of the “chilly climate,” is especially vulnerable to such criticism. Stalker and Prentice (1998: 26-27) state that “equity reports are vilified . . . through critiques of their research basis. . . . The net effect of methodological questioning is to deny that any problem exists.”

To account for their perceived subjectivity, flaws and bias, feminist researchers most often identify and indicate that their research is generated from or based on women’s lived experiences. This aspect distinguishes feminist research from traditional research. Thus, what makes feminist research different from traditional research is that there are assumptions within research that are distinctly feminist, and that feminist researchers within the major perspectives practice specific ideas, e.g.:

1. Feminist research is critical and emancipatory (Saarinen, 1988).
2. Feminist research is participant-focused and reciprocal (Oakley, 1981).
3. Feminist research may be grounded in and may generate the problematic from women’s experiences, including the researcher’s own (Harding, 1987; Kirby and McKenna, 1989; Nielsen, 1990; Smith, 1987; 1990).
4. Feminist research may choose to focus exclusively on women (Eichler, 1986).

5. Feminist research gives voice to the researched and emphasizes equality between the researcher and the researched (Kirby & McKenna, 1989).
6. Feminist research stresses collaboration and co-operation and tends to be cross/inter/multi-disciplinary and community-based (Reinharz, 1992).
7. Feminist research methodology emphasizes greater awareness of the moral and affective implications of using highly intimate and personal information as data, so that the informants will not suffer, neither individually nor collectively (Finch, 1993).

Feminist research methodology has gone through major development over the years. From the androcentric exclusion of women's experiences and realities, feminist research attempted to 'add women' both to traditional analyses and as scientific researchers. The difference was the inclusion of women in sampling while still investigating the problematic in traditional, positivist fashion.

The second and third waves of the women's movement have done much to move research through this 'add' phase into a women-centred approach where the focus is on women and the female condition (Eichler, 1986). Harding (1986, 1987, 1990, 1991) and Smith (1987, 1990) deal extensively with 'women's experiences' as valid representations of knowledge and social reality. By approaching the problematic from women's experiences, research can be designed 'for' women, as opposed to traditional research designed 'for' men (Smith, 1987, 1990). Harding (1987) stresses that women's experiences and women's realities must be considered in the plural, and Eichler (1986, 1991) envisions feminist research moving into a non-sexist approach which she blends with the women-centred approach in order to facilitate a collective integration of feminist research. However, because of the dearth of woman-centred research, and because women's struggles to achieve gender equality are often met with apathy and jeers about political correctness (Stalker and Prentice, 1998), non-sexist research may be farther into the future than Eichler may have hoped.

Feminist Epistemology

Within the feminist theoretical perspective to end oppression and to establish specific feminist research strategies, there are three major epistemological divisions: feminist empiricism, feminist standpoint ideology, and feminist postmodernism (Harding, 1991) all of which critique the traditional scientific research method (Eichler, 1991; Harding, 1987).

Feminist empiricism adheres to the liberal feminist perspective of adding women to conventional research methodology, thereby correcting what is perceived as “bad science” (Harding, 1991). Feminist standpoint epistemology bases its construction of knowledge in the socialist feminist perspective, historical materialism and experiences from women’s lives (Harding, 1991; Hartsock, 1997; Smith, 1990), while feminist postmodernism rejects Enlightenment assumptions in favour of deconstruction to illuminate the absence of universality (Harding, 1991). In short:

- *Feminist Empiricism* is careful to include women as subjects but retains the empirical and scientific methods and their assumptions.
- *Feminist Standpoint* researchers see taking the perspective of women as an advantage, rather than as a bias. They see all research as subjective and believe it is better to disclose that subjectivity.
- *Feminist Postmodernists* consider gender itself to be a socially constructed phenomenon to be de-constructed. They, too, believe that all research is subjective, not objective.

These different approaches do not share the same assumptions, other than that women must be included in research. Although feminist theorists are divided over the extent to which the mainstream, masculine culture should or could be changed, there is agreement that change is needed.

Feminist Empiricism

Feminist empiricism makes use of traditional methodology, stressing rigorous use of the rules of the scientific method. Feminist empiricists apply the traditional scientific method to feminist research concerns in an attempt to correct what they consider “bad science” or badly done science (Harding, 1991). They believe such correction is possible by adding women both as researchers, as research objects and while examining feminist issues, although the “add and stir” approach cannot by itself eliminate old beliefs (Eichler, 1986). Feminist empiricists therefore suggest that androcentric bias in the sciences can only be eliminated by even “stricter adherence to existing methodological norms [e.g. objectivity] of scientific inquiry” (Harding, 1991:111) which will then result in “good” science. The feminist empiricists assume a value-neutral, objective and impartial vantage point, a so-called “Archimedean” point (Jaggar,

1988:370). They argue that by paying attention to androcentric bias within the rigors of the scientific method, their research is more amenable to, and therefore accepted by, traditional, mainstream approaches. Sandra Harding also argues that feminist empiricism has radical potential since the result of this research led to the undermining of many assumptions about the male culture of science.

Harding (1991:112) states that many claims from feminist empiricist research, especially in biology and social science, are true, or “at least less false than those [traditional claims] they oppose.” She refers to feminist discoveries in biology and the social sciences about, for example, “Woman the Gatherer,” women’s moral reasoning, and women’s contributions to social activities that have changed our understanding of women’s traditional capabilities and roles. Feminist empiricists also indicate that “one cannot simply ‘add’ feminist claims to those [claims] they challenge” (Harding, 1991:113) because the different sets of beliefs are in tension with or contradict each other. Thus, while feminist empiricists encourage more rigorous use of traditional methods and norms, Harding and Smith claim that it is precisely the rigors and norms of the androcentric scientific method that are the problem and that when feminists look beyond the “universal” androcentric sampling and conclusions, universality does not exist. What is needed is a wider scope of research that includes social values. Although she argues that feminist empiricists challenge androcentric positivism by including the perspective of women, she agrees with Dorothy Smith (1987, 1988, 1990) that it is necessary to adopt an alternative starting point, a feminist standpoint, which focuses its assumptions on women’s experiences.

The Feminist Standpoint

As stated in Chapter Two, feminist standpoint theorists generally adhere to the ideology of socialist feminism. The major assumption is that women’s lived experiences create knowledge. Feminist standpoint theorists argue that all knowledge is socially and situationally located, and it is especially particularly important to start from the bottom of the social hierarchy to seek this knowledge (Olesen, 2000). Feminist standpoint research critiques the entire scientific enterprise with its practices, purposes and functions (Harding, 1991). The standpoint theorists believe that knowledge is socially situated and base their epistemology in

the lives of women. For example, Smith (1988; 1990) insists that knowledge is not 'something out there' but is rather created through the experiences of everyday people, especially women, who have been silenced and ignored by the male power establishment. A standpoint is an achievement that women develop from their lived experiences through their position in the social hierarchy of gender, race and class (Smith 1988). It becomes a privileged, alternate vantage point for analysis, opening up an area of research that is necessary in order to balance our knowledge of a more complete social world.

While feminist empiricists critique "bad science," feminist standpoint research also challenges "science as usual" and "the fit of science—past and present—with the gender, race, and class projects of its surrounding culture" (Harding, 1991:60; Smith, 1987, 1988, 1990), using "the distinctive features of women's situation in a gender-stratified society . . . as resources" (Harding, 1991:119). An approach that focuses on women's lives is, therefore, not gynocentric in order to counteract androcentricity, but rather emphasizes the difference between men's and women's lived experiences (Harding, 1991; Smith, 1988). By focusing on standpoints in the plural, feminist standpoint research has been criticized for becoming relativistic and having possibilities for essentialism (Olesen, 2000). However, standpoint epistemology emphasizes a population that has been under-researched and misinterpreted and is a way of validating lived experiences from a different vantage point (Smith, 1987, 1988, 1990) and as feminism itself, is continually under revision (Hartsock, 1998).

Both standpoint epistemology and feminist empiricism are considered modernist approaches. Harding (1990, 1991) argues that both of these epistemologies are emancipatory and want to improve the conditions for women. Both want more accurate accounts of and stories about the natural and the social worlds and both seek some sense of the capital T Truth through science.

Feminist Postmodernism

In contrast to empiricists and standpoint theorists, feminist postmodernists are sceptical of the possibility of a realistic liberation for women through science. They particularly critique and reject the Enlightenment's assumptions of generalized truths. Instead of one Truth, they suggest that there are several truths depending on individual subjectivities (Harding, 1990;

Rosenau, 1992). In particular, 'racialized' women, i.e., women of colour, call attention to the impossibility of universal truth claims and propose a multitude of feminist standpoints as a challenge to the existence of *a* feminist standpoint.

Instead of the modernist approaches, feminist postmodernists focus on difference and base their research on discourse analysis, interpretation and deconstruction. Feminist postmodernists have used deconstruction to call attention to the difference between the many groups of women and have thus opened the door to specific analysis of the lives of black women and other 'women of color.' Feminists who apply postmodernist analysis to their works, research such issues as identity and gender (Nicholson, 1990). However, the goal of deconstruction is to undo construction, to fragment, to tear apart texts, to reveal contradictions without revision, improvement or reconstructive action and can lead to relativism (Rosenau, 1992).

From the above brief discussion it may appear that feminists cannot agree on a unified theoretical approach. However, the tensions between feminist approaches are valuable because they challenge traditional, androcentric authority (Harding, 1987; Nielsen, 1990; Saarinen, 1988). Feminist empiricism and feminist standpoint epistemology are both interested in advancing feminist science, in contrast to feminist postmodernism, which has no such interest or intention (Harding, 1991).

Choosing the Method: Qualitative vs. Quantitative.

Once it is established that there are distinct categories or approaches within feminist research, the next question is often whether or not there is a specific feminist research method. The answer is no; there is no particular method or technique that is distinctly feminist, feminist researchers use all available methods, traditional or otherwise (Harding, 1987; Reinharz, 1992).

Some feminist researchers see the quantitative/qualitative question as an important issue when designing feminist research. The decision to use a qualitative or quantitative approach must, of course, fit the nature and the goals of the research. Qualitative research includes methods such as structured, semi-structured or open-ended interviews and participant or non-participant observations. Among these methods, semi-structured interviews have become one of the major methods for feminists to elicit data about the lives of their research

respondents (Reinharz, 1992:18). Qualitative research differs from quantitative research through the distinctive feature of

its reliance on the words and voices of the people being studied. Instead of recording people's thoughts and feelings on scales or in categories, the researcher records their actual words on magnetic tape, paper, computer memory, or any combination of these (Judd et al., 1991:300).

In contrast, in quantitative research the individual "disappears" in the numerical aggregate. Judd et al. (1991:239) suggest that responses to closed-ended questions in surveys and interviews are easy to code in order to facilitate meaningful analysis of the results, while open-ended responses may cause problems in coding although they provide more in-depth understanding of the issues.

The use of open-ended rather than closed-ended questions facilitates a reciprocal approach, which appears to be the preference for some feminist researchers (Reinhartz, 1992).² Applying methods in a feminist way, Oakley (1981) would have seen Judd et al.'s preference for closed-ended questions as a one-way process that restricted the interviewer to eliciting and receiving information without the possibility for sharing. Oakley, instead, violated the traditional assumption of subject-object separation and abandoned her outsider objectivity in favour of an open-ended, dialogical question and answer approach where all the questions do not necessarily originate from the interviewer. Oakley's approach to interviewing thus suggests a degree of equality and collaboration between interviewer and participant that is specifically feminist. During such dialogical interviews the researcher listens in order to understand the informant, not merely to record data. In contrast to traditional surveys and interviews, feminist qualitative research allows the participants the possibility of expressing their experiences in their own words, or "voice" (Belenky et al., 1986; Kirby and McKenna, 1989), rather than simply responding to the researcher.

Therefore, if feminists are finding research results that differ from traditional expectations, it does not mean that they are using different research methods but rather that they use the same methods differently by, for example, asking their questions differently

² That is not to say that only feminists use this approach.

(Oakley, 1981) and asking questions about women's world (Smith, 1988). Moreover, Harding (1991) posits that the perceived problem of relativism in using women's experiences rather than men's as basis for theory and empirical research is a false supposition. She argues that reliable knowledge claims can be drawn from both female and male experiences, although they may be expected to differ.

The Role of the Researcher

The role of the researcher is an important issue in feminist research and may be one of the elements of feminist research that makes it specifically feminist. As with the choice of a theoretical perspective for analysis, when deciding on a research approach it becomes necessary to negotiate between desirability and practicality. While it might have been desirable for my research to interview an entire incoming cohort, or a complete class of graduating students, or conducting a four to five-year longitudinal study of a proportion of the incoming class, none of these options are practical or possible for a one-person, time-limited doctoral study. However, regardless of research approach, theory or epistemology, feminism is always committed to women.

It is the feminist commitment to women that has guided my research into the experiences of young female and male engineering students. In this research, I have positioned myself within feminist standpoint theory (Chapter Two), and in the empirical research there are elements of all three feminist epistemologies. The overarching assumption of gender issues and gender difference reflects a major postmodernist research interest. The survey method is an empiricist approach, and true to feminist non-sexist research, I included both women and men in the sample. As a researcher, I asked questions of interest to both women and men, and I asked then from a feminist perspective. In the observation and interview components, I conducted the research from my own feminist standpoint, as a student, as a woman, and as a mother of a son with an engineering degree. In concordance with my choice of theoretical perspective, I identify most with the feminist standpoint epistemology, which allows me to build more fully upon my own life experiences throughout the research. That approach also permits my informants to relate their life experiences from their own points of view. Therefore, what one respondent perceives as truth and of great importance, may well be trivialized or

ignored as insignificant by another, depending on each individual's achieved and privileged vantage point.

THE CURRENT STUDY

This study was designed to reveal the social conditions women and men encounter when they choose a career in engineering. It sheds light on those features of engineering and engineering education that both attract and discourage women in particular. My study adds to our understanding of the sociologies of education, of science and technology, and of gender. In the study, which by its nature is considered "fieldwork" or "ethnography," I combine a quantitative survey of a first-year cohort with the qualitative methods of observations in the classroom and interviews with volunteer students. My approach is inductive, and my analysis is feminist. With the help of my participants, I explored the university experiences of engineering students, both female and male, rather than testing pre-determined hypotheses. The qualitative research process served to investigate issues in depth, searching for concepts and ideas around the issues.

The study of female engineering students is an emerging field, with broad areas of investigation. The fieldwork approach to my research permitted involvement in the lives of a minority population in an educational field and in its natural setting. Inductive analysis of the interview data from the feminist theoretical perspective and research methodology provided valuable insights into and "thick description" of the university experiences of engineering students, the female students in particular. Anthropologists use the term 'thick description' for paying attention to the details of everyday social life in cultural settings (Jary and Jary, 1991:520). The inductive aspect of the research brought to light conditions and experiences I had previously not considered. The challenge was to limit the scope of the research to manageable proportions.

Description and Application of Methods

Because no single research method could elicit all the data I required for my study, I have used a combination of methods for my feminist analysis. Combining various methods of data gathering has become a major strategy in feminist research (Reinharz, 1992). Generally

known as triangulation, the strategy is well known to mainstream research. The research consisted of a descriptive demographic analysis of survey questions and a content analysis of the themes that emerged from individual and group interviews with both female and male students. My intent to assemble one or more focus groups of first-year students in order to discuss issues that would be of general interest to this group was abandoned because the students' study and work schedules were already overloaded. In the study I use three major research methods:

- Non-Participant Observation
- Survey
- Semi Structured, In-Depth Interviews

Non-participant Observation

In order to familiarize myself with formal engineering education and to understand the experience of being a female engineering student, I audited engineering courses as a non-participant observer. A non-participant observer, in general, observes without interacting with the actors in the site.³ The University Calendar's description of courses required for the various years of education cannot explain classroom interactions and relationships, which were of interest to my study. Sally Hacker (1990:4) found participant observation, which she called her "method of being with people," essential to her studies of engineering education. She believed that unless the researcher lived under the same conditions as the research subjects he/she could not fully understand the research situation.⁴ However, unlike Hacker, my status as non-participant observer cannot provide the exact conditions the students experienced, such as the tensions of homework and examinations, sudden quizzes, questions and answers during class time, etc. Although I did not take an active part in classroom activities and course requirements, I began to understand the students learning environment by attending classes with them.⁵ Attending the classes, I was also able to develop a network of contacts for later

³ A non-participant observer is often unknown to the individuals or situations under observation. However, there are times when the observer is known yet does not interact (Singleton et al., 1988).

⁴ Hacker registered as a full-time engineering student while working as a full-time sociology professor.

⁵ After all, I was studying engineering education, and not engineering, *per se*.

interviews while at the same time gaining the trust and confidence of my “classmates.”

I attended several courses required for the degree of Bachelor of Engineering (B.E.) at the first-year, third-year and fourth-year levels. For all the courses and sections I had, in writing, requested the professors’ permission. All but one consented to my presence in the class. The professor who denied my request to attend a course required for all students (GE 449.3, Engineering and Society) offered me, instead, access to a technical course in his discipline, which I declined, simply because I would be unable to understand the technical concepts. However, he gave me permission to address the students at the beginning of one class session to describe my research and to ask for interview volunteers. The following academic year I was able to attend three sections of this course taught by three other professors.

During the fall semester of the 1996/97 academic year, I attended two sections each of the following required first-year classes:

- *GE 163.3, Graphics and Descriptive Geometry* (drafting)
- *EP 124.3, Mechanics*, (a physics course), including two sections each of problem solving and practical laboratory sessions.
- *Eng 115.3, Literature and Composition* (English for non-arts and science students)
- *GE 131.1, Introduction to Engineering*, consisting of large (about 200 students each) tutorial sessions featuring lectures and presentations on themes and issues of general interest to all the engineering disciplines. An additional component featured smaller (about 30 students each) seminar sessions, focusing on features of the engineering profession, which required more personal interaction and instruction. I regularly attended five of these small seminars, where the professors in charge were assumed to be the students’ faculty advisors.

While I was an anonymous observer in the EP 124 lecture course, the professors in the GE 131, GE 163 and Eng 115 courses introduced me to the class as a doctoral student researching engineering education and permitted me to explain my research to the class. Because all first-year students were required to attend the GE 131 lectures in the first semester, the complete first-year cohort had knowledge of my presence and my research. Most of the students appeared to accept me as just another student, although not in their own discipline. However, some of the students did take interest in my work and from time to time asked questions about my findings. This personal contact permitted me to ask them if they were willing to participate further in my research and gave me an opportunity to establish contact

with prospective interview participants.

During the winter term 1997 I attended two sections of:

- *GE 390.3, Oral and Written Communication,*

and during the following academic year, 1997/98, I was able to attend three sections of:

- *GE 449.3, Engineering and Society* that I had not been able to attend the year before, two in the fall and one in the winter term.

Both these courses were “general interest” courses to which I could relate, as opposed to “technical courses” where my own background would not qualify me to understand the content. In both of these courses, the professors identified me as a student/researcher and gave me the opportunity to explain my project. Several fourth-year students volunteered for my interviews in one of the GE 390 sections, and one GE 449 student contacted me for an interview about combining motherhood and engineering.

While in class, I was usually seated in the rear of the room so that I could observe the actions and interactions in the room. I took notes of the interaction in the classroom: e.g., how the students seated themselves, who asked questions, who answered questions from the professor, and any other interaction among the students and between students and professors.

Survey Research

In the process of discovery, the survey instrument has many uses. One purpose of the survey is to “explore the distribution of some variable in some population of interest” (Judd et al., 1991:101). That was the case in the current study. Although I believe that surveys of large numbers of respondents lose some of the colour and richness that can emerge from interviews, I believe a survey is useful for investigating the presence of a trend or a general characteristic. The purpose of the survey was to establish a descriptive profile of the first-year cohort, for which only frequency distribution was of interest.

Through my research I expected to discover issues that motivate young women and men to seek an engineering career: their primary socialization, their perception of the engineering profession, the adequacy of high-school career guidance and their expectations of education and training required to become engineers. My research would thus be important to gender equality strategies in the College of Engineering at the U of S. Since a number of

students have opportunities for summer employment in engineering oriented work situations, it would also be possible to discover if the “real world” of engineering met with the women’s expectations of the profession *per se*, and whether the work experiences reinforced or discouraged their initial decision to pursue a career in engineering.

The professor responsible for coordinating both the tutorial and seminar components of the GE 131 course allowed me to conduct the survey of the cohort in the tutorial sessions. I administered the survey questionnaire (Appendix B) to the 1996 first-year cohort toward the end of their first semester during class November 12 and 14, 1996. Thus, I had a captive audience of students in a classroom. Participation in the survey was voluntary; I offered no rewards, and nobody was penalized for declining to respond.

The total first-year registration in October 1996 was 397 of which 83, or 20.9%, were women (University Studies Group, 1999). Toward the end of Term 1, 349 students wrote the mid-term exam in the *GE 131.1* course the week following the survey.⁶ Of those 349 students, 230 were present in class on the days of the survey, from whom I collected 216 usable responses: 58 students were female and 158 were male; four students did not indicate their gender. Four returns were spoiled and six students left the room without completing the survey, which gave me a 61.9% rate of response based on the class size at the mid-term exam.

I used closed questions that could be answered “yes” or “no” or rated on a five-point scale. The questions were projected on overhead screens and the responses recorded for computer analysis. With the professor, I monitored the students while they completed their answers, giving them time to complete the questions on one overhead slide before presenting the next series of question. I was also able to respond to any questions from the class during the survey.

The survey questions focused on primary socialization, high school counselling and guidance, perceptions of the profession, and expectations of the required education and training

⁶ The discrepancy between the 397 total registration in the first-year cohort and the 349 registered in the *GE131.1* course has several explanations. Each year a number of students already have credit for the course and consider themselves second-year students although they are still completing first-year requirements. Others had received dispensation from attending this course because they were older students who had either transferred from other programs or had worked in engineering settings and believed they did not need assistance adjusting to the university setting and the engineering profession. As well, some students had already left the program.

for the engineering profession. The questions also probed the relative importance of social and academic experiences, problem solving strategies, general interests and the influence of role models. Research had shown these variables to be significant for women's achievement in mathematics and sciences (Carter and Kirkup, 1990; Hacker, 1990; Javed, 1988; McIlwee and Robinson, 1992). The survey also investigated when and how interest in mathematics and sciences developed. The responses were computer analyzed by the mainframe SPSS program.

In connection with the survey, and on a sheet separate from the response sheet, I asked the students to indicate if they were willing to participate in interviews and focus groups and to indicate their name and method of contact. There was not enough interest in focus groups to go ahead. However, 26 female and 37 male students volunteered for interviews, which was enough to proceed.

Semi-Structured, In-Depth Interviews

The primary research method of this study was the semi-structured interview. Semi-structured refers to the researcher's intention to ask questions about certain topics while at the same time conducting the interview as a conversation rather than a strictly question-and-answer session. This method "has become the *principal means* by which feminists have sought to achieve the active involvement of their respondents in the construction of data about their lives" (Reinharz, 1992:18). The method becomes beneficial to my research within the feminist standpoint theory. The advantage of interview research is Oakley's (1981) concept of the interview as a dialogue between the researcher and the researched, although some structure is necessary. In dialogue, participants are involved, and the informant is free to volunteer any information that is important to her or him within the parameters set out by the researcher. Even though it is the participant who decides the importance of the information, the researcher is still in control of the interview by probing and guiding and by keeping the conversation on track. Another advantage of the personal interview is the possibility it affords to clarify questions or issues that the informant may not understand, for example, because the interviewer has used the jargon of the discipline. Watching a puzzled facial expression may be a cue that the question is not clear. However, the major disadvantage of interviews is that the researcher is limited to the number of respondents who can be interviewed; therefore, the method is not

suitable for building a large database.

Following the survey, from January through March 1997, and during the 1997/98 academic year, I conducted in-depth interviews with

1. fifteen (nine female, six male) volunteer first-year students;
2. eighteen (eleven female, seven male) volunteer fourth-year students;
3. sixteen (ten female, six male) transfer students, all academically able, who had voluntarily withdrawn from the study of engineering;
4. a group of six women in their third and fourth year who were the major organizers of the college's recruitment and outreach committees.

In addition, I interviewed two administrators as well as conducted informal conversation with some of the professors whose courses I was observing.

The most extensive part of my research was the interview component. Here I could hear the students' own voices as they related their lived experiences in engineering education. The issue of 'voice' emphasizes the particular over the general and allows the respondent to participate more fully and determine the direction of the research (DeVault, 1999). However, the use of 'voice' in the data chapters does not mean that one student's 'voice' or statement necessarily represents the views of an entire group. It does illustrate that a particular issue or problem is important to that individual and could be equally important to other members of the group (Olesen, 2000). Giving the respondents 'voice' is then a strategy for active involvement, and as such an important feature of feminist standpoint ideology as it reinforces the notion of standpoint, both for the researcher and the respondents. I believe such involvement is necessary in order to achieve first-hand understanding of the climate of interaction and education in the College of Engineering.

Sampling

In the observation and survey components of this research, all the incoming first-year students in the College of Engineering for the 1996/97 academic year became participants by attending the classes I observed. For the interview component, there were four non-random sub-samples as stated in the previous section.

The First-year Students

During the survey, 26 female and 37 male students indicated an interest in being interviewed. I selected a sample of nine women and six men; five of the women and two of the

men had self-selected by contacting me previously, indicating that they wanted to participate in the interview research. The remaining four women and four men were drawn randomly from the volunteers. Through the random selection two men declined: one due to too much home work, the other had dropped out of the program. They were randomly replaced from the remaining pool of male volunteers. Three women had not returned for the second semester but were willing to participate as transfer students.

The Fourth-year Students

I recruited the fourth-year students partly through contacts I had made previously, partly by circulating sign-up sheets for volunteers in one section each of GE 390 (that had a number of fourth-year students) and the GE 449 class to which I was denied access, as described above. Having already interviewed the first-year students, I found that the fourth-year students were considerably more able to reflect on their education. The following year I was able to interview an additional three female graduating students: one who approached me about her experiences as a mother, one who had recently returned from a year's leave of absence, and one who had for several years worked with the outreach committees.

The Transfer Students

The College of Engineering was concerned with attrition that was not related to academic ability, and I hoped that my research would shed some useful light on the problem. Students who had discontinued engineering studies were more difficult to locate. The college kept no specific records because no official notice of withdrawal was required. The effects and efforts of the initial observation/auditing stage were helpful in this case. "Grape-vine" referral by friends of non-returning classmates aided in locating some of these students. Three of the first-year volunteers had left the program after the first term and were still willing to be interviewed. As well, I had previously become acquainted with two other transfer students. In total, through snowball referral, I located and was able to interview ten women and six men who had left the program, all of whom were "non-returners" (Pascal and Kanowitch, 1979). Interviewing these volunteer transfer students was an ongoing process over several semesters.

The Group Interview

At one point in my research I became aware that women were the chief organizers of the college's recruitment and outreach committees. I was able to arrange a group interview

with six of these female organizers to discuss why they were spending their spare time doing unpaid volunteer work for the college. This interview took place in the Dean's boardroom after office hours and was totally unstructured. My first question was simply, "Why do you do this work?" This approach encouraged participants to discover and develop common thoughts and ideas and was useful in determining if present college strategies for recruitment and retention are successful and sufficient.

The Interviewing Process

During the interviews, all students answered the same initial questions (Appendix C), with additional questions for the graduating students and the transfer students. The graduating students answered questions about all their years as engineering students while transfer students provided their reasons for withdrawal, to where they had transferred, and whether or not available counselling or support programs addressed the students' social and/or educational needs.

I interviewed the first-year students in their second semester, and the fourth-year students in the last semester before graduation. I conducted as many interviews as necessary to achieve "saturation of information," defined as the point in the research where there is a significant degree of repetition in the material gathered (Kirby & McKenna, 1989:123). The use of open-ended questions in the interviews permitted a free exchange of thoughts and experiences beyond the initial research questions and allowed me to expand on the survey questions. The interview questions probed some of the themes emerging from the survey and elicited more detailed information, especially about the women's understanding of the engineering profession and their experiences during their education. The questions sought information about classroom, laboratory, and leisure relationships with their peers, interaction with faculty and staff, and the effect of studies on their private lives, e.g., intimate relationships and, possibly, children.

The office of the Dean of Engineering provided me with a small office in which to conduct my interviews. Because all the students spent their days in the engineering building, interviewing them there caused the least amount of interruption and inconvenience for them. With the door closed, we had complete privacy. The following year, when the office was not

available, I was able to use an office belonging to the Graduate Students' Association in a building away from the engineering building. At that time I was interviewing transfer students, and this arrangement suited them. In one case I interviewed a graduate student in his office, and on another occasion I travelled to a transfer student's home away from the city.

The students all agreed to tape recording the interviews, making it possible to concentrate on the students rather than on taking notes. I thoroughly informed all about my research, and all signed Informed Consent forms (Appendix D). In order to make the interviews anonymous and confidential, yet provide a 'human face' when paraphrasing or citing the students' information, each student gave me a pseudonym or asked me to provide one for them. I have used these pseudonyms throughout the study. The interviews lasted about one hour and followed an interview schedule, although the questions did not necessarily always follow the same order, and each interview took the form of a conversation. I made a point of informing the students when their information and experience was also available in the literature, and they appeared pleased that the literature confirmed and validated some of their experiences. I was also able to re-connect with some students for clarification or expansion on some answers.

The themes that emerged from the analysis of the interviews made the interviews the major source of data. The interviews express the students' experiences in their own words, and I want the reader to hear how these words illustrate the issues or problems they experienced. Thus, I have given the students 'voice,' which is one of the assumptions of feminist research.

Analyzing the Interviews

After recording the interviews at the end of the 1996/97 academic year, I was able to hire a typist to transcribe them into THE ETHNOGRAPH software program, version 4.0.⁷ The typist kept transcribing as I collected more interviews. THE ETHNOGRAPH is a software program "designed to facilitate the analysis of data collected in qualitative research"

⁷ Although I used my own, licensed copy of the program, the University of Saskatchewan has a site license, available at the College of Education.

(Seidel et al., 1995:1), such as interviews, field notes and other text-based data. The program replaces the time and space-consuming, physical 'cut and paste' method by allowing the researcher to manage concepts, themes or variables through the computer. The transcripts are code mapped according to the researcher's themes; these coded sections can later be printed across the transcript files (Seidel et al., 1995).⁸

After transcription, I printed the transcribed interview files and read the hard copy for the purpose of identifying and coding issues or themes. I assigned code names of maximum eight letters according to the theme of each interview question. For example, my first questions asked when and why the student had decided to study engineering; this was coded as "WHENWHY" (See Appendix C-1). Another question about the quality of instruction was coded as "BADPROF" and "GOODPROF." These codes were then entered into the data files to produce coded files, which can be printed separately. However, the respondents did not necessarily answer all my interview questions in the same manner of organization. If, for example, a student made comments on what constituted a 'good teacher' and gave an example of being 'harassed' in class by a 'bad teacher,' there would be an opportunity for either "overlapping" or "nested" segments (Seidel et al., 1995:74). In such cases, the criteria for a 'good teacher' would be coded as such, while the 'bad teacher' and 'harassment' comments would also be coded within the same segment of text (Appendix C-2). This type of coding makes it possible to extract statements regarding several variables from a single paragraph, even from a single sentence. A single statement can then be used to illustrate any and all of the variables expressed in the statement (Appendix C-3). Appendix C-4 shows how all the responses to one variable are printed separately.

In contrast to closed-ended survey questions that have to be answered in a certain order and manner, interview questions invite open-ended responses. Although my interview questions were developed to follow a certain order of themes (See Appendix C), that was not always the case. Depending on the volunteer's responses, I sometimes asked a question out of order because it followed the flow of the conversation. And although the questions were

⁸ I compare this process to a deck of cards where the data files can be imagined as the suits while the various card values become the coded variables.

thematically formulated, there were times where I interpreted the response to one question more as fitting another question. As well, again because of the dialogue, a comment from me could elicit further elaboration of a question that we had discussed previously. It was in such cases that the software program was especially helpful in assembling the responses from different questions into major themes or variables.

During the reading of all the transcribed interview data files, the responses and issues were marked and coded as they pertained to one or more themes. Thus, during the printout of the coded files, certain lines could appear under several headings, e.g., harassment, workload, and 'bad professor.' While re-reading the coded printouts, it became possible to identify sub-themes, which shed further light on the attitudes of the students and the experiences they shared in the interviews, such as women's invisibility, the workload involved and satisfaction (or dis-satisfaction) with the various classes, and gendered interaction such as flirting and exclusion of women.

Qualitative methods, such as interviews and observations, have been known to yield rich, descriptive data. That was also the case in the current study. The fourth-year students had gained quite mature insight and attitudes toward women as engineers. The women, in particular, reflected upon their experiences as minorities in a male-dominated setting, while their male classmates also had formed opinions toward women in engineering. At times, it was difficult to decide which statements were the most salient. I have attempted to select those sections of the interviews that I believed best described the issues or the situations. Through the interviews, I was able to enter into the everyday lived world of a group of engineering students, some of whom were ready to enter the "real life" work force, and some who had decided to abandon their studies. The ethnographic approach, and especially the interview component, provided much needed, rich data about a student population that is struggling against the particular traditions and culture of a masculine profession and the tensions arising from increased enrollment of women.

LIMITATIONS OF THE STUDY

This research has been a case study of a particular population at a particular time in a particular place. It is limited to the education of students in the College of Engineering at

the University of Saskatchewan at the time of my research and does not extend to the workplace. The data are limited to, and derive from, a specific voluntary, non-random sample of engineering students; it does not assume to be replicable nor to generalize to all engineering students, female or male.⁹ The survey was limited to one cohort of first-year students in the college. I used the results of this survey for demographic frequency purposes only. The observational component depended on which professors allowed me to audit their courses or sections and which courses could fit into a reasonable timetable. The student interviews were limited to a small number of students who either self-selected for the study or were recommended by other students as being possible participants. The voluntary, self-selected nature of the samples may have had an influence on the results, inasmuch as all these students had some interest in the research for whatever reason. Interviews with faculty and administrators were limited to two assistant deans who agreed to provide information, and to informal, impromptu conversations with course instructors.

My own attributes as a mature woman, mother of a male engineer, and myself a student, likely had some bearing on the research. I believe my informants considered me as just another student, at their own level of power, as opposed to a member of administration or faculty. As a woman, familiar with feminist theory and methods, I believe I can understand some issues that the students may not have considered, for example, harassment and power dynamics. As discussed above, feminists tend to ask different questions and ask them differently.

In the next chapter I begin my analysis of the data, starting with a demographic description of the first-year cohort.

⁹ As the analytical chapters will show, my results confirm research at other engineering colleges.

CHAPTER FOUR
THE BUILDING MATERIAL
(Who Wants To Be An Engineer?)

This chapter is the first of four in which I analyze my research results. In the chapter I present selected results from my survey (Appendix B) of the first-year students who enrolled in the College of Engineering in the 1996/97 academic year. The survey was designed to answer my first two research questions:

Which social factors or forces influence and motivate young women and men to choose engineering as a career?

Is any engineering specialty particularly attractive to women?

To set the stage, I offer a brief description of the University of Saskatchewan (U of S) and the geographical setting in Western Canada. From the survey responses, I have compiled a socio-demographic description of the first-year cohort that entered the U of S College of Engineering in the fall of 1996. I will further discuss the factors that the students' survey responses indicated to be the most important to their choice of engineering as a career. The chapter concludes with a presentation of the distribution of female students in the various engineering departments and how the students made their choice of specialization.

THE COLLEGE OF ENGINEERING, UNIVERSITY OF SASKATCHEWAN

The University of Saskatchewan (U of S) was established in the city of Saskatoon by an act of the provincial Legislative Assembly in 1907. The first classes in Arts and Science were offered in 1909 with 70 students registered. The university is located in one of the Western provinces of Canada. In 1996, Saskatchewan had a population of about one million, with about 40% living in the two largest cities, Saskatoon and the capital, Regina. In the 1996 census, Saskatoon was the largest city in the province with a population of 193,647 (Government of Saskatchewan, 1996), which is projected to reach 215,000 by 2001 (City of

Saskatoon, 2000). Although the rural population in the province is shrinking, the mainstay of the economy is still agriculturally based, with multiple crops and livestock production. Value-added processing, communication technology and biotechnology¹ are the fastest growing industries in the Saskatoon area. Mining, as well, is an important industry in Saskatchewan, with rich deposits of potash and uranium. The manufacturing industry is producing increasingly technologically sophisticated farm equipment, quite often through innovative ideas supplied by farmers and local engineering enterprises.

The university offers academic degrees, diplomas and certificates in 16 colleges, schools and divisions, some of which are direct entry while others have pre-entry requirements. There are also programs available in one federated college, five affiliated colleges and one junior college as well as off-campus and distance programs. The total student population, including graduate, certificate and diploma programs, was 18,811 in 1996/97, the year of my data collection (University Studies Group, 1999).

Research at the university has resulted in an industrial park, Innovation Place, located on the university grounds. The Canadian Light Source Synchrotron, the largest and most costly technological undertaking in Canada, now under construction on the university grounds, is a development of the former Saskatchewan Accelerator Laboratory in the Department of Physics and Engineering Physics.

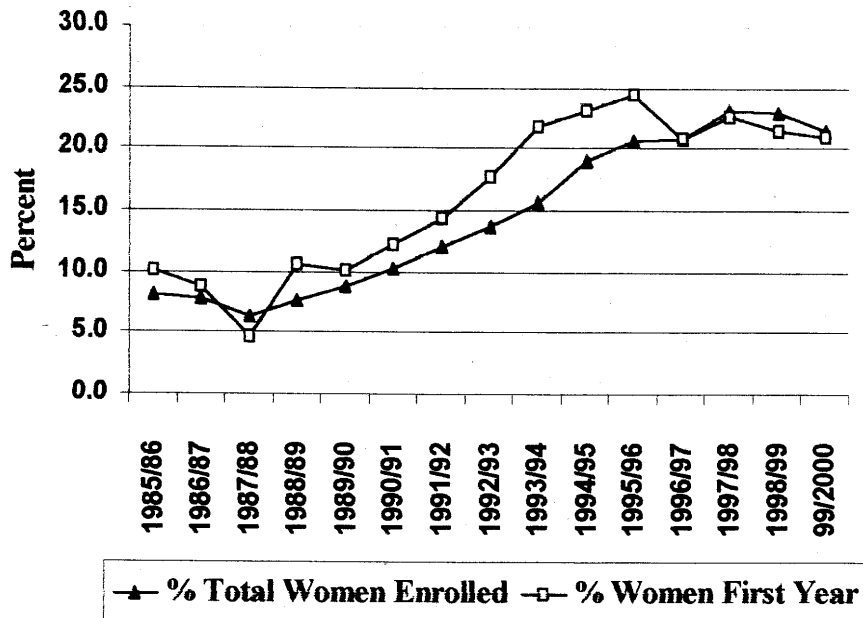
The School of Engineering grew out of the Agricultural Engineering Department in the College of Agriculture and became the College of Engineering in 1924. The first female student may have been admitted to the college in the early 1940s², and the first female professor was appointed in 1991 (Association of Professional Engineers of Saskatchewan, 1993). The College of Engineering is the third largest college at the university with 10.3% of the total undergraduate student population, exceeded only by the Colleges of Arts and Science (45.9%) and Commerce (12.3%) (University Studies Group, 1999).

¹ Biotechnology recently received a boost when the National Research Council announced a major expansion to its Plant Biotechnology Institute on the university grounds (StarPhoenix, July 1, 2000).

² The university registration information did not become gender based until the 1960s. However, one woman graduated from Mechanical Engineering in 1946 (Association of Professional Engineers of Saskatchewan, 1993).

The College of Engineering is a direct entry college, although there is an admission quota at the first-year level. Until 1993, the first-year enrollment limit for the college was 300; it was increased to 350 in 1994 and to 410 in 1995 (University Studies Group, 1999). There are also upper-year enrollment limits for the seven speciality departments. The highest first-year enrollment occurred in 1997 with a total of 453. Of these, 22.7% (n=103) were women. The year 1995 had the highest proportion of women entering first-year engineering, when women constituted 24.4% (n=103) of the first-year enrollment of 422 students. This is an increase both in proportion and in real numbers from 1987, when 4.8% (n=16) of the 333 first-year students were women. In 1996/97 the total enrollment in the College of Engineering was 1156, of which 21% (n=242) were women. In the first-year enrollment of 397 students, 21% (n=83) of the students were women (College of Engineering, 1996; University Studies Group, 1989; 1994; 1999). The movement in female enrollment is displayed in Figure 4.1.

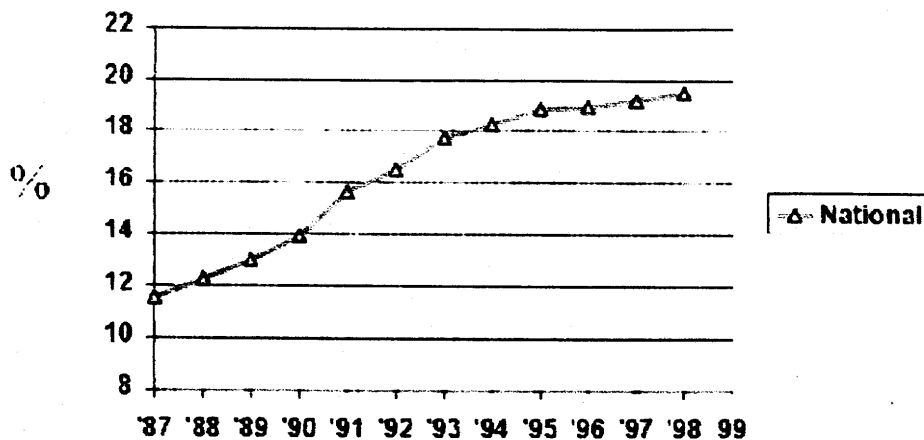
Figure 4.1. Proportion of Women Registered in the College of Engineering Total (Four Years) and in First-Year 1985-1999.



Sources: University Studies Group 1990, 1994, 1999. The 1999/2000 numbers are College of Engineering statistics.

At the U of S, first-year female enrollment peaked in 1995/96 at 24.4% (n=103) from a low of 4.8% (n=16) in 1987/88 and is now approximately 21%. Nationally, female enrollment has also been increasing steadily over the past two decades and has now stabilized at 20% to 21% from 10% in 1992, as illustrated by Figure 4.2 below.

Figure 4.2. Percentage of Women in Engineering Undergraduate Programs in Canada.



Source: Women in Science and Engineering, Prairie Chair/CCPE (Canadian Council of Professional Engineers) Report "Trends in Engineering Enrollment."
<http://www.geomatics.ucalgary.ca/cwse/Univers.html>.

Figures 4.1 and 4.2 show that until 1995, female enrollment at the U of S was on par with the national trend. At that time, female enrollment in Saskatchewan, including the University of Regina, was slightly higher than in the engineering colleges in Alberta and Manitoba (Chair for Women in Science and Engineering, 1999). However, national enrollment is still increasing, although not as rapidly as up to 1995. In other words, female enrollment has stabilized nationally, whereas it has stalled at the U of S, in fact, it has decreased slightly year by year. In comparison, Frehill (1997b) points out that the proportionate increase in female engineering students is slowing also in the United States. Moreover, she attributes the growth in the proportion of female engineering students to a declining interest in engineering among men.

One possible explanation for the increase in enrollment in the 1980s and 1990s is that government, industry and university strategies combined to encourage greater participation of women in engineering and science. The mandate of Monique Frize,

P.Eng., Ph.D., the first NSERC/Nortel Women in Engineering (WIE) Chair, was a strategy that spawned a number of recruitment initiatives at many universities. However, at the U of S, the Encouraging Enrollment in Engineering (EEE, or E-cubed) Committee was established in 1988 and predates the 1989 establishment of the WIE chair. Other initiatives followed in 1991 and 1993.

An event that had a profound effect on engineering colleges was the massacre of 14 women at L'École Polytechnique in Montreal, December 6, 1989. The thought that women could be murdered simply because they studied engineering was appalling, yet it caused the population to take notice of the gender imbalance in the profession. In order to encourage young men and women to consider careers in engineering and sciences, the federal government launched the Canada Scholarship Program, which awarded generous scholarships to outstanding students in these disciplines. The program ran from 1991 to 1995, awarding 50% of the scholarships to female and 50% to male students. All these events contributed to the present level of female enrollment in engineering colleges.

The main criterion for admission to the College of Engineering is high school grades. The attained averages for students accepted into the college are the second highest in the university (behind the College of Commerce) and tend to be higher for women than for men. For the 1996/97 cohort, the averages were 86.6% for women and 84.1% for men (University Studies Group, 1999). In my 1996 survey, 82% of the women (n=47) and 78% of the men (n=123) had admission grades of 81% or higher. Thus, both the women and the men entering engineering have the strong academic backgrounds necessary to succeed in the college. Yet, despite the high academic standing of students entering the college, first-year student withdrawal is high and varies widely from year to year as illustrated in Table 4.1.

Table 4.1. Student Attrition from Engineering 1994-1998

Attrition	1994/95		1995/96		1996/97		1997/98		1998/99	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
1st year Withdrawal	12.0	50	12.2	50	9.2	38	15.0	64	11.0	47
Total withdrawal (all 4 years)	5.3	61	5.7	68	4.4	50	6.1	75	5.5	69
1st yr. Required to Discontinue	17.9	75	15.9	65	13.7	57	21.5	92	17.2	68
Total Required to Discontinue	9.9	114	10.5	124	7.0	80	11.0	135	6.5	108
Total Student Loss %	15.2		16.2		11.4		17.1		12.0	

Source: University Studies Group, 1999. These statistics are not gendered. The year of my study is highlighted.

In 1996/97 the college had a first-year withdrawal rate of 9.2% plus a first-year “required to discontinue”³ rate of 13.7%. In total, the college that year lost 11.4% of its students to voluntary and required attrition during the academic year, yet that year showed the lowest rate of loss compared with the two preceding and the two following years in the five-year period represented in Table 4.1 (University Studies Group, 1999). Both the withdrawal and required to discontinue rates are considerably lower for the upper years. No gender division was available for these statistics, but I will attempt to arrive at a gendered rate of student loss in a future chapter on attrition.

SOCIO-DEMOGRAPHIC PROFILE OF FIRST-YEAR COHORT 1996/97

The data for this section derive from my survey of the 1996/97 first-year cohort (Appendix B). The survey yielded 220 usable responses where 58 students indicated they were female, 158 that they were male. Four students did not respond to the question on gender. Of the 220 respondents, 67.5% (n=146) indicated that they had entered the college directly from high school. Among these were 70.6% (n=41) of the women and 66.9% (n=105) of the men. Another 14% of the women and 10% of the men had been out of school for a year or more before starting their engineering education. In addition, 7% of the women and 3% of the men had some prior academic credit, 2% of the women and 10% of the men had transferred from another college or institution while 3.4% of the women and 4.5% of the men had spent time in

³ “Required to discontinue” occurs if a student has a sessional weighted average of less than 55%, or 5 or more failures within any sessional average. Students may re-register in the program after a minimum of one year, and if admitted, must repeat the year.

the work force. Table 4.2 illustrates the elapsed time since completion of high school.

Table 4.2. Time Elapsed Between High School and University Entry

Time	Total		Women		Men	
	%	(n)	%	(n)	%	(n)
Direct entry	66.4	146	70.6	41	66.9	105
One year or more out	10.9	24	13.8	8	10.1	16
Credits from other college.	4.1	9	6.9	4	3.2	5
Second try in engineering	2.7	6	3.4	2	2.5	4
Transfer from other college	7.3	16	1.7	1	9.6	15
Second degree	2.3	5	0.0	0	3.2	5
From work force	4.1	9	3.4	2	4.5	7
No response	2.3	5				
Total	100.1	220	99.8	58	100	157

First-Year Students' Ages and Marital Status

The students' ages (Table 4.3) corresponded with the time of entry after Grade 12. At the time of the survey, the students' ages ranged from 16 years to 31 years and older with the overwhelming majority between the ages of 17 and 20 years of age. Of the 213 students who responded to the question on marital status, 93.4% (n=199) were single. Of the remaining 6.6% (n=14), one woman and three men were married, two women and three men were cohabiting and two men were divorced (Table 4.4). Six of the students in the survey, two women and four men, had children, but only the two women had children living with them.

Table 4.3. First-Year Students' Ages

Age	Total		Women		Men	
	%	(n)	%	(n)	%	(n)
16 years	0.5	1			0.6	1
17 and 18 years	59.1	130	67.2	39	58.3	91
19 and 20 years	25.0	55	22.4	13	26.9	42
21 to 25 years	9.1	20	6.9	4	10.3	16
26 to 30 years	1.8	4	1.7	1	1.9	3
31 years and over	1.8	4	1.7	1	1.9	3
No response	2.7	6				
Total	100	220	99.9	58	99.9	156

Table 4.4. First-Year Students' Marital Status

Marital Status	Total		Women		Men	
	%	(n)	%	(n)	%	(n)
Single	89.2	196	93.0	53	93.5	143
Married	1.8	4	1.8	1	2.0	3
Cohabiting	2.3	5	3.5	2	2.0	3
Separated/Divorced	.9	2			1.3	2
Other	1.4	3	1.8	1	1.3	2
No response	5.5	12				
Total	101.1	220	100.1	57	100.1	153

First-Year Students' Residences

In the Saskatchewan 1996 census, 52% of the provincial population, not accounting for age group distribution, lived in the 13 cities in the province, 20% lived in rural municipalities and hamlets, and 27% in towns, villages and reserves⁴.

In the 1996/97 cohort of first-year students, 51.8% of the students had grown up in the cities. However a significant number of students, 34.5%, hailed from farms and rural villages. The remainder came from smaller towns, acreage and native reserves. The students divided quite evenly between urban and rural residential status, 52% versus 45% (Table 4.5).

Table 4.5. First-Year Students' Residence

Residence ⁵	Total		Female		Male	
	%	(n)	%	(n)	%	(n)
Cities	51.8	114	48.3	28	55.1	86
Farm, Rural Village	34.5	76	44.8	26	32.1	50
Town, Reserve, Other	10.9	24	6.9	4	12.8	20
No response	2.7	6				
Total	99.9	220	100	58	100	156

⁴ Because the survey took place in the 1996 census year, making the current census comparisons was an unexpected benefit for my study.

⁵ Using Statistics Canada definitions, there were 13 communities in Saskatchewan classified as cities in 1996. There is also a list of communities classified as towns. Urban areas have a minimum population of 1,000 and a population density of at least 400 per square kilometre. Rural areas are all sparsely populated lands lying outside urban areas. In my survey question (Appendix B, number 73), I listed samples of cities and towns.

Thus, the 1996/97 first-year cohort corresponds quite closely to the provincial population. While the female student population was evenly divided between rural and urban representation, the majority of the male students were urban. Proportionately more male than female students had grown up in cities.

First-Year Students' Ethnic Origins

The 1996 census recorded a total provincial aboriginal population of 11.4%, with the provincial aboriginal proportion of the age group for the students in this first-year engineering cohort as 14%. In contrast, only 2.8% of the total provincial population falls into the visible minority category⁶ (Statistics Canada, 1996). These two segments of the population, aboriginals and visible minorities, are populations of interest because of equity concerns. Table 4.6 shows the self-described ethno-cultural distribution of the students.

Table 4.6. Students' Self-Described Ethnic/Cultural Origin

Ethnicity	%	Total
Canadian	30.5	67
WASP, Caucasian, white	10.9	24
British Isles	14.5	32
French, French-Canadian	3.6	8
German	12.7	28
Ukrainian, Slavic	8.2	18
Scandinavian	6.8	15
Indigenous, Métis	2.7	6
Asian (Chinese 10, Japanese 1)	5.0	11
Asian (East Indian, other)	2.7	6
Philippine	1.4	3
African	0.5	1
Latin-American	0.5	1
Total	100.0	220

For their ethno-cultural origin, students self-identified on the response sheet and were coded *post hoc*.

⁶ The Employment Equity Act defines visible minorities as "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour. This includes Chinese, South Asian, Black, Arab/West Asian, Philippine, Southeast Asian, Latin American, Japanese, Korean and Pacific Islander" (Statistics Canada, 1996 census).

A recent report from the USA (Mendoza and Johnson, 2000) aimed at increasing the participation of women, minority populations and persons with disabilities in the fields of science, engineering and technology (SET). The report compared the distribution of these target populations within the general population with their distribution in SET fields and found that the general population in the USA was 36.7% white male, 37.9% white female, 0.8% aboriginal and 24.7% minority populations. However, the SET workforce was 67.9% white male, 15.4% white female, 0.3% American Indian and 16.4% minority. Thus, in the USA, the SET workforce is overwhelmingly male and white.

A similar distribution appeared in my study, where only 3% (n=6) students in the sample self-identified as indigenous, including Métis. Compared to the proportion of indigenous people in the province (11.4%), it would then appear that indigenous students are seriously under-represented in this engineering cohort. In contrast, while 10% (n=22) of the students in the survey can be considered visible minorities, this group may be over-represented in the 1996/97 first-year cohort in engineering in comparison with the provincial population of minority groups (2.8%). Of the remaining students (n=192), 30.5% (n=67) described themselves simply as "Canadian," (and some added "eh?") while 10.9% (n=24) self-identified as "WASP," "Caucasian" or "white." In addition, 46% (n=101) of the students indicated that their cultural roots were in the British Isles or other European countries. Thus, it appears that equity strategies are necessary for women and aboriginals, while not urgently needed for minorities.

First-Year Students' Parents' Education and Occupation

The educational attainment of Saskatchewan's population over 15 years of age lags behind the national average according to the 1996 census. While the national average for persons with no degree or diploma is 37%, Saskatchewan registered 45% in this category. Nationally, 23% had graduated from high school, but only 19% provincially. However, Saskatchewan Education statistics (1996:12) indicate that this trend may be changing. Of all the students registered in grade 12 during the years between 1980 and 1992, 77.5% had graduated after a period of five years. Moreover, Saskatchewan and the Atlantic provinces are the only provinces where women have, on average, more education than men. In 1996 in

Saskatchewan, the average years of schooling was 11.9 years for women and 11.8 years for men 15 years and older (Saskatchewan Women's Secretariat, 2001). In general, women are more likely than men to complete secondary schooling and are now in a majority in university programs, yet little is known about the lagging participation of women in engineering. The problem exists in Canada as well as in most other countries (Finnie, Lavoie and Rivard, 2001).

While the national average for university education is 11%, the provincial average is 9%; the average at the Master's and Ph.D. level is 2.7% nationally and 1.4% in Saskatchewan. Overall, the statistics show that Saskatchewan's population has less formal education than the national average (Statistics Canada, 1996). The levels of formal education decline with age, from approximately 50% of the 25-34 year olds to just 20% of adults over 65 years. Women and men over the age of 65 years are less likely to have post-secondary education, while women between the ages of 25 and 54 years are more likely than men to have university degrees (Saskatchewan Women's Secretariat, 2001). Between 1976 and 1996, the percentage of adults with some post-secondary education increased from 28% to 46% for women and from 25% and 40% for men (Saskatchewan Women's Secretariat, 2001). Table 4.7 and Table 4.8 show the educational level of the first-year engineering students' parents. The data indicate that the parents of this cohort had considerably higher education than the national and provincial averages.

Table 4.7. Students' Mothers' Education (Total, Female Students' and Male Students')

Educational Level	Total		Female		Male	
	%	(n)	%	(n)	%	(n)
Less than Grade 12	9.5	21	10.3	6	9.6	15
Completed grade 12	21.8	48	19.0	11	23.6	37
Some Career, Vocational, Trade School	10.9	24	10.3	6	11.5	18
Career, Vocational, Trade School Certificate	14.1	31	12.1	7	15.3	24
Some University	7.3	16	12.1	7	5.7	9
University Graduate	28.1	62	31.0	18	28.0	44
University Post-graduate degree	2.7	6	1.7	1	3.2	5
Don't know	3.2	7	3.4	2	3.2	5
No response	2.3	5				
Total	99.9	220	99.9	58	100.1	157

For the above table, answers were written in the identification section of the response sheet and coded *post hoc*.

Table 4.8. Students' Fathers' Education (Total, Female Students' and Male Students')

Educational Level	Total		Female		Male	
	%	(n)	%	(n)	%	(n)
Less than Grade 12	14.1	31	19.0	11	13.4	20
Completed Grade 12	13.2	29	5.2	3	17.4	26
Some Career, Vocational, Trade School	10.5	23	15.5	9	9.4	14
Career, Vocational, Trade School Certificate	15.0	33	16.5	9	16.1	24
Some University	5.9	13	5.2	3	6.7	10
University Graduate	20.9	46	24.1	14	21.5	32
University Post-Graduate Degree	9.5	21	8.6	5	10.7	16
Don't Know	5.0	11	6.9	4	4.7	7
No response	5.9	13				
Total	100	220	101	58	99.9	149

For the above table, answers were written in the identification section of the response sheet and coded *post hoc*.

For the 1996/97 first-year cohort of engineering students, the students' mothers had higher levels of basic formal education than the fathers; 14.1% of the fathers had less than grade 12 schooling, compared to 9.5% of the mothers, which confirms the Women's Secretariat's statistics (2001). The number of fathers with less than grade 12 education, I believe, is not uncommon for rural areas, where in the past, many boys tended to complete only the minimum of schooling required at the time, often in order to help their fathers with the farm. In the past, higher education was not critical to success as a farmer. Only during the last few decades has it become customary for most adolescents to complete at least the basic 12 years of schooling in order to qualify for the labour market and to seek education beyond high school. In the past, girls in rural areas would be more likely to complete high school and take further education, e.g., hairdressing, secretarial, nursing or teacher training. At the highest level of education there were also differences between mothers and fathers: 35% of the mothers and 27% of the fathers had some university education with 28% of mothers and 21% of the fathers having university degrees. In my sample, 3% of the mothers and 10% of the fathers had degrees beyond the Bachelor's level. According to the 1996 census, these levels are well above both the national and provincial averages. The remainder of the parents had various levels of education, from completion of grade 12, through career or trade certificates to some university experience. Women now constitute the majority of university undergraduates

(Finnie et al., 2001), particularly women under 55 years of age, and women younger than 45 years are more likely to have degrees compared to men of the same age (Women's Secretariat, 2001)

There is an interesting comparison of my survey results with a study of engineering students at the University of Calgary (U of C). This study (Wallace, Haines and Cannon, 1999) found that 55% of engineering students' mothers and 54% of the fathers had university degrees. Although that is more than the 31% of mothers and 30% of fathers with university degrees as reported by the U of S engineering student cohort, the parental educational pattern at the U of C is fairly parallel to the pattern at the U of S.

The students' parents' occupations are shown in Table 4.9 and 4.10.

Table 4.9. Students' Mothers' Occupations (Total, Female Students' and Male Students')

Occupation	Total		Female		Male	
	%	(n)	%	(n)	%	(n)
Professional, not Teacher	12.7	28	16.1	9	12.1	19
Teacher	13.2	29	14.3	8	13.3	21
Nurse	10.0	22	5.4	3	12.1	19
Sales	5.9	13	3.6	2	7.0	11
Clerical	9.5	21	8.9	5	10.2	16
Homemaker	18.2	40	12.5	7	21.0	33
Farmer	2.7	6	5.4	3	1.9	3
Service Worker	10.0	22	17.9	10	7.6	12
Self-employed	4.1	9	5.4	3	3.8	6
Other	10.5	23	10.7	6	10.8	17
No response	3.2	7				
Total	100	220	100.2	56	99.8	157

For the above table, answers were written in the identification section of the response sheet and coded *post hoc*.

Table 4.10. Students' Fathers' Occupations

Occupation	Total		Female		Male	
	%	(n)	%	(n)	%	(n)
Professional, not Teacher	18.6	41	17.2	10	20.1	31
Teacher	7.7	17	6.9	4	8.4	13
Manager, Administrator	7.7	17	5.2	3	9.1	14
Sales	1.8	4	1.7	1	1.9	3
Clerical	2.3	5	5.2	3	1.3	2
Craftsman, Mechanic, Technician	19.5	43	20.7	12	20.1	31
Farmer	20.9	46	20.7	12	22.1	34
Service Worker	2.3	5	1.7	1	2.6	4
Self-employed	9.1	20	15.5	9	7.1	11
Other	6.4	14	5.2	3	7.1	11
No response	3.6	8				
Total	99.9	220	100.0	58	99.8	154

For the above table, answers were written in the identification section of the response sheet and coded *post hoc*.

Despite the level of parental university level education, it appeared that the U of S students' families were fairly traditional with a farming or wage-earning father and a mother as either homemaker or employed in sex-stereotypical female occupations such as nursing and teaching. Occupationally, in addition to the 18% of the women who were homemakers, a large number of the mothers had traditionally 'female' occupations, such as teacher, nurse, clerk and service worker (43%) and miscellaneous other occupations.⁷ The largest numbers of fathers were farmers (21%). In addition, it would appear that the 19% of the fathers who were mechanics or technicians could, conceivably, be supporting the farming industry in their occupations. Moreover, some of the managers and self-employed fathers might be involved in agriculturally related business, e.g., in farm implement sales and in professions such as accounting and teaching (Table 4.9 and Table 4.10).

Ten per cent of the fathers and 4% of the mothers were self-employed. Although there were more mothers than fathers in the teaching profession, there were more fathers than mothers in other professions. Seven per cent (n=16) of the male students in the survey stated

⁷ Six students classified their mothers as *farmers*, not *farm wife*, and one male student was amused when he during an interview told me that his mother's title at the telephone company was "toll-equipment-man."

their father's occupation as "engineer," but no female student had a parent who was an engineer, and no mother was classified as engineer. However, 5% of the female and 17% of the male students indicated that there were engineers in the extended, if not in the nuclear family.

When comparing the U of S with the U of C study (Wallace et al., 1999), we find that at the U of C, 3% of the female and 1% of the male engineering students there had a mother in engineering while 34% female and 25% male students had a father in the profession. Overall, 51% of the students had a parent or relative in engineering. Wallace et al. state that this high percentage can be expected in Calgary where there is a high concentration of engineers due to the large number of petroleum companies with headquarters in the city.

MOTIVATING FACTORS FOR CHOOSING ENGINEERING

Many factors influence young people's choices of careers. Table 4.11 below shows the first-year students' responses to the survey questions that investigated reasons why they had

Table 4.11. Students' Motivations for Entering Engineering

Motivation	Total		Female		Male	
	%	(n=220)	%	(n=58)	%	(n=158)
I was good in mathematics and sciences.	89.5	197	94.8	55	89.9	142
I like problem solving	81.8	180	89.7	52	81.0	128
Engineering opens opportunities.	87.3	192	87.9	51	89.2	141
Engineering is a well-paid profession.	74.5	164	79.3	46	74.7	118
I like to design and build things.	81.1	180	53.4	31	94.3	149
I like to invent or make things.	71.9	158	46.5	27	82.9	131
I like to take things apart and put them back together	62.3	137	43.1	25	70.9	112
I like to work with machinery.	60.0	132	36.2	21	70.3	111
I was inspired by women's accomplishments in science and technology (e.g. Roberta Bondar).	11.8	26	36.2	21	3.2	5
I was inspired by general progress and accomplishments in science and tech.	42.3	93	31.0	18	47.5	75
I needed a career change.	16.8	37	20.7	12	15.8	25
I enjoyed Science/Engineering Camp	5.0	11	3.4	2	5.6	9
Not Applicable	81.8	180	89.7	52	81.0	128
I grew up in an engineering family	13.1	29	5.2	3	16.5	26

'Agree' and 'Strongly Agree' responses to several Likert Scale questions.

chosen engineering as a career. The responses were given on a five point Likert scale ranging from “strongly agree” to “strongly disagree.” Other factors may also be important; at the U of C, for example, family background has been found to be a relevant factor influencing students’ decision to study engineering (Wallace et al., 1999:5).

As the table illustrates, there are several factors that motivate young people to choose a career in engineering, some of which are results of gender role socialization (Frehill, 1997b). I will discuss the motivations that appeared the most and the least important to the students. The survey showed that high school proficiency in mathematics and sciences was a primary motivation in choosing engineering for both the female (95%, n=55) and the male (90%, n=142) first-year students, closely followed by a desire to solve problems and the opportunities that engineering opens up. Of least importance was attending science camps (3% for women and 6% for men). By marking the question in the ‘not applicable’ column, 90% (n=52) of the women and 81% (n=128) of the men indicated that they had not attended any science camps.

The responses to mechanical and technical interests showed a marked gender difference: between 70% and 94% of the male students had chosen engineering because of an interest in inventing, designing, building and working with machinery while only between 36% and 53% of the female students had such inclinations. Although Daniels (1988) believed that a ‘thing’ orientation for men in engineering was a misconception, it appears to have had an influence on the young men who enrolled in engineering education at the U of S in 1996. In contrast, Wallace et al. (1999) reported that female engineering students, instead, focused on using their engineering education for contributing to society. There was also a gender difference in the perception of women’s accomplishments in science and technology. While 36% (n=21) of the women were inspired by women scientists like Canadian astronaut Roberta Bondar, only 3% (n=5) of the men were inspired by women scientists. In fact, during the survey administration, some of the men asked out loud “who is Roberta Bondar?”

This section has examined some of the reason why women and men decide to enter the study of engineering. However, Finnie et al. (2001) state that we still know little about why women are reluctant to enter the profession. Based on their study of female engineers in the labour market, they found that the increase in numbers of women in engineering was not due to a female shift toward the profession but rather a greater number of female university graduates

in general. In the next sections, I will blend results of the survey of the first-year cohort with statements the students gave during interviews. Because graduating students and transfer students reflected on their entire education, I have also included these students' interview responses.

The Importance of Mathematics and Science Skills

According to the deficit model of education, women do not study enough mathematics and science in high school and therefore will have difficulty in engineering. Research by Eccles has suggested that girls lose interest in mathematics and science around the age of 12 to 16 years when these subjects begin to conflict with the adolescents' social and role expectations (Cannon and Lupart, 2001). However, science and mathematics are pre-requisites for entering engineering schools, and students without credit in these courses cannot be accepted, and most likely do not even apply. On the other hand, as time passes, girls become comfortable with computers at an increasingly earlier stage of their schooling (Cannon and Lupart, 2001), which could be important to keeping up the interest in mathematics. Because mathematics is the language of engineering, and superior skills in mathematics and science therefore are essential to success, Hacker (1990) saw mathematics as a gatekeeper subject to the engineering profession, as the lack of mathematics and science skills could prevent women from studying engineering. Other studies have found that women who have these superior skills seldom acquire them because they plan to study engineering. Rather, women "drift" into engineering after roughly two years of university studies when they learn that these skills are required in engineering (Carter and Kirkup, 1990; McIlwee and Robinson, 1992). Mathematics and science proficiency was the most important motivation for the women in my study (95%), but the men (90%) also gave that as a primary reason for choosing engineering. Thus, the students' responses to my survey confirmed the literature that women were attracted to engineering because they had good high school marks, especially in mathematics and sciences.

Although mathematics and science grades were important for both women and men in my survey, proportionately more of the women gave this as a reason. Later during the interviews, 46% (n=12) of the 26 women, but only 16% (n=3) of the 19 men in my interview samples indicated that they thought engineering would be a suitable field of study because they

had good grades and a solid understanding of mathematics and sciences. Furthermore, during the interviews the women repeatedly expressed pride in their mathematics and science skills, while the men appeared to take these skills for granted and did not make a point of mentioning them. In addition, 90% of the women and 82% of the men in the survey stated that they enjoyed problem solving, an important skill in engineering which calls itself “the profession of problem solving” according to a pamphlet for the College’s EEE Committee.

As previously stated, unlike in most other provinces, Saskatchewan high school girls are on par with boys in both participation and achievement in grade 12 mathematics and science courses. A study by the Saskatchewan Department of Education (1988) indicated that grade 12 girls had on average as high or higher marks than grade 12 boys in mathematics and all sciences except physics. Follow-up studies showed that girls were as competent as boys in mathematics and sciences, subjects that are crucial to success in engineering (Saskatchewan Education, 1995; 1996). These studies also found that girls made up more than 50% of all classes except calculus and core physics in all schools, biology in rural schools, and physics and geometry-trigonometry in urban schools, although their lowest participation in any class was 44.1%. Provincial average grades in all science and mathematics courses ranged from 62.7% to 78.7% for girls and 62.1% to 77.2% for boys. Whereas the grade 12 girls’ average grade was lower than boys’ in physics in 1986/87, their averages were slightly higher than the boys’ in 1993/94 and 1994/95. Thus, for the female engineering students at the U of S, this aspect of the deficit model of women’s education is not confirmed as an explanation for lower participation.

Although only five per cent of the women and 16% of the male students had grown up in engineering families, they were all career oriented and wanted to reap the rewards of a well-paid profession. One difference between the female and male students appeared to be that the women wanted to use their mathematics and science skills to solve problems while the men had “tinkering” experience and wanted to “make things.” Later, during the interviews, the female students stated that they believed they could make the world a better place by being role models for other women or to improve the way society treats our environment through their choice of specialization.

The “Tinkering” Connection

Studies have found that while women chose engineering because of their mathematics and science proficiency, male students often chose engineering because they had an interest in working on machines and gadgets, having acquired what was called “tinkering skills,” while very few women engineers had such “tinkering” interests or skills (Carter and Kirkup, 1990; McIlwee and Robinson, 1992).

The responses to my survey indicated that “tinkering skills” was one difference between the female and male students’ choice of engineering as a career. Between 70% and 95% of the male students did, indeed, enjoy designing, building, making as well as dismantling and reassembling “things” and working with machinery, while only between 36% and 54% of the women indicated interest in these activities. During the interviews, only two women told me they liked to “tinker” with machinery, but then, opportunities were limited. One graduating woman added that only after her two older brothers had left the farm home, and she was the only farmhand left, did she get her chance to assist with machinery repairs. A first-year student had spent her childhood making her own toys from sticks and stones and other natural, no-cost materials, and that experience had twiggged her interest in engineering. At the time of the interview, she was considering specializing in toy-design. The benefit of giving building blocks and erector sets as gifts to boys became obvious when one man traced his interest in engineering to a childhood set of Lego blocks.

Because a large number of students in my sample came from a farming background, their experiences of hands-on work with equipment on the family farms may have contributed to their interest in engineering, at least for the men. As mentioned earlier, in the past, male students in rural areas often left high school to work on the family farm where they gained that all-important “tinkering” experience. It is likely that boys, more often than girls, are still encouraged to join their fathers in “tinkering.”⁸ In my study, students with a farming background had often taken an active part in farming operations and some expected their engineering skills to be a benefit on the farm. For example, one man’s motivation for becoming

⁸ Through my own experience as a farm wife I am quite aware of the multitude of “engineering” and “manufacturing” tasks farmers used to perform, such as repairing or making their own replacement parts from materials available in their workshops.

an engineer was to gain knowledge in electronics and to be able to identify and correct problems that could hamper the success of the family farming enterprise. He explained that

I may never practice engineering. I have an opportunity to be part of a very profitable family farming operation. . . . With my background, I will definitely know about the technology that goes into modern farming equipment. There is lots of electronic monitoring equipment and that keeps increasing (Dave, 4th year).

Farm machinery has been equipped with and controlled by so many electronic components that farmers have realized they need expert help with their problems. Dave believed that his engineering education would give him that expertise, thus benefit his family's farm operation.

Employment Opportunities

The increased use of electronics in farming is one of the many opportunities available in engineering, with technology becoming pervasive in almost any aspect of life and work. Where proportionately a few more women than men in my survey had chosen engineering because of their scholastic aptitude, and proportionately more women than men enjoyed problem solving, the gender difference disappeared in the responses to the statement "engineering opens up many opportunities;" 88% of the women (n=51) and 89% of the men (n=141) perceived this statement as a benefit, while 79% women (n=46) and 74% men (n=118) chose engineering because it was a well-paid profession.

The students I interviewed believed that engineering was offering opportunities beyond the traditional. One woman, in particular, stated that "there are so many opportunities in engineering, you don't have to only design and build things" (Nicole, 4th year). One woman and one man had education degrees and had taught high school mathematics and science. For the woman, engineering had been a coping strategy:

I was teaching mathematics and sciences, but after three years, I felt my brain was shutting down from doing only routine things. I would like to combine engineering and education by teaching at a technical level. I am not divorcing myself from education; I just want to incorporate more technical areas into it (Marie, 4th year).

I have an education degree and I taught for two years. Then I remembered that I had actually always wanted to be an engineer. I wanted to come back and learn more about science and the world, and engineering was the field that gives me that opportunity. I almost have a degree in chemistry, and lots of biology classes. I want to learn more for myself just about the interaction of things in physics (Bob, 1st year).

In addition, another woman, who had left engineering and was working on a degree in education, wanted to use her knowledge of engineering as a guide/interpreter at science fairs and exhibitions.

Employment opportunities in engineering may be opening up for women in particular. Since 1978, the work force has increased one and a half times for engineers, scientists and technologists in general. For women, the proportional growth in this category is three and a half times (Carter and Kirkup, 1990). One woman commented on employability for women in engineering by saying that "right now, we are favored in the workplace" (Betty, 4th year). Inch and Frize (1991:4) cite a female engineer's report of a visit to an electronics plant. At the end of the tour a company official, an older man, indicated that the firm was looking for "people with social skills, people who could interact well with others, people who one day would make good managers." Turning to the only woman in the group, he said: "You may be pleased to find out that most of the women we interview are better at these social skills than men are. So don't feel too bad, dear, if they beat you at mathematics because you're heads above them in social skills." To which the woman confidently quipped "I can beat them in mathematics, too." Although this particular company was recruiting "bright, young, innovative minds . . . with creative solutions to problems," they had realized that social skills were equally important. However, the patronizing "dear" in the official's comment is an indication of how some engineers of 'the old school' still view women in the profession.

Some of the women I interviewed believed they could make their marks in engineering with their better social skills. A few women suggested that they were better communicators than their male counterparts and, consequently, would be better able to promote and explain engineering concepts to the uninitiated. Moreover, the women knew that if they wanted to be information consultants to engineering firms, they had to have engineering education, expertise and experience. According to Inch and Frize's story above, some industry leaders have taken note that communication and social skills were as important as technical expertise. These skills then, open opportunities for women in engineering.

In addition to communication skills, women have interests and concerns for social and environmental issues. According to Frehill (1997b), women pay less attention to the monetary rewards and are more likely than men to select jobs with social meaning. Some examples are

women's campaign against nuclear weapons and against certain reproductive technologies, as well as a comment on why women protest: "They [women] may very well be consciously refusing a course of action which seems to them likely to waste their energies" (Carter and Kirkup, 1990:141 citing Cockburn, 1984). During her interview, one woman had numerous environmental interests, which she suggested could open a variety of employment opportunities within her particular engineering training:

I'm interested in biological systems, working with living things and making the environment more comfortable for living beings like plants and animals. I am interested in wastewater treatment and clean air and helping people living their lives to the fullest, things that directly relate to people's health. I know a lot of women who really like the fact that you get to work with living things. I know of a few studies that indicated that women are known to associate with other people and other living things more than just computers and gears and things like that. They relate to other living beings. My roommate is in her third year of electrical engineering and she wants to get into the entertainment section of electrical, not specifically working on computers, but working with music and things like that. I think it is typical for women to look for ways where they can touch people directly (Nicole, 4th year).

As the above statements and examples demonstrate, engineering does indeed offer a wide range of opportunities within employment where the individuals may integrate their particular outside interests. These statements also confirm the findings from the U of C, which indicated that "[f]emale students place more importance on having a job where they can contribute to society, using their engineering skills and working with people rather than things, and male students place more importance on receiving good pay in their future job" (Wallace et al., 1999). This attitude starts early for female students, as Cannon and Lupart (2001) found in their study of grade 7 and grade 10 students.

The Impact of Role Models and Encouragement

Role Models

Role models are individuals who encourage emulation through their actions, behaviours and example (Carter and Kirkup, 1990; Geppert, 1995; McIlwee and Robinson, 1992). Role models may be considered at several levels, from generally encouraging achievement in education or training, through promoting the field or profession in which they work, to actively encouraging others to follow in their footsteps and mentoring interested

individuals. High school mathematics and science teachers have been known to be role models for students who want to study science or engineering, especially if such a teacher is an engineer (Inch and Frize, 1991). Other women, especially mothers, are important as role models for women, and the mothers' level of education can pique young girls' interest in attaining higher education (Kahle, 1986). The influence of a practising engineer is crucial, especially in families where the father is an engineer and can be both a model and a source of practical information to his children (Carter and Kirkup, 1990). In their study of American and British female engineers, Carter and Kirkup found that for one in three and one in seven, respectively, the father was an engineer. They also found that professional families were more likely to encourage their daughters to enter non-traditional fields of study. Carter and Kirkup believe that the visibility of female engineers is key to establishing a critical mass, which in turn will influence other women to become engineers. The importance of female role models for female university students became evident for me when a professor in a professional college told me about some of her students who admitted to her that they were still in that college because she and other female faculty members had been role models for them. As Figure 6.1 in the introduction to Chapter Six shows, there are no such role models in the College of Engineering.

Except for the statement about women's accomplishments in science and technology, the importance of role models was not included in the series of statements for choosing engineering in my survey of first-year engineering students. However, my survey data indicated that 14% ($n=30$), among the 220 participating students had grown up with engineers in the family. In addition, 53% of the students ($n=116$) stated that there were engineers in their extended families or their circle of friends, but only 9% knew any female engineers. Twenty-nine per cent ($n=64$) then indicated that these role models had encouraged them to pursue a career in engineering.

During the interviews, when we discussed the importance of knowing engineers, both female and male students told me they had engineering role models such as cousins, other relatives, acquaintances or boy friends, who had been able to either advise or encourage them. One graduating woman explained in her interview that she had found her niche when she met engineering students while living in residence during another pre-professional program. On the

other hand, in the case of three female and four male students, engineers had discouraged them from pursuing a career in engineering.

In my survey, 7% (n=16) gave their fathers' occupation as 'engineer,' and during the interviews it became clear that several others had fathers who were employed in technological occupations. This is a low rate compared to the U of C study where over half of the students had such connections (Wallace et al., 1999).

In universities, both female and male engineering professors who can project proper, non-sexist behaviour are much-needed role models for female and male students alike. However, because less than 4% of registered engineers in Canada in 1991 were women, there is a dearth of female engineers and engineering professors to serve as role models (Inch and Frize, 1991). This shortage of female role models in engineering may be a deterrent to young women who may consider a career in the profession (Kahle, 1986). In addition to female professors and scientists being a small minority in universities, they are often not very powerful. As well, they tend to be unmarried or divorced without children and do not project as models for combining science or engineering with family (Hicks, 1991). At the time of the study, there were only two female engineering professors at the U of S, neither of whom taught first-year classes that year.⁹ While there were no female role models visible among the first-year faculty, some of the students thought of themselves as trailblazers and role models for others, despite being labelled as "crazy."

People think I am crazy to be in engineering. When I say my favorite subjects are mathematics and science, they still think I am crazy. But I can do something for the world; I can do something and be noticed. Being female helps a lot. I am also half [visible minority], although nobody can really tell. But as a visible minority in engineering, I think I can promote the profession to other young women and be a role model (Lei, 1st year).

A graduating student, who had an education degree and had taught high school mathematics, saw the low number of women as a deterrent:

I have also been asked if I would like to become a professor, but that is a pretty big step (even with an education degree). The role model of a female professor in any subject, but particularly in engineering, is quite noticeable (Marie, 4th year).

⁹ During the interviews, even graduating students did not know that there were two female professors in the college. Both have since left the college.

Role models, then, are important for young people's career selection, and parents and friends are the most important sources. Moreover, when some students become trailblazers, they realize that they themselves become role models for others.

Encouragement and Attitudes

Mothers are important role models, particularly for women, as previously noted, but family attitudes in general are important elements of encouragement. The importance of family members cannot be under-estimated, and parents play a crucial role (Inch and Frize, 1991).¹⁰ The early socialization process starts in the home, and parental attitudes toward women's contributions to any profession or vocation is essential (Carter and Kirkup, 1990; Geppert, 1995; McIlwee and Robinson, 1992, Wallace et al., 1999). In my survey, the parents of 57% (n=33) of the women and 62% (n=98) of the men had encouraged their children to enroll in engineering, either individually or jointly. On the other hand, 14% (n=8) of the women and 22% (n=33) of the men had no encouragement from any source.

Carter and Kirkup (1990) found that professional parents often encourage daughters to seek non-traditional occupations. In the case of one graduating student, both parents had post-secondary education but had steered their daughter away from their own occupations:

My father has a Master's degree in social work, and he is currently the director of [agency], and my mother has a Bachelor of Education and teaches French immersion. Both my parents told me that if I went into either education or social work they would disown me! They said they wanted me to go into the sciences, and luckily I was interested in the sciences and I was good at it (Nicole, 4th-year).

In this case, social work and education are professions that are considered more traditionally female occupations, and they encouraged their daughter to enter a non-traditional profession. According to the first-year students' survey responses, teachers and school counsellors had almost no influence on their career choices. Only two women and three men named their

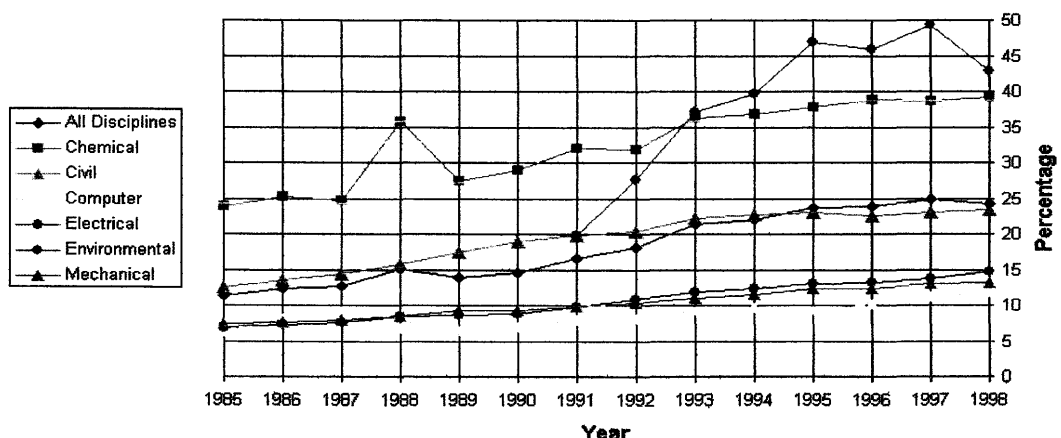
¹⁰ The College of Engineering has record of a Saskatchewan farm family who saw seven of their nine children, including one of two daughters, graduate from the College of Engineering. When the youngest child graduated, the parents received a plaque. As well, during my M.A. research I interviewed a female engineering student who had known her career path since childhood by being close to her engineer father (Anderson, 1994).

teachers as a source of encouragement, while teachers had discouraged two women and two men. On the other hand, some counsellors had realized that being female could be an advantage in engineering. Two women had been encouraged into engineering by teachers or guidance counsellors, not because the counsellors believed they would enjoy engineering but because there were few women in the profession. One woman stated in her interview that in addition to encouragement from her two brothers, both engineers, a teacher had told her “as a girl in engineering, you’ve got it made” (Betty, 4th year). Another woman had also been encouraged into engineering because she was female; however, she eventually left the program because it did not appeal to her.

THE CHOICE OF ENGINEERING SPECIALIZATION

One of my initial research questions was to find if there was a difference in the choice of engineering specialization between female and male students. The U of C study (Wallace et al., 1999) as well as Cannon and Lupart (2001) found significant gender difference in choice of specialization. The female students at all levels were more interested than their male counterparts in making the world a better place. Not only in Saskatchewan, but consistently throughout Canada, environmental issues are reported to be of greater concern and interest to female engineering students, and they seek out the departments at each university whose focus is environmentally based. Figure 4.3 illustrates this national distribution of female engineering students within the various disciplines.

Figure 4.3. Canadian Program Choices for Female Engineering Students



Source: Women in Science and Engineering (CWSE) Ontario Chair.
<http://www.carleton.ca/cwse-on/enrolment1.gif>

A study by the Canadian Council of Professional Engineers reported in 1996 that female participation was more than 45% in environmental engineering and between 35% and 40% in civil and chemical engineering, whereas female participation in mechanical and computer engineering was below 15% (CWSE, Calgary, 1999). Moreover, Wallace et al. (1999), in their study at the U of C, found that female students showed a higher environmental concern than the men (statistically significant at $p < .05$), and that female and male students differed in how they believed their career choices would affect the environment. Frize (n.d.:4) states that:

Courses that emphasize the beneficial applications of technology and engineering will increase the appeal of engineering programs to women. Examples include solving environmental problems, inventing tools and equipment for the disabled, . . . safe highways and . . . user-friendly technologies for use in health care institutions and for home-care programs. . . . the best solutions are based on a blend of technological, political and societal values.

At the U of S, all first-year students take the same courses, and specialization starts in year two. My survey, in the first term of the first year, was not likely to yield definitive answers to the question of specialization, as only two departments had presented their programs and opportunities to the new students at that time. Therefore, it was not surprising that 35% (n=20) of the women and 27% (n=42) of the men were undecided as to specialization. Even by the time of the interviews two to three months later, the students were undecided.¹¹ Moreover, they wanted to wait as long as possible, until the end of the first year, to make their choices. The students had just completed their first semester in the college, and some were faced with setbacks by either failing (and needing to repeat) a course or needing to rewrite an examination. Of those who indicated a preference, the women tended toward the departments of Chemical (13%, n=8) and Agricultural and Bioresource Engineering (12%, n=7) as well as combined programs (10%, n=6); the men were more likely to choose Mechanical (18%, n=28) or Electrical Engineering (12%, n=18) and combined programs (13%, n=21).¹²

Both at the U of S and the U of C the students chose specialties that would affect their

¹¹ The departments were then in the process of presenting and promoting their programs to the new cohort, and many students told me they needed to see all the presentations before making their decisions.

¹² Most departments have course schedules and strategies that allow students to combine their engineering programs with a B.Sc. in Computer Science in a five-year program.

employment or career interests and goals. Other than finding a department where the courses and employment opportunities were of particular interest to them, the students did not indicate how or why they had chosen their departments. This strategy concurs with Wallace et al.'s (1999) findings in the U of C study that individual interest in the subject and personal skills and strengths were the overwhelming reasons for specialization. Seventy percent of both female and male students at the U of C gave interest in the subject as their major influence, while 51% of women and 54% of men gave skills and strengths as their reason.

When I interviewed the fourth-year students, they had studied their specialties for three or more years and were specific about their individual choices. In choosing an engineering specialization, many students arrived at their decision by eliminating the subjects they did not want to study (or did not like), and trying to fit their favourite subjects into a department. Anne (4th year) summed up her choice as "I really hated electrical, I didn't like chemistry, and civil was 'for dummies.' Mechanical seemed to be just the type of classes I enjoyed." A frequent response was that mechanical engineering was fairly general and might provide a wider field of opportunities. One woman wanted to work with her hands and had originally considered becoming an auto mechanic, which "would be fun, because so many women get screwed around at mechanics places" (Amber, 1st year). Although, as illustrated in Figure 4.3, Mechanical Engineering is not considered a favourite for women, five of the eleven fourth-year students in my sample had chosen the department of Mechanical Engineering, among them a woman whose dream was to design roller-coasters.

A total of six graduating male students had elected electrical engineering. Three of them had combined their engineering degree with a degree in computer science, one because he "used to like to play with radios and stuff." One man had spent two years in mechanical engineering at another university before settling in electrical, and another male student had selected electrical engineering because of his interest in computer controlled farm machinery. A woman who was graduating with a degree in civil engineering had chosen that department because the geo-technical aspect of the discipline would give her "awesome opportunity to go into an environmental graduate program" at a later date, while another woman, who professed a preference for "living things" and was bent on saving the environment, believed bioresource engineering had been a good choice. One woman, who admitted to being a tomboy, was

considering geological engineering because she enjoyed working outdoors rather than at a desk. Alternatively, her interest in aviation might lead her to mechanical engineering. One of the first-year students had returned to his education in engineering because of an interest in biomedical research, for which the biology element of his education degree gave him a good foundation. With a degree in engineering, he would also have an opportunity within the clinical aspect of Biomedical Engineering. However, other considerations than individual interests also influenced the students' choices. One first-year woman, for example, was hyper-sensitive to chemical compounds and thought electrical or electronic engineering, with a focus on the computer industry, would be the least hazardous to her health.

A common element in these students' statements was that engineering allowed them to incorporate engineering into their personal interests and vice versa. The fourth-year students, who were close to completing their engineering education, saw the advantage of combining their other skills and interests with their engineering degree. Two students perceived that their previous commerce degrees would greatly enhance their employability, and a woman working on a combined engineering and science degree realized how much the science aspect of her education had added to her employability. Moreover, those students who had education degrees, and even a student who had transferred to education, believed that such a combination would be beneficial to their careers, whether in engineering or in education.

My survey of the first-year students indicated that 60% (n=35) of the women and 32% (n=50) of the men were undecided about their future and of employment options after graduation. They had already pre-selected engineering as their major field, but were looking for their own niche within the profession. However, 12% (n=7) of the women and 22% (n=34) of the men thought private industry, such as manufacturing, might be an option. Another 12% (n=7) of the women and 12% (n=19) of the men appeared to favour the oil industry. But as with the choice of specialization, the thought of life after university was too far into the future for the first-year students to have given it in-depth consideration. By the time the fourth-year students approached graduation, they were much clearer about their future than the first-year cohort. By then they had some work experiences from summer employment and were applying and being interviewed for positions after graduation. They had completed their programs and were beginning to think and feel like engineers rather than engineering

students. They had become socialized into their profession and their particular chosen fields.

Although I completed my research in 1997, the latest data supplied by the College of Engineering indicate that the present preferences of the upper-year students are consistent with other studies. The students in my first-year cohort would be in the 1999/2000 graduating class if they had followed the four-year program. Table 4.12 shows the total numbers of male and female students and the proportion of women in each year of registration.

Table 4.12. Total Engineering Student Registration 1998 and 1999

	1998/1999				1999/2000			
	Total	Male	Female	% Female	Total	Male	Female	% Female
Total year 1	448	353	95	21.2	442	349	93	21.0
Total year 2	284	213	71	25.0	273	209	64	23.4
Total year 3	301	238	63	20.9	313	243	70	22.4
<u>Total year 4</u>	<u>316</u>	<u>245</u>	<u>71</u>	<u>22.5</u>	<u>321</u>	<u>256</u>	<u>65</u>	<u>20.2</u>
Total enrolled	1349	1049	300	22.2	1349	1057	292	21.6

Source: Office of the Dean, College of Engineering, 2000. All upper years are combined.

Table 4.13 and Table 4.14 illustrate the distribution of the upper-year student population within the College of Engineering and which departments appear to appeal to the female and to the male students.

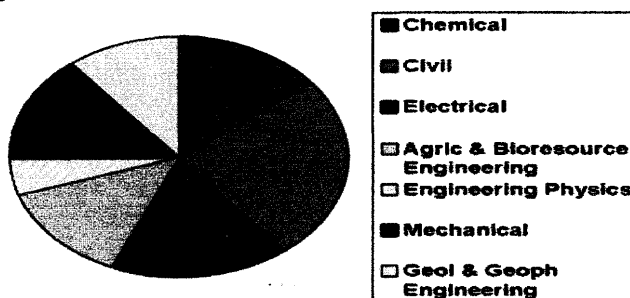
Table 4.13. Gendered Departmental Preferences, Upper-Year Students 1998 and 1999

Department*	1998/1999					1999/2000				
	Total	Male	%	Female	%	Total	Male	%	Female	%
Agricultural & Bioresource	57	32	4.5	25	12.2	48	27	3.8	21	10.6
Geological	66	37	5.3	29	14.1	46	26	3.7	20	10.1
Chemical	100	65	9.3	35	17.1	109	69	9.7	40	20.1
Civil	168	118	17.0	50	24.4	176	125	7.7	51	25.6
Geophysical**	4	3	0.4	1	0.5					
Eng. Physics	56	46	6.6	10	4.9	70	59	8.3	11	5.5
Electrical	212	184	26.4	28	13.7	214	186	26.3	28	14.0
Mechanical	238	211	30.3	27	13.2	244	216	30.5	28	14.0
Total	901	696	99.8	205	100.1	907	708	100	199	99.9

Source: Office of the Dean, College of Engineering, 2000. *All upper years are combined.

Table 4.13 demonstrates how the male and female upper-year students had positioned themselves throughout the various engineering specialties, while Figure 4.4 offers a graphic illustration of the distribution of female students in the various specialty departments at the U of S, and Table 4.14 indicates the proportion of male and female students in each department.

Figure 4.4. Women's Choice of Program in Undergraduate Engineering at the U of S.



Source: University of Saskatchewan Studies Group Fall 1996 Data (CWSE: Women in Science and Engineering, Prairie Chair).
<http://www.geomatics.ucalgary.ca/cwse/Univers.html>.

Table 4.14. Gendered Distribution of Upper-Year Students registered 1998 and 1999

Department*	1998/1999				1999/2000			
	Total	Male	Female	%Female	Total	Male	Female	%Female
Agricultural & Bioresource	57	32	25	43.9	48	27	21	43.8
Geological	66	37	29	43.9	46	26	20	43.5
Chemical	100	65	35	35.0	109	69	40	36.7
Civil	168	118	50	29.8	176	125	51	29.0
Geophysical**	4	3	1	25.0				
Eng.Physics	56	46	10	17.9	70	59	11	15.7
Electrical	212	184	28	13.2	214	186	28	13.1
Mechanical	238	211	27	11.3	244	216	28	11.5
Combined Programs #	170				149	130	19	12.8
EPIP+	68	58	10	14.7	15	13	2	11.4
Total	901	696	205		907	708	199	

Source: Office of the Dean, College of Engineering, 2000.

* All upper years are combined. **All students were in Year 4. The program has been phased out.

Not divided by gender that year. + Professional Internship Program.

The tables show a clear gender-based preference for the individual departments. However, based only on the numerical distribution of the students in the college and the small number of interviews, it is beyond the scope of this study to make assumptions as to why students in general choose their departments other than reiterating that such choices reflect the individual students' particular strengths and interests. It is possible that the departments do not fully elaborate all the opportunities available through their course structures. For example, the bio-medical opportunities in Electrical Engineering may not be fully understood.

The largest departments within the college are Mechanical and Electrical Engineering. The total student population in these departments shows a proportion of between 11.3% and 13.2% female students (Table 4.14). These departments had been selected by between 13.2% and 14 % of the upper-year female students while between 26.3% and 30.5% of the upper-year male students had selected to specialize in the departments (Table 4.13).

The smallest departments, after phasing out Geophysical Engineering, are Engineering Physics, Agricultural and Bioresource and Geological Engineering. The last two departments show a proportion of female students just below 44% (Table 4.14). Ten percent to 14.1% of the upper-year women had selected to specialize in these departments compared to only 3.7% to 5.3% of the upper-year men who had done so (Table 4.13). This is possibly the strongest illustration of the women's declared interest in environmental issues.

The departments that most of the female students selected were the Civil and Chemical Engineering Departments. These two departments had between 29% and 37% of female students (Table 4.14). Approximately 25% and up to 20% of the upper-year women, respectively, had chosen these departments. In comparison, only 17% and almost 10% of the men had selected these departments (Table 4.13). Here as well, there is a gendered difference in choice of specialization, possibly related to the women's concern for both the natural and the social environment.¹³

The gender differences in choice of specialization at the U of S are consistent with previous studies. Over one-fourth of the male students had selected Electrical Engineering, the

¹³ One professor in Civil Engineering suggested that the almost 50% female participation in his department reflected women's interest in architecture and human environment, e.g. infrastructure.

department that Hacker (1989; 1990) had identified as the most prestigious department at MIT. In contrast, approximately 25% of the female U of S students had selected Civil Engineering, which Hacker had found that had the lowest prestige. The relationship between gender and the prestige of an occupation is complicated. It is unclear, for example, whether male students deliberately select more prestigious over less prestigious departments. Alternatively, the prestige of a department may be constructed based on its 'masculine' character, and is therefore more attractive to men than to women. Moreover, research has found that when women become interested in, or allowed entry into certain fields of study or occupations, the prestige of these fields is lowered. For example, when women in the former U.S.S.R. became numerous within medicine, the medical profession lost prestige in the eyes of Soviet men. As well, when more women became involved in politics and government, national and international power decisions moved from legislatures to the multi-national corporate boardrooms, where women have not yet achieved demographic parity (Anderson, 1991).

CHAPTER SUMMARY

This chapter has placed the University of Saskatchewan in its geographic setting and discussed a descriptive profile of the 1996/97 first-year cohort of engineering students. Most of the students were young, single and had entered the College of Engineering directly from high school. This cohort was, generally, racially homogeneous. However, according to the 1996 census, the aboriginal population, in particular, was poorly represented in the cohort compared to the provincial population, while visible minority students were over-represented. It was also apparent that the students in this cohort, in addition to having very high grades on entrance, also had parents with education higher than the national average. These students were 'the cream of the crop.'

The literature had indicated that women and men choose engineering as a profession for different reasons. The findings of my survey of the first-year cohort and the interviews with the various groups of students were consistent with the literature. In the literature, women entered engineering with high academic credentials; that was an important motivating factor also for the women in my study. On the other hand, the male students appeared to take their mathematics and physics skills for granted while the women took particular pride in these skills.

The men claimed interest in making and constructing objects as a motivating factor, while women had little “tinkering experience” and chose departments with an environmental focus, again confirming previous studies.

Most of the students had the encouragement of their parents to pursue engineering, and some had the added benefit of having role models in engineering, either within the nuclear or extended family or within the circle of friends. However, while few women had been encouraged into engineering by teachers or guidance counsellors, some had been urged to study engineering because of women’s minority status in the profession.

Because the survey and the interviews took place at a very early stage of the first-year cohort’s education, most of the students were just beginning to grasp the extent of engineering and had no clear picture of their future goals. They were, however, enthusiastic and fascinated by the many opportunities for careers in the field, for the possibilities of promotions and monetary rewards, and they believed they had chosen an exciting profession. The first-year students wanted to complete their first year of studies before making any decisions about engineering specialization. The graduating students, who had completed their requirements for graduation within their chosen specializations, had been able to combine personal interests with their own skills and strengths in their specialization choices. More recent data showed that, similar to other studies, there were gender differences in choice of specialization. Women were more interested in environmental specialties such as Civil, Chemical, Geological and Bioresource Engineering than in Mechanical or Electrical Engineering. The largest proportion of female students had chosen Civil and Chemical Engineering while the men favoured Mechanical and Electrical Engineering and had only marginal interest in the departments of Agricultural and Bioresource and Geological Engineering, the departments with the highest proportion of female students.

In this chapter I have described the setting for the study and profiled the actors. I have also discussed the students’ goals and perceptions of engineering as they entered the College of Engineering. In the next chapter I analyze student attrition from the college and the reasons students gave for withdrawing from engineering education.

CHAPTER FIVE
LEAKY PIPELINE OR CORRIDOR OF OPPORTUNITIES?
(Attrition from Engineering Education)

In the previous chapter I addressed the factors that encouraged and motivated young women and men into the College of Engineering and how the students chose their specializations. However, to encourage women into the fields of science and technology without having any strategies for retaining the students until graduation appears to be a problem. The College of Engineering has one of the highest attrition rates of any college at the University of Saskatchewan (U of S), and the attrition of female students has been a particular concern for the college administration.¹ In 1996/97, the first-year withdrawal in engineering was 9.2%, and total withdrawal was 4.4% (see Table 4.1). Only agriculture had higher first-year withdrawal (10.2%), and education had a slightly higher total withdrawal (4.9%) (University Studies Group, 1997).

Student loss is often referred to as 'leaks' in the educational 'pipeline', and the loss of academically proficient female students in particular has been, and still is, a concern for faculty and administrators in the college. In this chapter I examine the dominant 'Leaky Pipeline' model used to describe the attrition of women in engineering and the sciences. I present the narrative data and discuss attrition from engineering education based on recorded interviews with ten female and six male former U of S engineering students who had transferred to other programs. I will also discuss the adequacy of the leaky pipeline model for explaining the students' experiences. This discussion addresses my third research question:

The attrition, or non-completion rate in engineering education has always been high. Why is it higher for women than for men and for women apparently not related to grades?

¹ When I approached the Dean of the College of Engineering for permission to conduct research, he particularly asked me to "find out why we loose our female students."

THE EDUCATIONAL PIPELINE

Strategies to encourage more women to enter the engineering profession have not produced gender parity in the College of Engineering. As discussed in Chapter Four, statistics since 1986 (University Studies Group, 1993, 1997, 1999; Office of the Dean of Engineering) indicate a steady increase in the rate of female student enrollment in first-year engineering programs until 1995 when it reached 24.4% (Figure 4.1), with the resulting higher proportion of women over the four years of the engineering program. In the 1996/97 first-year cohort in the College of Engineering the proportion of women had dropped to 20.9%. In comparison, other professional colleges at the U of S (agriculture, dentistry, law, medicine and veterinary medicine) now have gender parity in enrollment, while the colleges of Education, Nursing and Pharmacy and Nutrition are overwhelmingly favoured by women (See Appendix E).

The educational path of children and youth from playschool through primary and secondary schooling and on into post-secondary and graduate studies has been described as the educational pipeline (e.g. Barinaga, 1992; Tovell and Madill, 1993). For students in science and technology, the pipeline metaphor demonstrates a linear progression from elementary school to the Ph.D. degree and faculty, senior research and management positions. As the students progress through this pipeline, some choose to discontinue their education. For example, children are by law obligated to attend school until their sixteenth birthday, and some take advantage of the opportunity to discontinue at that point. As well, not all students choose to proceed to post-secondary education in either trade schools, colleges or universities.

Female students' failure to enter post-secondary education in science and technology disciplines has caused concern, and the concept of a "Leaky Pipeline" was coined as an explanation.² The leaky pipeline model assumes that of all the children who study science and mathematics courses in elementary school, fewer will continue these courses in high school, which in turn gives even fewer students the pre-requisites for studying engineering and sciences in colleges and universities. Holes, or open valves in the pipeline, indicate the various stages of

² I first learned about the Leaky Pipeline while attending GASAT 7 (International Conference on Gender and Science and Technology) at Waterloo University in 1993 when the metaphor appeared in several presentations (e.g., Tovell and Madill, 1993). In December 1997, Dr. Elizabeth Cannon, P.Eng., holder of the NSERC/PetroCanada Prairie Chair for Women in Science and Technology, presented the Leaky Pipeline model during a lecture at the U of S College of Engineering.

education where students leak out. It follows that the pool of students, especially female students, who qualify for graduate studies becomes quite small, leaving only very few female candidates for university appointments.

The leaky pipeline concept appeared in the special Women in Science section of *Science*, March 13, 1992³ and focused specifically on women in neuroscience. At that time, Marcia Barinaga (1992:1366) stated: “Although the pipeline supplying the field of neuroscience starts out with lots of women in it, it is leaking--like a sieve.”⁴ The April 16 1993 issue of *Science* showed that the leaky pipeline was still an issue, although it was now seen in general terms as loss of female students in science and technology programs. The use of a pipeline model, or metaphor, may be appropriate and understood in engineering where the construction of pipelines is part of engineers’ work. Pipelines can carry resources or products uninterrupted over long distances without depending on land transportation. The pipeline concept can also be a part of the plumbing and heating infrastructure of a house, or building, even in the ‘house of engineering.’

In the 1993 issue of *Science* there was concern that the under-representation of women in science and engineering was a result of the possibility that “bright women with scientific aptitude get diverted into other careers along the line” (Alper, 1993: 409). Although women constituted 45% of the work force in the U.S.A. at the time, they represented only 16% of scientists and engineers. Sue Rosser, a well-known feminist scientist and author, noted the consequences of the leaky pipeline:

[except for] the feminine field--psychology . . . the pipeline is leaking women. . . . And unless this country does something to plug those leaks, women will continue to be denied opportunities in rewarding, high-paying careers, and this country is going to be the worse for it (Rosser, cited in Alper, 1993:409).

³ This was the first time *Science* had offered a comprehensive and concentrated focus on women scientists, the sciences where they practised, and the issues and concerns they faced in a predominantly male working environment. The issue, which focused on neuroscience, drew a large number of mostly positive responses to this special section, causing the magazine to promise an annual feature on topics related to women’s participation in the sciences. *Science* is not a scientific journal but rather a popular magazine aimed at a science interested, yet non-scientific, general public. The articles do not always provide citations for their sources, making it difficult to trace statements and research to their origins.

⁴ Note that Barinaga mixes her metaphors, shifting from the male, industrial pipeline to the sieve, a utensil used in the kitchen, which is generally a female domain.

Explanations for why the pipeline is 'leaking women' have focused on the socialization of girls to be caring, nurturing and non-aggressive (Lerner, 1993; Eitzen and Baca Zinn, 1994; Etzkowitz et al, 1994). Sadker and Sadker (1994) have shown how teachers pay less attention to girls than to boys in the classroom. Support for girls in the science and technology fields is lacking, and girls who like these courses are often subjected to teasing (Baum, 1989; Geppert, 1995). Such systemic discrimination and dismissal of girls' interests throughout their education has robbed them of equality and equity in the classroom. Strategies for counteracting the leaks in the pipeline have been additional training, attention to and support for girls in mathematics and science courses, measures to reduce discriminatory behaviour, including girls-only courses or schools, and increasing the use of role models, mentors and other forms of support (Baum, 1989; Davis and Hollenshead, 1993; Frize, 1993; LeBold, 1983; Ryerson Polytechnic University, 1994; University of New Brunswick, 1995; CBS Television, 1999).

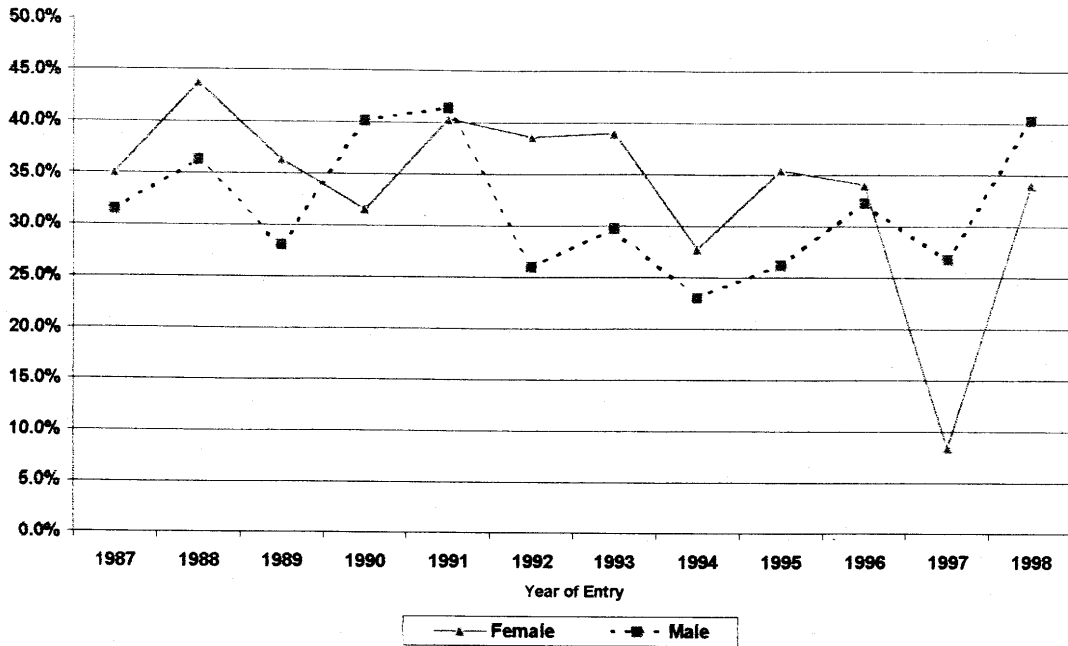
However, recruiting without also having in place strategic measures for retention of the students until they complete their education results in a science and engineering pipeline that leaks. LeBold (1983), for example, stated that women as well as minority students were difficult to keep in engineering programs. U of S statistics show that attrition from engineering is highest between year one and year two⁵ (Figure 5.1) and the proportion of women decreases throughout the program. However, the increasing female first-year enrollment has increased their proportion in upper years and degrees awarded to women (Figures 5.2 and 5.3).

⁵ This is not an official U of S statistic nor is it a College of Engineering statistic. Because the official attrition statistics are not gendered, I was forced to devise my own by subtracting the gendered second year enrollment from the gendered first-year enrollment the previous year, and calculating the difference, or loss of students, as per cent of the first-year enrollment.

There is no explanation for the abnormally low female attrition in 1997. A statistician at the University Studies Group has informed me that no different tests were applied that year. As always, the information was based on reports from the Registrar's Office. I can only speculate that either: 1) it was an exceptional cohort because also the male attrition was one of the lowest over the twelve-year period covered in the figure; 2) that the students in the 1996 cohort decided to wait and see if year two would be easier and therefore delayed the decision to withdraw; 3) that so few student had opted for the 5-year program and completed so many courses that almost all were considered second-year students; 4) that students who had previously been "required to discontinue" had re-registered; 5) that there had been a significant number of third-year students opting for the 5-year program that contributed to the number of students still in year two. As the figure shows, the attrition for both women and men increased dramatically the following year.

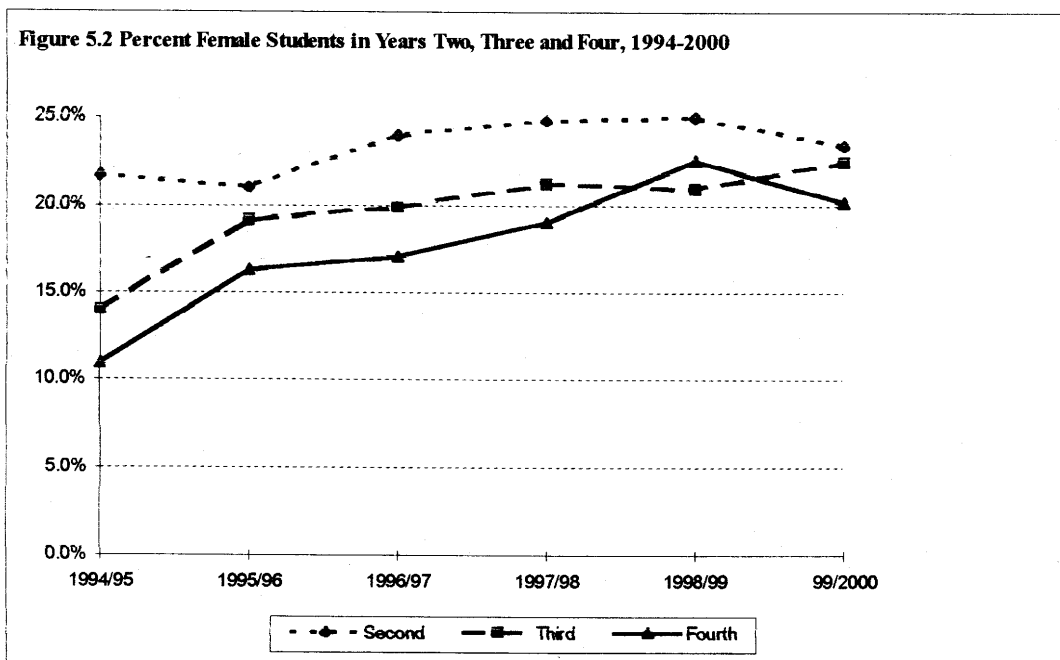
It is useful to compare Figure 5.1 to Table 4.1 (Chapter Four), which shows that attrition in 1996/97, both voluntary and required, was the lowest of the five-year period in that table. However, although those are official statistics, they are not gendered.

**Figure 5.1 Per cent First-Year Students NOT Returning for Year Two
1987-1998**



Source: Derived from University Studies Group, 1993; 1997; 1999. Calculated as percentage of female and male students not registering for year two immediately following completion of their first year in the college.

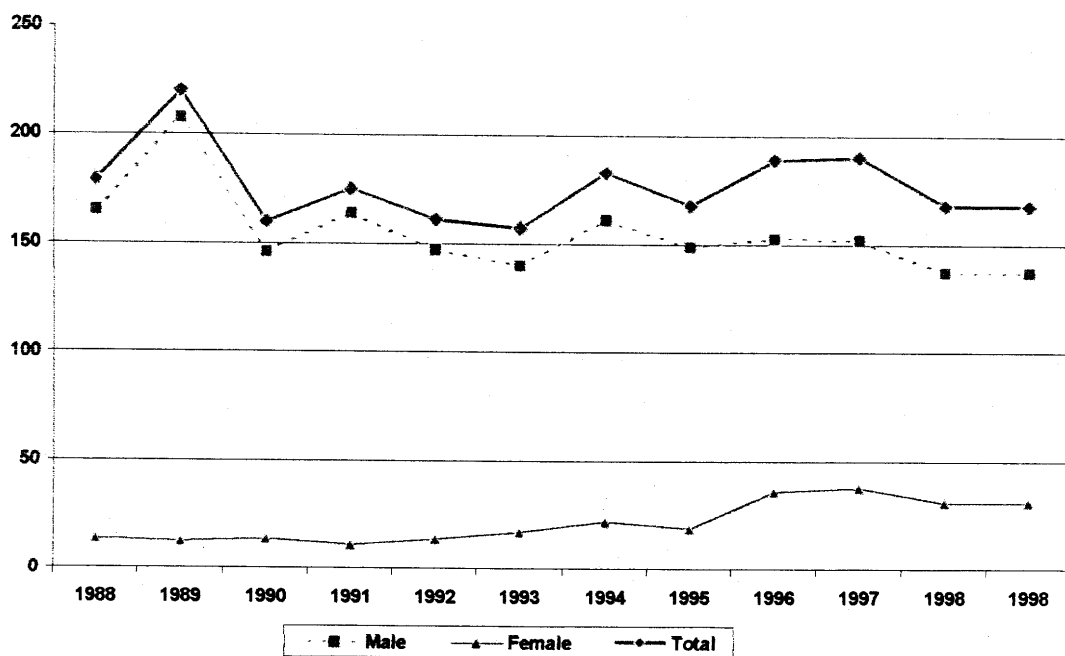
Figure 5.2. Percent of Female Students in Years Two, Three and Four, 1994-2000



Source: Office of the Dean, College of Engineering.

In comparison, Dryburgh (1999) found that the percentage of female and male students who continued to year two from year one varied, but that attrition was higher for men than for women although the challenges were greater for women than for men. Based on her retention rates between 1992/93 and 1995/96, the attrition rates in her setting ranged between 4% and 11% for women and between 7% and 13% for men.

Figure 5.3 Degrees Awarded 1988 - 1998



Source: Office of the Dean, College of Engineering.

WHY DOES THE EDUCATIONAL PIPELINE LEAK?

Reason for Leaving and Transfer Responses

With the emphasis on and support for increasing the numbers of women in engineering, many young women, as well as men, are attracted to engineering schools mainly because of their proficiency in mathematics and sciences (McIlwee and Robinson, 1992; Carter and Kirkup, 1990). This reason for choosing engineering also figured prominently in my survey of the first-year cohort as well as in the interviews with first-year, fourth-year and transfer students (Chapter Four). However, as the slogan for the Women in Engineering Chair

indicates, there is '*More Than Just Numbers*' involved in increasing the proportion of women in science and engineering. For example, studies by Sheahan and White (1990) and Baignée (1993) found that students who left engineering felt overpowered by too much and too difficult work, which left no time for family or friends. Consequently, they felt exhausted and alienated. Another possibility may be that the women have little or no knowledge of the actual work of engineers because they lack the "hands-on tinkering" experiences that boys and young men are encouraged to obtain. A further explanation is that women do not have the necessary science and mathematics skills to prevail in engineering (Carter and Kirkup, 1990; McIlwee and Robinson, 1992). As a result, women feel marginalized and like outsiders in a masculine environment.

The College of Engineering does not keep a record of students who exit the program prior to completion, nor does it conduct exit interviews with students who leave. To determine just why capable students choose to leave then becomes difficult. I was able to locate ten women and six men who had transferred to other disciplines, mostly through referrals from former classmates. During my interviews with these sixteen transfer students, certain themes emerged as reasons for leaving engineering. One young woman summed up her early first-year engineering experiences:

It was not what I expected. The work is not hard, but it is boring, and all numbers; there is lots of work, which makes for very long hours. It [the college] is snobbish and elitist—'we are the engineers, we are better than the rest'—with a party attitude (Annie, transfer student).

In her short statement, Annie expressed the major themes and reasons for not continuing in engineering education:

- Unexpected workload,
- Unrealistic expectations for the engineering programs,
- Elitism and a male dominated culture.

While these themes predominated in the interviews, a number of other reasons surfaced for transferring from engineering, including issues related to the process of engineering education, to family concerns and simply losing interest in engineering. What the transfer students all had in common was that after trying the study of engineering, they discovered that they were not happy, neither in the discipline nor in the college.

Unexpected Workload

One common reason for leaving the study of engineering can be called the 'not for me' response. The students admitted that they had made a mistake in choosing engineering and realized that they did not enjoy what they were doing. That is in itself a major discovery for young students. Matt, for example, simply stated: "I just decided it really wasn't for me. I just didn't want to do it. It was partly the workload, I had not expected it to be that heavy." In a similar vein, Holly called the first-year experience a "harsh aptitude test," a "rude awakening," and suggested that the college had not been suited to those who left. Holly's comments coincide with some of Dryburgh's (1999:671) responses of "purposely trying to get you out" by making courses really hard. Although Holly had grown up in an engineering family, she had been ambivalent about entering engineering and explained:

After two complete years I took time off to travel in Europe. When I was not immersed in engineering I realized that it was not what I wanted to do the rest of my life: I didn't like my classes, I couldn't see myself as an engineer, I just didn't want to do it (Holly, transfer student).

Similarly, Diana stated:

I didn't like most of my classes. I just didn't feel it was something I wanted. I don't regret dropping out, because I was exposed to university and higher education. I really liked living in the city. Although I really hated the classes, it was a good semester. I think it is wrong to push; you have to let people go where they are suited, and engineering just wasn't for me (Diana, transfer student).

There is a high degree of ambivalence in Diana's statement, such as a love/hate relationship between higher education in general and the engineering curriculum in particular. It was the latter that caused her departure. Because engineering would result in a professional degree and possibility for well-paid positions after only four years, some students, like David, had decided to try engineering first. If they did not like it, they would transfer to their second choice:

I had a difficult time choosing between philosophy and engineering. In engineering I really didn't want to do the work, . . . I had some interest in the topics, but only in knowing what came out of it. It was a miscalculation of how much interest and effort to put into it (David, transfer student).

Like so many other transfer students, Sarah had complained about the heavy workload:

Even if I don't do anything with my engineering classes I don't regret coming here because it kind of made me proud that I was doing all that work and survived. . . . It

was so overwhelming that I don't know if I really didn't like what I was doing or I just did not like what I was doing because it was too much work (Sarah, transfer student).

Having realized that they were not comfortable with or interested in engineering and the required workload, the students were quick to change their educational strategies without losing credit for the time spent in engineering. Consequently, David had transferred to philosophy. In the process of completing his degree and applying to the College of Law, he was adamant that "I feel better in a different college, [but] what I learned in engineering about how to learn, will help me" (David, transfer student). At the time of the interview, Diana had taken time off to work while she considered her future directions. She was undecided, but having rejected marine biology, thought of returning to the Bible College she had attended the year before. Holly chose an education degree, and Matt moved from the impersonal setting of the main university campus to the more intimate environment of a rural satellite campus. He could then live at home with family support while completing his first-year courses. It also gave him the chance to "grow up," which he deemed necessary to his later successful studies. Back on campus, Matt majored in mathematics because he "liked the problem solving. I didn't mind theory, but I would rather do problem solving" and earned an M.Sc. in computer science.

From the interviews, it was clear that there had been a mismatch between the students' general interests and choice of educational field. Just as the successful students had selected their engineering specialties based on a combination of individual dislikes, interests and skills (Chapter Four), the transfer students applied the same strategies in their next educational choices. For example, Tanya had chosen a commerce program. Tanya looked back on her first year in that program as "being in a different world. I felt like I was able to do the classes, whereas in engineering I didn't want to." Cory had transferred from agricultural engineering and became comfortable in agricultural economics. Don, Stewart and Curtis had decided that they did not enjoy the courses in engineering and transferred to computer science, a department in the College of Arts and Science. Curtis had expected that engineering would be a good employment option, but had found it boring. After completing first-year requirements in Arts and Science, he majored in computer science, which he found fascinating and thought it would provide "a roof over my head and something to eat," in other words, stable employment. When I interviewed him, Curtis was preparing for a sixteen month Professional Internship

Program (PIP) with a large corporation as part of his degree in computer science.⁶ Just what the students had expected from engineering is not quite clear because many admitted that they had considered engineering as only one option.

Unrealistic Expectations

The 'not for me' response is related to the concept of 'unrealistic expectations' of engineering among many of the transfer students. Some of the transfer students commented that they had chosen engineering simply because school counselors had suggested engineering to their best mathematics students. However, they did not have enough information about the programs within the study of engineering or the work engineers do. Without proper knowledge about the field of study they were entering, it is very possible that students had constructed false or unrealistic expectations of both themselves and the discipline. Whether they entered the study of engineering after serious consideration or by coincidence, it was possible that the choice, in the end, was not suited to individual talents or interests.

Sarah, for example, realized that she had not known what engineers did and did not know if she really wanted to do engineering work. "I think they should get more out to high school students what engineers do," she said.⁷ Similarly, first-year student Louise related that one female friend "did very well in first year engineering but quit because she didn't know what she was getting into." Many students did not expect the difference between high school and university classes and were intimidated by the large class sections, sometimes close to 100 students or more, as compared to their high school class sizes. This difference may be more difficult for rural students who could have experienced rather small class sizes and more intimate environments in their high schools. Sarah, for example, was disappointed that her professors did not know her name, and she felt lost in the large, impersonal classes. However,

⁶ In this program, students who have completed their third year, register at the university and pay tuition while they earn salary and gain work experience before they complete the last year of the degree program. For Curtis, the internship was very successful and beneficial to securing employment after graduation.

⁷ Although the college has an outreach committee, the Encouraging Enrollment in Engineering (EEE), whose mandate it is to promote engineering to high school students, the effectiveness of the committee depends on invitations from the provincial high schools. A large number of first-year students in my survey indicated that their schools had not had such visits, nor had the majority of the transfer students. The EEE is student run and college supported. It will be discussed in Chapter Seven.

one of the successful fourth-year students had also thought so, but she had come to realize that

It is hard to explain engineering, to put into words what it really is, so many students don't have the correct information at the start. The classes are not enjoyable, and the profs don't seem to care, and a student is only one in a sea of 420. Everybody say [sic] that first year is tough, but it does get better in second year when you start specializing (Christina, 4th year).

Holly, who had spent two full years in engineering, expressed similar sentiments:

First year [in engineering] is an 'aptitude test' but an awfully harsh one. It is a rude awakening. I think that if the girls realize they don't want engineering they drop out a lot sooner than the boys, who are more likely to stay with it because engineering is a guy thing, even if they don't want to actually do it [engineering] themselves. I know lots of guys who have *failed* out, but I don't know any girls who have failed. . . . I think that for whatever reason, we made a bad choice and went into a college that was not suited for us and I don't think that has anything to do with gender. It is a personal thing, a personal choice for the girls (Holly, transfer student).

Despite Holly's protestation that gender had nothing to do with the attrition rate, her observation indicates that the construction of engineering as masculine does in fact influence the decision to leave. Female students, rather than continuing to participate, withdrew; male students, however, accepted the 'macho' values even at their own expense and left only when they failed academically.

Even though Holly left engineering, she pursued a career in science and technology, but this time as an interpreter of science at science fairs or in a science centre. By doing so, she believed she could reach out to more people by promoting science to the public at large and especially to girls. Her education degree would be important to her because she would have learned how to *teach*. She also knew that she could return to engineering later if she changed her mind. Holly's decision to redirect the focus of her interest in science and technology suggests, as Hacker and others have indicated, that some fields of science are constructed as 'feminine,' particularly those that are associated with teaching—itself a feminized activity—while others, such as engineering, are steeped in dominant forms of masculinity.

Sarah, who had been overwhelmed by class size and was disappointed that professors did not know her name, was also critical of the university bureaucracy. Her marks had been recorded so late that she did not know if she had passed her final exams until just days before the start of the next semester. Because she feared failing a certain course, which would upset

the entire second semester and leave her a year behind her classmates, she decided to transfer to another program where she could get credit for the courses she had passed.⁸ Sarah was taking general arts and science courses; so was Megan, who was trying to choose between chemistry and international studies and indicated that she enjoyed her arts and science courses “immensely.” Both Megan and Sarah were amazed at all the free time they had in their new programs, an indication that the heavy workload in engineering was real, and the students who complained about it were not using it as a lame excuse to quit. Megan’s difficulty was finding enough one-semester courses to fill her schedule. Most of the first-year arts and science courses at the U of S are full-year courses, and Sarah was benefiting from taking her second semester at another university, which offered all one-semester courses.

Thus, unless students themselves, especially the female students, had consulted knowledgeable sources, such as interviewing or work shadowing an engineer, they did not know what to expect when they entered the study of engineering. The first-year students did not realize the extent of the workload of required classes, added laboratory sessions and the amount of homework and independent study needed. Nor did they understand the extent of the mathematically based courses in engineering and how these courses are imbued with objective, linear, analytical thinking. Such thinking has been associated with masculinity (Kerka, 1993) and ‘separate knowledge,’ while women prefer ‘connected knowledge’ (Belenky et al., 1989).

Elitism and Masculine Culture in Engineering

Science, engineering and technology have a privileged position at the top of the academic hierarchy. This is in part due to being a historically exclusively male domain associated with the military and in part seen as ‘macho’ and ‘hard’ (Hacker, 1989; 1990). Because men were historically privileged, so were the male domains and activities (Lerner, 1993; Eitzen and Baca Zinn, 1994). In addition, the hierarchical structuring of the discipline, which is placing working with and studying objects as superior to working with and studying

⁸ Certain first-semester courses are prerequisites for continuation. Without credit for these courses, students cannot complete first-year requirements on time, and their entire program might be compromised. On a happier note: Sarah returned to the university and graduated with a B.E. degree in 2001).

people, has led to the discipline's denigration of the humanities and the social sciences (Hacker, 1989; 1990). Holding social relations in contempt leads to disdain for people themselves, particularly for women, the 'softest' of all people. Scorn for 'soft' people often manifests itself in jokes and snide remarks directed at women and feminine characteristics (Baum, 1989; Hacker, 1989; 1990; Sadker and Sadker, 1994; Benokraitis, 1997). These attitudes persist in engineering, which remains one of the most male-dominated disciplines and professions. In exploring these attitudes, Sally Hacker found elitism, denigration of the social sciences, disgust for cooperative social relations and crude, rude and sexist, racist jokes and comments.

In addition, Hacker (1989; 1990) found that the faculty members she interviewed at MIT (all male) considered engineers the most qualified to become managers. Yet, they saw little need for any knowledge of social relations as long as they had technical expertise "because they can treat people like elements in a system" (1989:36). These engineers thought only of the efficiency of technology, not of the effects of technologies on people. When Hacker queried them about cooperative information sharing between engineers and technicians, many faculty members were appalled. Among their comments were (1990:132): "to be out working with [name], . . . and talking with his laborers, I don't think would help them and I don't think that's a good use of my time." "I don't mean to be snobbish about this, but the help [laugh] you know what I mean, . . . A lot of people who are technicians don't really have the basic skills that would be necessary." "It really sounds to me like a waste of time and a waste of talent. . . . I do not believe that all people are equal."

Asked about their opinions on the social sciences, some of the engineering faculty gave the following responses (Hacker, 1990:135): "I don't understand them. What use is it if you can't control the object of study?" "Engineering questions and systems are much more controllable." "Soft. For engineering dropouts. Engineers are an elite group." These selected responses are indications of the attitudes of elitism in an engineering environment. If these are the attitudes of faculty, these are the attitudes they convey to their students. Hacker concluded that:

It seems to me that responsible engineering education must teach the students how social relations at work are built into technological systems. Current forms of organization encourage lack of responsibility on the part of most workers, and lack of responsiveness to the concerned engineer (Hacker, 1990:137).

In my study, Annie had noticed that students in the College of Engineering projected these same attitudes of being better than the rest of the student population, and that engineering students felt they were in a class of their own at the top of the student hierarchy at the university. During my observations in the first-year classrooms, I noticed the attitude that only science courses were worth studying and that social sciences and humanities were not needed in engineering. The then required English course, for example, was trivialized and considered a waste of time. It followed that students who majored in such disciplines were sub-standard, as reflected in the low esteem in which the engineering students held 'artsies' (Arts and Science students) and 'agros' (Agriculture students, especially the diploma students, as opposed to the degree students). Some of the engineering students found this elitist attitude unacceptable.

The attitude of superiority created an impersonal, exclusionary atmosphere where some students, especially women, were uncomfortable. For example, a mature first-year woman called the atmosphere 'testosterone poisoning.' Fiona said: "I didn't feel like I was one of the engineering students; I didn't have the same attitudes they had." Megan was annoyed with the prevailing idea that only engineers were worthwhile people and did not want to become part of a supercilious culture with negative attitude towards others:

Everything is needed in this world. This world will not survive on engineers only, nor on B.A.s only. If you are doing something you like, you will do well and be successful at that (Megan, transfer student).

However, some men also took issue with the attitude of elitism. Matt admitted that it had been one reason why he had left engineering: "It was partly due to the attitude in engineering. I didn't like the 'I'm better than you are' type of thing."

The literature cited above (Baum, 1989; Hacker, 1989; 1990; Sadker and Sadker, 1994) indicates that the hierarchical structure of engineering encourages denigration of 'soft' disciplines and the people within them and often appears as derogatory jokes and remarks about women and feminine characteristics. Such defamation of people and social relations was also evident in the college paper and college activities. Some of the students in my sample, especially the women, were offended by the *Red Eye* (the college paper), which often published off-color jokes, both sexist and, sometimes, racist. Some students, both female and male, also

took issue with what they considered childish attitudes in such activities as the E-plant and the *Red Eye Stomp* during the college's 'Hell Week' in the fall.⁹ In general, the transfer students objected to the masculine culture the students' society promoted.

The male students have traditionally dominated the Saskatoon Engineering Students' Society (SESS). Some of the students I interviewed explained that women who ran for seats on the SESS had only minimal chances of being elected to anything but the secretary's position because of their numerical disadvantage in the college. Because the SESS arranged social and extra-curricular activities, most of these events appealed to the male students, especially the frequent bacchanals at a designated city bar. Transfer student Diana stated: "I did not enjoy the students' activities in engineering. I think there's a push for drinking, and I'm against it because of my religion and because I've seen what alcohol can do to people. I was there to learn, not to do pub-crawls."¹⁰ However, some of the older male students, as well, did neither approve of nor participate in these activities and considered them childish.

If the professional and student cultures are not welcoming, and sometimes even offensive to women, it is no wonder that some women—and even some men—feel uncomfortable and choose to transfer to another educational opportunity where the environment might be more appealing to them. Yet some men, too, found the atmosphere uncomfortable; they realized that they did not enjoy what they were doing and admitted that choosing engineering had been a mistake. To remedy Bowen's (1988) observation that women were difficult to retain in engineering and LeBold's (1983) concern for equity in engineering, faculty and administrators would do well to heed Stalker and Prentice's (1998:22) warning that if the classroom was not welcoming, "women may 'voluntarily' withdraw their time and interest and elect not to complete first degrees or pursue graduate studies." Similarly, Eisenhart and Finkel (1998) believe that in order to retain women, organizations would have to treat women well.

Creativity and Interdisciplinarity

Many of the female students found the courses, especially the required first year

⁹ The SESS, the *Red Eye* and 'Hell Week' will be explained in Chapter Seven.

¹⁰ The legal drinking age in Saskatchewan is 19 years. In 1996, 61% first-year students were under the age of 19 (see Table 4.3).

courses, too theoretical, too abstract and not creative and meaningful enough. Both Annie and Fiona commented that the relentless focus on basic mathematics and physics in the first year of study had been detrimental to their own creative thinking. Annie remembered that in grade nine, her class had visited the College of Engineering's triennial *Spectrum* Exposition where students, faculty and industry display their work and innovations. *Spectrum* is open to the public and is popular as a field trip for school classes. Annie had been greatly impressed with the kind of work she saw, and when she started in engineering, she had expected to "do neat things like those at *Spectrum*." She became discouraged when she realized that she was expected to spend most of her time solving physics and mathematics problems and decided to transfer out after first semester. "I wanted more options, variety and flexibility. Crunching numbers was not what I wanted to do for 40 years of working life" (Annie, transfer student). Annie finished her semester and transferred to a program that would earn her access to the College of Education. Don, Stewart and Curtis, who had chosen computer science, supported Annie's critique. They all appreciated the variety of required courses within their liberal arts program, in contrast to the engineering courses which were "boring and all numbers," just as Annie had experienced.¹¹ Stewart especially enjoyed philosophy and psychology, courses for which there was no time in engineering. Fiona was also disappointed and quite vocal about her first-year experiences:

There was no free thought in engineering; no analysis, no getting deeply into things. If it was a five-year program, like most people make it anyway, it would be possible to explore some more options. . . . It might be better if you had a year of liberal arts and natural science first. But with that background, students would already have their own 'identity' and it would be harder to get them for engineering (Fiona, transfer student).

Fiona missed deeper analysis of concepts within her courses, which coincides with Tobias' (1990; 1990b) finding that non-science students expressly missed and wanted discussion of concepts in science subjects. Fiona distinguished between education and job training and is an example of Alper's (1993) concern about 'diverting' talented women away from science.

¹¹ The Saskatoon *StarPhoenix* reports that the local Public School Board is instituting a program to emphasize of understanding mathematics through applications to "real life problems." For example, sports statistics, weather reports and data management can contribute to "get the concept of thinking about why numbers are going here and there, not just filling in the blanks to arrive at an answer" (Bernhardt, 2001).

Although creativity may have different meanings to different people, the perceived lack of breadth of creativity and meaningful projects in the first year of study had diverted both Fiona and Annie away from engineering.¹² Fiona had transferred to an inter-disciplinary program in land use and environmental studies. There she had discovered that mathematics, which in engineering had been too abstract, theoretical and boring, had taken on 'social meaning' in 'real life' economics. She also believed that the inter-disciplinary aspect of the program gave her a more diverse education, which she had found lacking in engineering.¹³

The perception that engineering was abstract, narrow and not creative suggests that the structure of engineering knowledge will appeal only to particular students with an aptitude for this kind of knowledge. Creativity in Fiona's mind entailed applying thought and imagination to bringing products into existence, preferably something that would make life easier for living individuals. Based on Fiona and Annie's experiences, students who are interested in applied sciences will be discouraged by the engineering approach to knowledge.

The distinction between abstract and applied science brings attention to the male/female binary where abstraction is coded male and more highly valued, and application is coded female and less valued. In their studies of patriarchal structure of physics and nuclear weapons respectively, Brian Easlea (1995 [1987]) and Carol Cohn (1990) have shown that scientists in these areas can indeed be quite creative in producing weapons of mass destruction and using euphemisms to lessen the impact when describing their destructive powers.¹⁴ Extensive use of sexual metaphors, and comparing the development and production of nuclear bombs to scientist 'mothers' 'gestating' the ideas with which other scientist 'fathers' had 'inseminated' them, then 'giving birth' to 'babies,' exemplify a high degree of creativity, although not the

¹² The present Dean of the College of Commerce at the U of S started her academic career as an engineering student. During a private conversation she, too, volunteered that she had left engineering because she thought the first year of courses had lacked creativity. She was told that she could be creative in year three.

¹³ The program had some similarities with Agricultural and Bioresource Engineering, a department that is one of the favorites with female students in the college (see Chapter Four, Tables 4.13 and 4.14). I have since learned that Fiona was accepted in the College of Medicine.

¹⁴ Cohn (1990) reports that 'collateral damage' masked the mass murder caused by the nuclear warheads and that the only 'dirty' legacy of the bomb was radioactivity. When military personnel encouraged her to "pat the missiles," which she called "high-tech phalluses," in a nuclear submarine, Cohn (p.36) stated that such "patting removes the object's lethal purpose." She also divulged that New Zealand was accused of "nuclear virginity" (p.37) when it refused nuclear warships entry to its harbours.

kind Fiona and Annie expected to find in engineering. The metaphors also express misogyny, as during testing of the bomb, a successful test was announced as a 'boy' whereas a failure was referred to as a 'girl' (Easlea, 1995).

This is not to say that engineering knowledge and physics are constructed in identical ways, but Cohn's and Easlea's studies suggest that physics, which is thought to be the most abstract science, is not only disinterested, objective, technical knowledge. Rather, it is produced and embedded in a particular set of social relations, which are partly gendered. Because engineering theories and technology are firmly anchored in physics, we may expect similar views and creativity in that discipline. Fiona's views of creativity in engineering suggests that a closer study of the metaphorical structure of engineering would provide greater understanding of the particular ways in which masculinity is constructed in engineering.

Education vs. Job Training

In addition to her dislike for the course content of the engineering curriculum, Fiona perceived engineering simply as 'job training.' In that context, she was disappointed with her summer work experience:

I found engineering suffocating. It is totally job training and they are lacking in so many other areas. Another thing about engineering—it [specialization] is so narrow so early and I felt I was missing out on too many things. In engineering you learn that everyone wants to work for these big corporations and now I'm learning how technology is the root of all evil! . . . I got hired by [firm]—a guy and me. They hired two summer students that year, and *he* got the engineering summer job and *I'm* a clerk. *He* is paid \$14something/hr, and *I* am paid \$11something, but we had exactly the same qualifications. I don't know any guy who got a clerical job, yet every girl engineer that I know got a clerical job. The guys got an engineering or technical support job and they got paid more. That's largely why I am not in engineering because I worked with engineers and it was unbelievably boring (Fiona, transfer student).

This kind of differential treatment of men and women in the workplace can easily undermine women's sense of worth to a profession. Even with qualifications equal to male workers, women are relegated to lower-paid and less prestigious positions in the gendered division of labour. While her classmate had benefited from being a man in the segmented labour market, Fiona's lower status as a woman had worked against her in that market. For Fiona, what she learned in class about a supposedly exciting and creative profession did not correspond with

the drudgery of clerical work and was one of the reasons why she left engineering education. To train for a job that she might find boring was not what she wanted. Fiona continued:

There's more group work in engineering because everybody has the same assignment. In arts, there's more individual work and not so many assignments. [In arts] there is a lot of reading—you never read in engineering. It is more independent study, and less job training, you acquire more general knowledge in arts, it is not job preparation like engineering is (Fiona, transfer student).

The group work Fiona referred to applied to groups of students working together to solve assigned, mostly mathematical problems, not to discuss issues or concepts.

In her study of what she called 'the second tier,' Tobias (1990; 1990b) contracted successful social science and humanities students, both men and women, to do fieldwork for her by auditing university science courses. In their journals, those students described how the questions and answers in the science courses (physics and chemistry) were all about 'how' to do or solve problems. In their own disciplines these students were used to discussing 'why' situations or concepts occurred and how to connect them to a wider social context. These non-science students missed class discussions about the science concepts they studied and how they applied to that wider context. Belenky et al. (1986) realized in their study that women were most comfortable with learning in cooperative learning environments while male students preferred a competitive class environment. Women wanted to see connections and relationships; men wanted the right answers. Fiona may have found that her 'job training' education lacked meaning because, as a woman, she was seeking more context and connections in her courses.

Marriage, Motherhood and Engineering

Marriage and motherhood are major barriers for women's career expectations because it is often assumed that women will structure marriage and motherhood around the rhythms of the work world rather than vice versa. Etzkowitz et al. (1994) cite three particular times when marriage interferes with women's career aspirations: when they apply for university admission, when they apply for employment, and when they decide to have a child. The time it will take to attend classes and complete expected homework will be at the expense of the time previously devoted to a partner and/or family. The same happens when employment includes

working hours that are incompatible with leisure or family time, for example when employment includes frequent or long absences from the home. For men who choose such employment, there is an assumption that there is a mother at home to care for children.¹⁵ The possibility of having a child, either while studying or working full-time, may entail a lengthy absence from the place of employment,¹⁶ which may be detrimental to the woman's benefits and promotions.

Because of the assumption that women, as mothers, are primarily responsible for the care of family and children, the interruptions above do not affect men the way they do women. Predominantly male science and engineering faculties are therefore often reluctant, if not unwilling, to grant women any reasonable maternity leave without building punishment into it: "Marriage and children are generally viewed by male faculty members as impediments to a scientific career for women" (Etzkowitz et al, 1994:6). Moreover, when it is a matter of a man's career move, his wife or partner is expected to give up her own career even if the move offers no opportunities in her field; very few men are willing to make the same sacrifice for a wife's career. As pointed out in the review of the literature on masculine culture in engineering, Cole and Fiorentine deal women's career aspirations a further patriarchal blow by suggesting that women, if they are not successful in the workforce, can always escape into and "rely on the socially sanctioned safety net of marriage" (Schiebinger, 1999:59). Therefore, women often have to choose between career and intimate relationships.

Marriage and motherhood might explain why some women drop out of science and engineering. Kate, for example, whom I interviewed as a mature first-year student, informed me later that she would not be returning because her husband had taken a position in another city where she hoped to be able to continue her engineering studies. One graduating fourth-year student told me that going through pregnancy and childbirth had upset her program schedule. With the help of her husband, a practicing engineer, she had persevered, but she had felt like "a minority within the minority." She stated that over the several years it had taken her to graduate, she knew no other woman with children who had graduated but could remember several who had left. If it is difficult for women in so-called 'female' occupations to combine

¹⁵ A fourth-year student remarked that "women are still the main caregivers in the family, and it is hard to raise a family if you are forever travelling."

¹⁶ In the Federal workforce, one-year parental leave permitted with guaranteed return employment.

family and work, it is even more so in a male-dominated field because the family is not included in the job description. When women face the difficulty of balancing work and family, they are more likely than men both to withdraw from the workforce or to seek part-time employment or contract work¹⁷ (Ranson, 1998; 2000).

Motherhood had also put Jean's education and career plans on hold. When she entered engineering in the late 1970s she was very young, calling herself a 'child prodigy' with an interest in aerospace engineering. She was also newly married and pregnant. It had not bothered her to be the only girl in her classes because she had found most of her classmates very helpful, almost as if they were taking care of a younger sister who needed their protection, but also willingly sharing knowledge with her. However, her professors had not all been kind and helpful, and one had told her she had no business being in the college. Jean completed her final Christmas exams with marks in the 70s and a week later gave birth to the first of her four children, returning to the university only after her youngest child was in school. Intending to return to engineering, she had instead found a program in paleo-biology because

I always liked fossils and rocks as a child. . . . Paleo-biology is over half women and I think that is because it is life-centered rather than industry-centered. We are looking at rocks and trying to figure out what used to be alive rather than thinking of how we could make money out of it. But I still think the creative end of engineering would be fun (Jean, transfer student).

When I interviewed her, Jean was completing an honours degree and was headed for graduate studies with an NSERC award. Jean has since completed her M.Sc. and started a funded Ph.D. program in biology.

Reproduction of Family Roles

In addition to marriage and motherhood posing as major barriers to women in engineering, other family expectations may influence women's decisions to enter or leave engineering. Patti, a South-east Asian immigrant, had not expected that her engineering studies would be incompatible with her family's expectations of working in the family business. Patti's

¹⁷ Although my research does not go beyond the students' graduation, it is worth noting that full-time employment in science and technology is not easy to combine with family and children.

parents depended on her labour to make their business profitable, while they did not have the same expectations of her brother. As a result of the conflict between working and the heavy engineering course load her grades had suffered and Patti had transferred to computer science where she had her highest grades. As Patti associated her voluntary transfer from the study of engineering with failure, she confided that her culture had made her feel “like ‘losing face’ to have to give it up.” Nevertheless, she was happy to have made the change.

In contrast, some students indicated that they had chosen engineering because their families expected it of them, even though it was not their first choice. Lorna’s father owned a farm implement manufacturing business; she had chosen engineering out of filial duty, but discovered that she enjoyed neither the required courses nor the workload:

In high school I originally wanted to do accounting, or possibly get a law degree. My father produces agricultural machinery and I thought I should follow in his footsteps. But I just felt engineering wasn’t for me, it was kind of a relief to leave (Lorna, transfer student).

Lorna admitted that when she left engineering, her father was disappointed, while her mother was relieved. Lorna did transfer to a major in accounting and saw the commerce degree as a steppingstone to corporate management or corporate law. She could still join her father’s firm, although in a different capacity.

These two examples illustrate the ways in which gender relations in the family shape women’s career choices. In the first case, Patti’s family demanded that she subordinate her needs to that of her family, an expectation that did not apply to the son. Work expectation in engineering conflicted with gender expectation. In the second case, Lorna had her family’s support and encouragement to enter science and technology, but she complied out of a sense of duty rather than interest.

In summary, the decision to leave engineering had been difficult for some of the students, both women and men. Although they did not perceive of themselves as ‘quitters’ or ‘losers,’ some had been worried that others might see them as such, that they just ‘couldn’t make it,’ yet all had felt relief when they had made their decisions to transfer to other fields. For the most part, they instinctively knew that they had made a wrong choice and were eager to correct their mistake. Terminating their study of engineering was based on a dislike for the courses, for the people in engineering, for the culture of engineering, or all three. The students

had considered their options and discussed leaving with their families and sometimes with friends. Some of the women indicated that classmates had commented on what they had perceived as their unhappiness in the college. Peer support, talking to people they saw every day and who, in many cases were in a similar situation, had been instrumental in making the break and getting on with their lives. While they had not enjoyed the engineering experience, they now enjoyed what they were doing and were successful in their new fields of study.

In my sample of transfer students there was a gendered difference in the choice of further education. Four of the six male students (66.7%) had transferred to other sciences: three to computer science and one to mathematics, while the remaining two had chosen agricultural economics and philosophy. In contrast, most of the women had chosen more environmental or people-oriented fields, both within the realm of science and away from science. Of the ten female students, only three (30%) had transferred to other science programs: one each to land use and environmental studies (LUEST), computer science, and paleo-biology. Two had entered commerce programs, one had entered the work force, while one upper-year student and the four women who had left after only one semester had transferred to arts and science courses. They had all received credits for several of the courses in engineering, and two of them were planning careers in education. During their time in engineering, the students had acquired some insights into university life that they found useful and helpful in selecting new careers. Being exposed to university education and student life, both of which were different from their high school days, had given them a sense of the adult world and its demands.

Some students offered remedies for the high attrition rate. One female fourth-year student suggested that a compulsory year of introductory liberal arts would be beneficial because it would give students an introduction to what the university had to offer before choosing a major. Such strategy could possibly divert some of the students before they became an attrition statistic in engineering. One woman believed that engineering should officially be a five-year program because many students did spread their courses over five years while a male transfer student thought that a lighter first-year course-load would reduce the attrition rate because few had energy for the demands the college placed on first-year students. He suggested more emphasis on science theory than on sheer numbers and suggested that the first-

year curriculum needed a social science course, maybe specifically developed for engineering. With a required social science course and an extra year of study students would be able to explore non-engineering courses that could connect them to social relations and make them better-rounded citizens.

DISCUSSION

In response to the problem of the high attrition rate, the College of Engineering (1995) conducted a study on attrition, based on available statistical information, whose findings echo many of those offered by my student informants. The study found that those students who had taken calculus in high school fared better in first-year mathematics than those who had not. The report recommended that students who had lower than 80% admission average should be required to attend a remedial pre-admission calculus camp, and that they should be discouraged from participating in extra-curricular activities. The study also found that transfer students from other university programs had a better success rate than students who entered directly from high school and recommended that such transfers be encouraged, although limited to a certain percentage of each cohort. Moreover, the report recommended integrating engineering students into mathematics courses in other colleges, which would be eligible for transfer credit between programs, instead of conducting separate mathematics courses for engineering students. Finally, the report proposed that the four-year curriculum offer a five-year strategy for completing the program. Spreading the curriculum over five years is one strategy that the college has acted upon and which the students use extensively.

In making these recommendations, the College focused attention on the individual failings of the students, rather than, or in conjunction with, the structure of the engineering education program. The report stressed the students' weaknesses, such as poor mathematical abilities, and urged them to refrain from extra-curricular activities as a solution. In part, the College's conclusions are the result of its methodology. By relying solely on the quantitative performance data, the College was unable to take into account the social, cultural and educational factors that impact on student experience and performance.

In contrast, the qualitative and narrative data of the present study revealed the ways in which the structure of the education program and the masculine environment shaped the

students' experiences, expectations, and possibly performance. In a telling comment from one woman, she remarked: "We made a mistake and entered a college that was not suited to us." Her insight is significant because she did not say "we were not suited to the college." Although she took responsibility for herself and others who had 'made the mistake,' the College of Engineering had not met her and other students' expectations, whether real or unrealistic. She realized that the poor fit between some students—especially female students—and the education they were seeking was not a personal student problem but a structural and systemic educational issue.

The students' perception of a heavy workload coincides with the literature on recruitment, attrition and retention of students in science and technology. The persistence of this problem strongly suggests that this is a structural as opposed to an individual problem, which engineering colleges need to address. Moreover, aspects of the culture in the College of Engineering create an environment that is alienating to some students. Both male and female students in my study complained about elitism in the college, about sexist and racist attitudes and about the masculine student culture in general. The insight in one woman's statements that "it would be a strange world if it was populated entirely by engineers" and that "when we enjoy our work, we will do it well and be successful" is worth considering.

While much attention has been paid to the problem of attrition, the retention side of engineering and science education was largely ignored. As a rule, most engineering schools tend to admit a large base of students because the model of engineering education is based on an expectation to weed out a significant proportion of the weaker students. Embedded in this approach is a 'survival of the fittest' mentality—only the tough survive—which in itself is a 'masculine' approach. Successful students then come to see themselves as members of an elite because, having survived, they are tough and deserving of the benefits conferred by belonging to this profession. White (in Sheahan and White, 1990) made the 'radical' suggestion that for attrition to drop, there had to be a willingness to retain. Therefore, White proposed that engineering schools should admit only those students they intended to graduate, which he believed would place the onus on the institutions to structure their engineering education so that graduation would be the expected outcome for all, rather than admitting students who were expected to fail or drop out.

The “Leaky Pipeline” Metaphor

Dorothy Tovell and Helen Madill (1993:1041) state that “a leaking pipeline is one metaphor that is commonly used” to call attention to the fact that the higher one goes in science and technology education, the fewer women participate. The leaky pipeline model fits the deficit model of women’s education. The assumption of a deficiency in mathematics and sciences may cause students to drop these courses and ‘leak’ out of the ‘pipeline’ at various stages of their education. The young women—and men—in my study who had discontinued their engineering studies had come a long way in the science pipeline, having achieved high enough marks in mathematics and science to gain entry to the study of engineering. In other words, they were *not* deficient in these subjects and were ‘leaking’ for other reasons, as my data reveals.

The leaky pipeline metaphor invites critique because of its inference that those who exit from science and engineering education are considered ‘waste’ that is involuntarily and passively flushed out. Moreover, it is one-directional and does not account for those students who enter or re-enter engineering. For example, in my samples, there were students who had completed degrees and had work experience in commerce and education before they entered the engineering programs. Tovell and Madill (1993:1041) were also critical of the metaphor:

In engineering, leakage implies wastage; however, to describe those who graduated with bachelor of science degrees as waste products if they did not continue on to doctoral work is totally inaccurate!

Tovell and Madill (1993:1048) stated that a linear career pattern, such as the leaky pipeline suggests, is not typical for women and that “the Pipeline, should it exist, is branching, not leaking!” Tovell et al. (1998) pointed out that the first years of engineering education are so focused on theoretical concepts that by the time students are allowed to show any creativity, usually in third year, it is too late for some; most of the creative students have withdrawn.¹⁸ Their findings support my evidence that several students left because they missed creativity.

¹⁸ Third year was too late for the U of S Dean of Commerce (see fn 5.8 this chapter). To even remotely suggest that a female university administrator should be classified as “waste” is grossly insulting. The idea of branching rather than leakage is more appropriate.

Moreover, Tovell et al. (1998) argued that the linear focus of the leaky pipeline is an example of the inherent masculine character of the engineering profession, which is not always attractive to women. In the leaky pipeline, the content flows in one linear direction until it encounters a 'leak' in the line through which the 'waste' is flushed out. In contrast, during my interviews I met young women who came into the study of engineering by accident. For example, one woman was in a pre-veterinary medicine program when she became friends with an engineering student. Another woman was planning to study physiotherapy when an engineering student became her roommate. Both of these women became interested in the work their friends were doing, and both switched *into* engineering. In addition, a participant in my M.A. research returned to complete her engineering degree after ten years in business (Anderson, 1994). The leaky pipeline explains only transfers out of science and technology and disregards transfers into these fields, whether deliberate or accidental.

The leaky pipeline model does not explain women's attrition from engineering education. Instead of the assumption of academic deficiency, it is likely that the decisions women in engineering or science make, and the directions they take over the years of their education, depend on the encouragement, discouragement or other incidents they experience en route. For example, Sadker and Sadker (1994) showed that when girls are not included in science, they tend not to choose science subjects but seek less exclusionary opportunities. In addition, both Eisenhart and Finkel (1998) and Frize (n.d.) argue that for women to stay in these fields, they have to be treated well and allowed to be women.

The leaky pipeline model not only fails to explain women's attrition, but its exclusive focus on women is also problematic. That is, the attrition rate for women has been defined as a problem, whereas the attrition rate for men is left unexamined. This differential treatment of men and women can be read in a number of ways. In part, the under-representation and the attrition of women reflect a genuine concern for the status of women in engineering. At the same time, a model that singles out women, particularly a model which focuses on individual failure, may have the unintended effect of reinforcing the view that women's abilities are inferior to men's.

The pipeline metaphor can be *one* way of depicting the educational system. Students *do* flow through the years of pre-school, elementary school, junior and senior high school, into

a variety of post-secondary educational fields and institutions. However, a pipeline is rigid and confining, leaving no room for lateral or reverse movements. The leaky pipeline metaphor assumes that it is the individual girl's or woman's responsibility to remain within the pipeline once she has initially entered it, and that she should 'tough it out' in the prevailing masculine environment. As a model or metaphor to describe university students who initially enter the study of science or technology and later change to other fields, a pipeline that leaks is not appropriate. Nor is it appropriate for any other change in educational direction. Changing from science subjects to the arts, social sciences, humanities, commerce, medicine, or vice versa—even from academic to vocational disciplines—cannot be considered as 'wasting' talents.

While the "pipeline" is a model that is relevant to engineering, another way of looking at attrition is through the medical ailment of "hemorrhaging." Sheila Tobias (1990) conceptualized the attrition of possible science workers at the college level as 'hemorrhaging,' a problem which she believes has been ignored for too long. Considering the sheer number of college students who, as a requirement or voluntarily, study introductory science courses, some flow from these fields must be expected. For example, one requirement for a B.A. degree at the U of S is a course in a science or mathematics. However, Tobias (1990:13) posits that "the flow out of science continues seemingly unchecked" even after students have completed their degrees. Unlike the leaky pipeline, which focuses solely on women, hemorrhaging also applies to men who decide to discontinue science or engineering education. The use of the medical term 'hemorrhage' suggests a diagnosis for a patient with a serious illness, where the patient and the illness are the science and technology disciplines themselves, not the students who flow into and out of them. Similarly, a pipeline that leaks suggests a construction defect (or lack of maintenance) in the pipeline itself and not in the 'product' it loses. Both the hemorrhaging patient and the defective leaky pipeline require treatment to cure the ailments and stem the loss of qualified students.

Alternate Metaphors

My data indicate that the students made very deliberate choices when they decided to discontinue their engineering education. The men and women in my sample of transfer

students chose a variety of paths, ranging from returning to science education as a mature student after raising a family to suggesting that there would always be an option to return to engineering. They had discovered that their interests had changed. Therefore, I suggest other metaphors with more positive imagery. Instead of a 'pipeline' that 'leaks' students, we can see a river forming a delta of branches to the sea, and deltas are usually quite productive. In addition to the fertile river delta, we could compare career changes with 'taking another fork in the road' or 'sailing a different sea,' not to mention 'marching to a different drum.' These images have connotations of deliberate choice and action. Another possibility is to see all educational choices as items in a treasure chest or dishes on a buffet table, from which it is possible to pick any item, try it, and if it does not feel suitable, select another.

My personal image, in both real and metaphorical terms, is of students walking in corridors with doors on both sides, doors that open up to a variety of opportunities they may not have thought of or known about when they first enrolled in the university. In this "Corridor of Educational Opportunities" there is two-way traffic; students walk back and forth and cross over, opening, closing and re-opening doors at various points. If a door is closed, it may be opened later. Through the 'rooms' on either side of the corridor there may also be doors connecting directly to other rooms, other opportunities, without re-entering the corridor. This dynamic, positive and more flexible metaphor allows for re-entry and a flow *into* engineering as well as transfer out of the discipline. Or, if we choose to stay with the pipeline concept, we must, with Tovell and Madill (1993), consider that it is 'branching' off.

CHAPTER SUMMARY

In this chapter I have discussed the attrition from engineering education at the University of Saskatchewan. Engineering and science education has often been explained as an educational pipeline flowing in one direction from primary school to post-graduate education. Starting with a wide base at the entry level, the pipeline narrows as the educational level increases; when students discontinue science education there are 'leaks' in the pipeline. The 'Leaky Pipeline' has been used to both explain and lament the decreasing student population, particularly women, in science and engineering. Students who drop out of sciences and mathematics in high school are deemed to have had an educational deficit. Remedial strategies

to stem the leak and eliminate the deficits have been mostly stopgap and piecemeal, such as calculus camps.

I have presented the narrative data, both verbatim and paraphrased, from my interviews with six male and ten female students who chose to discontinue their engineering education. I have connected these statements to the research literature I reviewed in Chapter Two, as well as to other literature. My empirical data suggest that these students left, first, because they were uncomfortable with the male dominance in the college, which several students perceived to be an attitude of superiority and elitism and, second, because they had unrealistic expectations of the study of engineering and the workload involved, mainly due to a lack of knowledge about the study and the profession. In addition, there were other reasons for discontinuing the study of engineering, such as motherhood and dissatisfaction with the university bureaucracy in general. As well, the linear feature of engineering education does not appeal to women (Tovell and Madill, 1993).

All of these students had entered the College of Engineering at the U of S with enthusiasm and a vision of earning a professional degree in a relatively short period of time, a degree that would give them access to a prestigious profession with varied assignments and well-paid positions. Their attitude was not to cry over spilt milk but to learn from the experience. When choosing alternate careers they were a little slower deciding on what they wanted to do, as they said, for the rest of their lives.

My data show that most of the men who left engineering sought other sciences as their majors, especially computer science, although some did choose non-science disciplines. The women, on the other hand, were more apt to search out non-science fields, and especially fields that would have social connections. Even those who stayed within a scientific discipline sought out specialties that would feature social or environmental content.

My data, based on interviews with sixteen former engineering students, indicate that rather than plugging a 'pipeline' that 'leaks,' that negative metaphor should be replaced with a positive alternative. Women should not be required to change their person or their lifestyles in order to accommodate the masculine engineering culture. Instead, when there is a critical mass of female practitioners in engineering or science, engineering and science would of necessity have to change to accommodate the women. This would require a review of the negative

assumptions of the 'Leaky Pipeline' metaphor, or possibly abandon it altogether. In its place, I have suggested several other metaphors to explain why men and women change career paths. I prefer the idea of a 'Corridor of Educational Opportunities,' which is a positive expression of deliberate choices that open doors to fields and disciplines not previously considered. Rather than changing women to fit engineering, engineering education and the engineering profession must make allowances to accommodate the steadily growing number of women in the profession, which is an enrichment to the entire profession (Frize, cited in Lang, 1997).

As this chapter has shown, the Leaky Pipeline as a metaphor and explanation for women's attrition from engineering education is not suitable because it is based on a model of an academic deficit for women, yet women do not enter engineering studies without a strong background in mathematics and science. Instead, I believe women's attrition and low participation in science and engineering are more related to a hostile atmosphere in the institution. This issue will be explored in the next chapter, which addresses the learning environment in engineering.

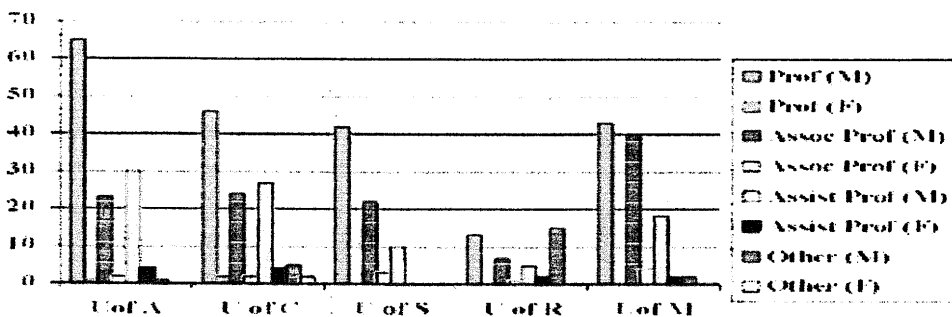
CHAPTER SIX
“CONSTRUCTING” THE ENGINEER
(The Learning Environment)

The learning environment in the College of Engineering at the University of Saskatchewan (U of S) reflects the fact that engineering has been, and still is, a profession for men. Because women have only recently become a critical mass in engineering, there is a dearth of women qualified for academic appointments. Consequently, the faculty is almost exclusively male with only the occasional female professor and some female lecturers, mostly in non-technical courses. The learning environment is then an important feature of socializing the students into the masculine professional culture. Fitting an increasing number and proportion of female students into this environment may be much like fitting square pegs into round holes.

The University of Regina, the other university in Saskatchewan, appointed a female professor of engineering in 1987. It was another four years before the College of Engineering at the U of S appointed its first female professor (A.P.E.S., 1993). Until 1991, the only female professors engineering students met were from other colleges and who instruct required or elective courses in the engineering curriculum. A mature female engineering student I interviewed in 1992 was quite excited when she told me that there was one female professor in the college. Later in the 1990s, a second woman joined the college faculty. It may be noteworthy that both of these women held positions in the Department of Agricultural and Bioresource Engineering, that is, in the department having the highest ratio of female to male students (See Chapter Four, Table 14). However, the first of these female professors resigned her position in 1999, and the other left in 2000. Presently, the only female professor in the college holds an endowed chair in communication and is not an engineer. In comparison, universities in Ontario report 1998 ratios of between 2.4% and 9.8% female faculty members in their engineering schools. Ryerson Polytechnic Institute topped the list with 9.8% (n=11) with a female student population of 16.1%. University of Toronto followed with 9.2% (n=16)

female faculty for 25.3% women. Waterloo University had the largest number of female professors, with 8.8% of the engineering faculty (n=26), and 20.7% female student population. Even the Royal Military College (RMC), with 20.5% women in their engineering program, had three female professors, or 7.1% of the engineering faculty. However, Guelph University, with the highest ratio of female students (36.4%),¹ had the lowest ratio, 2.4%, with one professor (Frize, 2001).

Figure 6.1. Engineering Faculty Members By Institution (1998)



Source: CCPE Report, "Canadian Engineers for Tomorrow" 1994-1998. On website for Chair for Women in Science and Engineering, Prairie Region. <http://www.geomatics.ucalgary.ca/cwse/Univers>.

Figure 6.1 illustrates the predominance of male faculty in engineering schools in Canada's Prairie Region in 1998. At that time, only the University of Alberta and the University of Calgary had women in full professor positions. All five Prairie universities had female associate professors, and all but the U of S had assistant professors.

The engineering students experience very limited exposure to professors, lecturers or students from other colleges because most instruction is done 'in house.' Female instructors, especially, are in short supply. However, one female practicing engineer who instructed a third-year communication course, had noticed that several of the sections in that course had female instructors from other university disciplines. She believed that this was good, because the 'outside' teachers were able to expose the engineering students to different academic cultures. Essentially, however, the only women working in the College of Engineering are

¹ The female engineering student population at Guelph peaked in 1995 at 42.9% (Frize, 2001).

secretarial and administrative staff. Thus, there were too few women in the college as faculty, role models, and mentors for the female students. How does this situation affect the students in the college? The interview data indicate that the men and women have differing opinions on the situation and that some female students felt excluded from many of the experiences that the male students perceived as natural parts of their education.

In the two previous chapters I have discussed what attracted the women and men in my sample of engineering students to the profession and the problem of attrition from engineering education. In this chapter and the next I address my final research question:

In light of the high attrition rate for women what kind of educational, social and cultural influences do women experience during their tenure as students? Or, in lay terms, what is it really like to be a woman and a student in a College of Engineering?

This chapter has two separate, yet interrelated, parts. In the first part, I discuss the classroom environment in engineering, which includes how class sizes and teaching approaches affect the interaction among students and between the students and their professors. While this research is not an in-depth study of pedagogy in engineering, pedagogy is an important feature of the learning environment and, as such, influences the students' well-being. The data for this section is a combination of my observations in several first-year, third-year and fourth-year engineering courses, my survey results, and interview statements by the students.

In the second part, I discuss the social environment, which involves the more informal student interactions both inside and outside the classroom. As the data will show, some students believed that women were favoured in the college. What they did not realize was that there were several types of sex discrimination in both the pedagogical and social environments. In this environment, the female students experienced in reality an illusion of being included as equals to the male students.

THE CLASSROOM ENVIRONMENT

The literature suggests that a good learning environment requires the partners in learning to have respect for one another, and that all partners focus on learning as an enriching and empowering experience (Eisenhart and Finkel, 1998; Stalker and Prentice, 1998). In the classroom, however, both students and teachers are gendered subjects, and women's intellect is often trivialized and negated in this setting (Briskin, 1994). Therefore, colleges must insist on

teachers knowing the rules for proper treatment of all students and enforce those rules (Baum, 1989). One way to do so is through Sheahan and White's recommendation that the school's best teachers should instruct first-year students in order to keep these students until graduation. Good teaching in introductory courses goes a long way toward cultivating human potential and instilling an understanding for the essential concepts, rather than weeding out surplus students (Sheahan and White, 1990).

While the emphasis in science education is often limited to the techniques used within the particular science, women, especially, value discussion of the subject as a means to constructing meanings within science (Donaldson and Dixon, 1995). Such discussion is one way for students to process the information they receive into knowledge that is meaningful to them. Sally Hacker (1989, 1990) found a heavy reliance on problem solving skills in engineering education. Recent research on engineering education in Canadian universities (Dececchi et al, 1998; Dryburgh, 1999) has found that problem solving is still a major part of the engineering education. Hacker also found a heavy reliance on what Paolo Freire (1970) called the 'banking method,' whereby teachers 'deposit' information with the students, from which the students would 'withdraw' to produce the correct answers at examination time. This kind of rote learning has been the traditional instruction in science education, augmented by laboratory experimentation. By testing students, the banking method would be able to 'weed out' those whose 'accounts' did not have a high enough balance. Hacker was particularly critical of this type of pedagogy and believed that the emphasis on test-taking, i.e., the importance of producing the only right answer, ignored or did not encourage an understanding of the ideas or processes involved.

This method, termed the "instruction paradigm" by Gwyer Schuyler (1997), has been criticized by a number of writers both within and outside the sciences. Alfred North Whitehead, an English philosopher and mathematician who worked in the United States early in the 20th century, would have characterized this type of teaching as testing memory, rather than testing students' understanding of the subject matter. Whitehead saw a difference between true education and simply dispensing knowledge without any real understanding of that knowledge. He believed that "students are alive, and the purpose of education is to stimulate and guide their self-development. . . . as a corollary, the teachers also should be alive

with living thoughts” (Whitehead, 1927/1957:v).

Among others, Hacker, Schuyler, and Whitehead promoted a learning paradigm where the focus would be on comprehension rather than on memory alone. O’Banion proposed a shift in education, exchanging the instruction paradigm for a ‘learning paradigm’ that would “place learning first in every policy, program and practice in higher education by overhauling the traditional architecture of education” (O’Banion, 1995-96, cited in Schuyler 1997). The learning paradigm is holistic and aids students in constructing their own knowledge. Such an approach would reduce the ‘weeding out’ of students and be appropriate for students of diverse backgrounds. Further, such constructivist approaches “are regarded as producing greater internalization and deeper understanding than traditional methods” (Abdal-Haqq, 1998).

Paradigm Shift in Engineering Education

In his treatise on *The Structure of Scientific Revolutions*, Kuhn (1970) argued that scientists are engaged in solving problems during periods of normal science. However, as anomalies appear the foundations of the paradigm are challenged, leading to a gradual shift through several stages to a new paradigm. Kuhn’s concept of paradigm shift has been applied to curriculum change (Shuster and Van Dyne, 1984; Lewis, 1993), feminist pedagogy (Belenky, et al., 1986), and women in science (Dyck, 1998; Rosser, 1988; Tripp-Knowles, 1998) among others. These writers have followed Kuhn’s development of stages to propose transformations of the paradigms in their fields to become inclusive of women.

Curriculum Change

In the late 1970s and early 1980, Marilyn Shuster and Susan Van Dyne (1984; Van Dyne and Shuster, 1985) outlined a six-stage model for curriculum transformation in college level liberal arts disciplines whereby women and women’s contributions would be implemented and incorporated at all educational levels and result in a paradigm change in liberal arts education. Shuster and Van Dyne’s (1984) first stage started at the point where women were invisible in most liberal arts courses. The ‘banking method’ or ‘instruction paradigm’ was prevalent, and courses were taught as if women’s and gender issues did not exist at all. By

gradually increasing gender content throughout the stages, by the sixth and final stage, gender would be a category of analysis; there would be a transformed, balanced curriculum focusing on how class, race and gender intersect; students would become collaborators in their own learning, contributing to knowledge from their own perspective. All courses would be transformed through “inclusive vision of human experience based on difference [and] diversity, not sameness [and] generalization” (1984:419), and students would become empowered to take responsibility for their education. The educational paradigm would be the ‘learning paradigm,’ having replaced the ‘instruction paradigm,’ and the curriculum would prevail in a new, inclusive paradigm.

At the same time as Shuster and Van Dyne worked on the academic infrastructure of integrating women into the general curriculum, Mary Belenky, Blythe Clinchy, Nancy Goldberger and Jill Tarule (1986) were studying the learning process of individual women as women’s ways of knowing. Their study describes a different way of learning and knowing for women than for men. Belenky et al.’s schema starts with a stage of silence, where women are not seen, not even heard. Thus they were invisible, similar to Shuster and Van Dyne’s first stage. Through the next stages, much like Shuster and Van Dyne’s, women learn to use their own experiences as valid and valuable knowledge. By adding their own knowledge to general knowledge, the individual may connect to a larger context and eventually incorporate personal knowledge with the public knowledge in connected, constructed and integrated knowledge.

Sue Rosser (1988) applied Shuster and Van Dyne’s model for liberal arts education to her discussion of integrating women and women’s contributions into science and science education. She showed the same progression from stage one where women are missing and not even noticed, through adding famous women’s names in stage two to reading about famous women’s scientific discoveries in stage three. In stage four, women would be the focus of the research (for example, health and reproduction), and stage five would use gender as a category of analysis. The sixth and final stage would be reached when students could understand that there is no single approach to practising science.

Other writers have used and expanded on Rosser’s idea. For example, Sue Lewis (1993) developed a taxonomy wherein the first three stages critique the present focus on changing the women to fit the existing system of male-dominated courses in science and

technology. She saw that such a model was exclusionary to women, resulting in 'self de-selection,' or attrition from these fields. In the last three stages Lewis concentrated on changing the system itself. She believed the problem rested with the structure of secondary education, with engineering education and with the engineering profession. She challenged the model by developing programs and strategies to transform curriculum and pedagogy in science and technology to reflect the feminine gender in the teaching of these courses. Similarly, Peggy Tripp-Knowles (1998) urged educators to change the curriculum and teaching methods to make both more amenable to girls' and women's learning styles. Lillian Dyck (1998), as well, has expanded the concept to include equity for female science faculty members. By heeding these writers' suggestions to adopt this type of education, post-secondary institutions would better reflect and encourage the ways in which women learn and thrive with pedagogies that would complement the transformed curriculum approach.

In an attempt to introduce a feminist perspective on gender, class and race in engineering and science courses, Lisa Weasel et al. (2000) revised an existing course in communication at their own university. As the course was already accepted as part of the engineering curriculum at the school, it was possible to incorporate subject matter and concepts related to general gender dynamics in communication. Furthermore, Weasel and her collaborators included harassment laws and policies as well as discussions of the power differentials between dominant and subordinate groups. They also recommended that the course be cross-listed and available for credit in other majors, especially women's studies. The addition of non-engineering students in the class, they believed, would add to the engineering majors' understanding of these issues. The selected text was the McIlwee and Robinson (1992) work cited in this thesis.

In addition to the revision of the existing course, Weasel et al. (2000) designed a course in seven modules based on the works of several well-known authors, e.g. Sandra Harding, Evelyn Fox Keller, David Noble and others, covering historical, philosophical and biographical approaches to science and engineering. The proposed modules cover gender and the intersections with theoretical and practical applications in the physical sciences. Assignments included such projects as personal journals, actual research and presentations, and class participation and discussions. Weasel et al. admit that their proposals are not the only

solutions to bringing gender into the curriculum in science and technology, but suggest that even small changes in curricula can lead to much broader revisions, subject to support and approval from faculty and students.

Weasel et al. (2000) have shown that it is possible to make curriculum changes and incorporate gender into courses that essentially must be classified as social science courses. From changing curricula to changing entire programs and climates may be a giant leap, yet Fox (1998) shows how some science and engineering institutions have made environmental adjustments specifically to accommodate and retain women in their graduate programs. One of those institutions had as its goal “to change the culture of the university and its science departments . . . [but] to do something substantial we need to change presentation of the curriculum” (Fox, 1998:214). By doing so, the institutions were creating more woman-friendly universities.

Pedagogical Approaches

Theory and research on pedagogy have examined the methods best suited to teaching and learning different subjects. Cove and Love (1996) stress the linkage between cognitive, social and emotional processes, stating that emotions, interpersonal relationships and social context are important to both memory and learning. Additionally, Belenky et al. (1986) and Abdal-Haqq (1998) have challenged the traditional teaching methods, which rely mainly on classroom instruction in a lecture format, what Freire (1970) called the ‘banking method’ where the teacher talks, and the students listen passively.

In her study of engineering education, Sally Hacker (1989; 1990) was critical of courses designed to weeding out students. After studying engineering from the outside through participant observations and interviews with engineers, engineering faculty and students, Hacker enrolled in engineering courses for two years, experiencing all the tensions of being a female engineering student and being trained as an engineer. She wanted to know what it really felt like learning from the inside, what she called “doing it the hard way” (Hacker 1990:108). During her engineering studies, Hacker discovered that “the right answer to the question was the crucial thing” (1989:40) and that the students “worked toward the tests, not for understanding” (p.41). Thus, test-taking itself became the chief criterion for success in

engineering; understanding how the engineering concepts worked and were developed was accorded little or no importance.

Sheila Tobias (1990; 1990b) is another researcher who examined science education at the university level and stressed the importance of understanding, as opposed to problem solving according to set formulae. In her study, she engaged social science and humanities students to critically and 'seriously audit' introductory science courses, especially physics and chemistry, including taking the various tests. These students, whom she called 'the second tier,' felt a lack of understanding for the subject because there was no opportunity to challenge and discuss the science concepts as they were presented. They saw the emphasis on solving problems according to prescribed patterns as a major barrier to understanding the concepts, which made these courses unacceptable to the non-science students. Through the students' participant observation journals, Tobias found that non-science students did not feel comfortable with the 'banking method' of course presentation. Because they were accustomed to interactive discussion about their majors, the students found the lecture with overheads lacking both context and depth. The students wanted more 'why' questions rather than 'how' questions, both asked and answered. They wanted the professors to demonstrate the creativity and finesse of the discipline rather than focusing on problem solving, using the one correct method to arrive at the one correct answer (Tobias 1990; 1990b). Tobias concluded that rather than being 'dumb,' these students had different expectations and values from science students.

Tobias (1990:59-61) also showed how it is possible to accommodate changes in science teaching through the 'grand reform' in introductory chemistry developed by Professor Dudley Herschbach at Harvard. Instead of assigning text or problems the first day, Herschbach played music and gave a philosophical lecture on 'the nature of science.' He had discovered two distinct types of students: the 'sprinters' who quickly grasped new concepts, and 'long-distance runners' who caught on more slowly, but who, in the end, had a more profound understanding of the subject matter. He humanized his teaching approach by 'covering less but uncovering more,' which forced students to think qualitatively before they could plug in formulaic numbers. Through regular meetings with a committee of students, Herschbach sought feedback on how the course progressed and was available for regular discussions in one

of the university's dining halls. Herschbach also rearranged marking for the course to reflect the difference in learning types, so that no student would fail because of a single exam or quiz. Instead, students could develop individualized weighting of final exams wherein it was possible to make up any point discrepancy. Following Herschbach's pedagogical changes, enrollment in his class doubled, average performance increased, and students enjoyed chemistry.

The literature indicates that women, in particular, feel uncomfortable with the present 'banking method' educational paradigm and that a paradigm shift is indeed necessary. For example, citing Belenky et al. (1986), Sandra Kerka (1993) emphasized that women develop their identity based on relationships, connections and intimacy with others. Women preferred cooperative learning to competition and chose interactive information and power sharing over individual control and command. Thus, competition is one institutional barrier to women's educational opportunities. Other such barriers, which are particularly evident at the Royal Military College of Canada (RMC), are group, or team sports that are traditionally male, and the pressure on young women to be physically measured by male standards. Female engineering students at the RMC experience a 'double whammy' because of the male predominance in both the military and in engineering (Dececchi et al, 1998). Referring to feminist critiques of education, Kerka stressed that

socialization, unequal access and power, and educational systems predominantly based on objective, linear, analytical type of thought typically associated with males have a number of effects: devaluing of emotions and relationships and lack of confidence and self-esteem in women (Kerka, 1993:2).

However, the presentation of course material is often dependent upon the size of the class and the classroom. Gerd Brandell (1996) reports that although all the students in the engineering program at a Swedish university preferred 'small' group classes of 25-30 students each to large lecture theatre presentations, the women were especially appreciative. Almost as an echo of Franklin (1993), Brandell states that projects and strategies like these may, in the end, help to create the "woman-friendly" university that would contribute to a "better education for all students—not only the women!"

A Woman-Friendly University

Over the years, feminist writers (Frize, 1996; Rich, 1979; Saunders, Terrien and

Williams, 1998) have called for a 'woman centred' or a 'woman friendly' university. Long before Shuster and Van Dyne developed their model of curriculum transformation, Adrienne Rich suggested that education is something for women to claim (to take as their rightful owner, i.e., acting) rather than to receive (to come in possession of, i.e., being acted upon). By claiming their education, especially a woman-directed education, women act upon their own destiny, "the experience of taking responsibility toward *yourselves*. Our upbringing as women has so often told us that this should come second to our relationships and responsibilities to other people" (Rich, 1979:233. Italics in the text). Rich also berated learning institutions and faculty that do not take female students seriously. "The undermining of self, of a woman's sense of her right to occupy space and walk freely in the world, is deeply relevant to education" (Rich, 1979:244). She envisioned a woman-centred university that would not be alienating to women. This change would, however, not be possible in a society that remained androcentric. A woman-centred university would require two categories of change to serve women's needs:

The first category includes both the content of education and the style in which it is treated. The second includes institutionalized obstacles that effectively screen out large numbers of women from full or partial engagement in higher education (Rich, 1979:141).

Franklin (1993) and Brandell (1996) also agree that a 'woman-friendly' university improves the university environment for everyone. To that end, the Professional Engineers of Ontario (PEO) and Dr. Monique Frize, P.Eng., then the NSERC/Nortel Women in Engineering (WIE) Chair, co-operated to establish a list of criteria to aid women in selecting an engineering college that would provide a climate conducive to female students (Frize, 1996). While Frize and the PEO had a particular interest in engineering colleges, the Canadian Federation of University Women (CFUW) had a general, universal concern about improved conditions for women in higher education. As a criterion for a generally woman-friendly university, the CFUW believes "it is a place where every woman feels comfortable living, studying, working and playing; a place where she can reach her full academic and personal potential" (Saunders et al., 1998:223). Frize (1996) and the PEO proposed several requirements that would be helpful in establishing a woman-friendly learning environment. There should be:

- Administrative leadership in response to women's needs and issues

- An initiation process and welcoming practices for female students
- Support, services and security measures for women on campus
- Improved collegial student behaviour toward women
- Equality in staff and faculty's attitudes toward and treatment of women
- Enrollment data available for the past five years to evaluate graduation and attrition

These requirements and their recommendations for implementation are similar to the suggestions in the CFUW report. Furthermore, the strategies coincide with many of the recommendations in the literature on recruitment, retention and attrition. The corollary of Franklin's (1993:15) statement, which is supported by Brandell (1996), would be "what is good for female students, is good for all students." Implementation of the combined recommendations by Monique Frize/PEO and the CFUW could make a difference in the education of all students, all female students, and female engineering students in particular.

Factors that Impact on Learning

In order to familiarize myself with engineering education, I believed that classroom observations would be meaningful. I also believed that by attending these courses, I would be able to make contact with individual students and gain insights into their daily routine and lived experiences in the male-dominated college, which is an aspect of engineering education that has so far not attracted much research (Dryburgh, 1999), and which would benefit the planned interviewing phase of the research. Through observations and informal conversations I realized that many factors influence the successful completion of a B.E. degree, such as the size of classes, the course load, the professors' skill, teaching style and dedication, and an inviting climate both within the classroom and in social interaction among the students and between the students and their professors.

The first-year program for the incoming cohort in the College of Engineering at the U of S in 1996 had a heavy emphasis on science and mathematics courses: Chemistry (1), Geology (1), Computer Science (1), Graphics (drafting)(1), Calculus (2) and Physics (3), all of which had a laboratory component. In addition, there was one course in English (literature and composition), one elective course in either Chemistry or Physics, and an "Introduction to Engineering" course, GE 131.1, for a total of 34 credit units. Most of the first-year courses in

the college are coordinated so that the content and work for the course are the same for all sections. Each course, except Eng 115.3, has a common examination for all sections.

The Size of Classes

The total number of students enrolled in the first-year curriculum in the College of Engineering is limited to 410² (University Studies Group, 1995; 1999) necessitating several sections in each required course. Lecture room and laboratory size limited the size of the sections. For example, the drafting course, GE 163.3, offered five sections during the academic year, three in the fall term and two in the winter term; each section had a class size of 70 (the capacity of the special drafting room), while the other first-year courses were taught in large sections of about 100 students, with laboratory sessions of about 50 students. In the first-year English course the sections admit roughly 30 students from colleges other than Arts and Science. The "Introduction to Engineering" course, GE 131.1, had a lecture component, which was given in sections of approximately 200 students, and a seminar component of between 25 and 30 students per section. In the upper-year classes, the third-year communications course had sixteen students and the fourth-year "Engineering and Society" course, popularly called 'ethics,' 50 to 80 participants each.

The Course Load

In the College of Arts and Science, five courses per semester (30 credit units per year) is considered a full course load, and only science courses have lab sessions. Prior to the 1999 curriculum revision, the first-year program in the College of Engineering consisted of six and seven courses per semester for a total of 34 credit units, and all the first-year science courses required up to three hours per week in laboratories or tutorials in addition to three hours weekly of classroom lectures. That meant that students could spend 30 hours or more in the

² The quota includes first-year and upper-year transfer applicants. This number also includes students who have not quite completed their first-year requirements and consider themselves to be second-year students, either by opting for a five-year program or by failing and needing to repeat a required course. The college, however, considers the year level according to how long it will take each student to graduate; if more courses are needed than the required course load for years two, three and four, the student is considered first year. The limit also included students who had transferred credits from other colleges or institutions and therefore the entire cohort may not participate in all the required first-year courses.

classroom or lab during the week. Moreover, there were homework assignments, some times as much as 15-20 hours per week, according to the survey responses. For example, in drafting there was an assignment for every class; physics had a set of problems each week; and GE 131.1 had weekly assignments. In the English course, where the syllabus consisted of a Shakespeare play, a novel, several short stories, poetry and grammar, the readings were discussed in class. Homework assignments, some of which could be completed during class time, consisted of some grammar exercises, as well as an essay. This type of course load, which required two full courses more than a first year liberal arts curriculum prevailed in at least one other Canadian engineering program (Dryburgh, 1999). Many of Dryburgh's respondents complained about this heavy course load; it was also a concern for several transfer students in my study (Chapter Five).

A student's schedule with seven courses in the term is as much a test of endurance as academics, which confirms Dryburgh's (1999:669) contention that the engineering culture requires students to "work hard." Therefore, in 1997 an accreditation committee recommended that the first-year schedule be lightened. The curriculum was revised as of September 1999, eliminating some courses and combining the contents of others. The curriculum now consists of 30 credit units, or five courses per semester. However, all but two of the present required first-year courses carry a three hours weekly laboratory element. Although some students graduate after four years, many students opt for schedules that spread the curriculum over five years, resulting in the average time for completing a B.E. degree of 4.8 years for both women and men. (See Tables 6.1 and 6.2).

Table 6.1, which was prepared by the Office of the Dean of Engineering, shows a 100% success rate for women with admission averages of 95% or more. However, the success rate drops dramatically for grades below 95% at admission, the largest drop being between 90% and 95%. In addition, the average time to completion increases from 4.2 years for the highest averages to 6.3 years for averages between 75% and 80%. It appears that this average at admission is the lowest possible for women, and even then, only one in four female students (24%) completed the program.

Table 6.1. Direct Entry Graduation Rate for Female Students. Years of Entry, 1988 - 1993

High school Average	Number Admitted	Number Graduating	Success Rate	Average Years to Graduate
95 and above	6	6	100%	4.2
90-94.99	48	37	77%	4.5
85-89.99	82	49	60%	4.9
80-84.99	53	14	26%	5.3
75-79.99	17	4	24%	6.3
Below 75	2	0		N/A
Totals	208	110	53%	4.8

Source: Table provided by Assistant Dean of Undergraduate Administration, College of Engineering U of S.

Table 6.2. Direct Entry Graduation Rate for Male students. Years of Entry unknown.³

High school Average	Number Admitted	Number Graduating	Success Rate	Average Years to Graduate
95 and above	6	5	83.3%	4.0
90-94.99	37	32	86.5%	4.3
85-89.99	57	43	75.4%	4.7
80-84.99	73	39	53.4%	5.0
75-79.99	72	20	27.8%	5.5
Below 75	28	5	17.9%	5.4
TOTAL	273	144	52.7%	4.8

Lowest admission mark 70 Highest admission mark 98.2

Lowest mark to graduate 72 Highest mark to withdraw 96

Source: Derived from raw data provided by Assistant Dean of Undergraduate Administration, College of Engineering, University of Saskatchewan.

Table 6.2 shows that only male students with high school admission averages of 95% or more were able to complete the four-year engineering curriculum in the prescribed four years, yet even an entry average of 96% did not guarantee graduation. At the lower end of the scale, no women admitted with an average below 75% completed the program, while 18% of the male students in the same category had completed. Only 19 women (n=17 and 2) had admission grades below 80%, and only 21% of them (n=4) had completed their program,

³ Table 6.2 is based on a random list of male admission averages and the time it took for each to complete the four year requirements. These numbers did not indicate if the requirements for a B.Sc. were included in the years to graduate. See also Chapter Four, fn. 14.

needing an average 6.3 years. In contrast, 100 men had admission grades below 80%; 25% of them (n=25) completed the four-year program in 5.5 years, almost a full year less than the women. At every grade level at admission, the women needed longer time to complete. In addition, only 53% of the students, both female and male, completed the program, the exception being the 100% success rate for women with an average over 95%.

During later interviews, some students, both male and female, explained that they had opted for the five-year completion strategy in order to “have a life.” They cited lack of time as a deterrent to their education; too many concepts were introduced in too short time and there was not enough time for thorough⁴ explanation. Whitehead’s (1927/1957:2) advice was “Do not teach too many subjects. [But] what you teach, teach thoroughly.” Otherwise, he believed the students would suffer from “passive reception of disconnected ideas.”

Teaching Styles and Approaches

The size of the class, the course content and the experience of individual professors⁵ influenced the teaching style applied in each class. In the classes I observed, the teaching style varied from straight lecture to interactive teaching, and the delivery from up-beat and lively to monotonous drone. The course sections were taught by different professors and showed different teaching styles between the sections. The first-year drafting course was presented as lecture *cum* problem-solving sessions where the professor with the help of monitor projection illustrated and solved a theoretical problem from the text, explaining each step as he proceeded. In the physics sessions, problems were solved through mathematical formulae on overhead screens. The problem-solving approach appeared to satisfy most of the students. In those classes, the students were able to assemble the correct procedure for solving specific problems and to use them as models for more general problem solving.

Course presentations that challenged the problem-solving approach were not always welcomed. A female student explained “I like lectures if the professor is good, but if he doesn’t interest me I don’t listen at all. [In contrast], in one class we didn’t have lecture format

⁴ “Thorough” is the motto for the College of Engineering. It is ironic, then, that the students complain that professors are not thorough in their teaching and explanations.

⁵ Because of the dearth of female professors in engineering, I use ‘he’ and ‘his’ throughout.

as much as round table discussions sessions, and I like that a lot” (Nicole, 4th year). One course that lent itself to a method different from problem solving was the ‘ethics’ course. At the fourth-year level, it could be compared to a social science seminar course with discussion of the various issues. However, by the time the students reached the fourth-year, they were so accustomed to mathematical problem solving by the professor that they did not appreciate the opportunity for discussing social and ethical issues.

Lecture format is efficient for getting the information across. We do have a couple of classes that lend themselves to discussion, but by fourth year, students are quite reluctant to discuss anything, they just say ‘just tell me what I need to know and I will write it down.’ The ‘ethics’ class went from a class of 50 to about 30 and only about ten of us would discuss anything (Marie, 4th year).

In the ‘ethics’ course, the presence of women was noted, and there was discussion about women’s role in engineering. Lynne (4th year) was disappointed with the ‘ethics’ course, saying that it “should have had more discussion than it does.” In one section there was lively discussion on issues that kept women from entering the profession. In another section, the class discussed whether or not a pregnant woman should be promoted when her project was due the same time as her baby, and the students thought she should not. Guest speakers representing the uranium industry were also able to elicit some questions, perhaps because it was controversial. However, the instructor usually had difficulty encouraging and sustaining a discussion

As an experiment, one professor had attempted a ‘reading class,’ which required the students to read a text and present its content to their classmates in a seminar format. The format was not well received by the students in the class, who saw this seminar approach not as an opportunity to think about and expand on the course content, but as an attempt by the professor to delegate his responsibility and to relegate his teaching to the students.

People who were in it didn’t like it. They got more recognition for their work during the year, but it wasn’t worth very much. Students were required to summarize text and present to the class. Professors should teach and we should read the text, and if we don’t understand, there should be discussion (Anne, 4th year).

The students did not appreciate the concept of a reading class, where they had to think deeper about the issues in order to digest and understand them. Anne’s rejection stands in contrast to Fiona’s complaint (Chapter Five) of just such lack of analysis in her engineering courses. The

resistance to reading classes and non-lecture formats in this class confirms Tobias' (1990; 1990b) conclusions that there are definite learning differences between science and non-science students. Moreover, the data in this study show that students are schooled in learning based on problem solving. In other words, the pedagogical strategies in engineering education become part of the engineering culture.

Good Professors, Bad Professors

In the College of Engineering some of the first-year arts and science courses are taught by professors in the College of Arts and Science, often in special sections for engineering students. The general perception among engineering students was that these professors were reluctant to teach engineering students. For example, one male student who had transferred to a mathematics program believed that the instructors in that department loathed teaching engineering students and had a totally different attitude toward 'their own' students. Similarly, one female English instructor had suggested that "engineering students are notoriously un-cooperative." Several students also admitted that they preferred the teaching staff in the College of Engineering to the Arts and Science instructors.

There is a difference between the engineering and the other profs. There is rivalry between engineering and the physics department. There is also difference between engineering physics and the math department. Engineering physics [profs] treat us more like engineers, as adults; they have fun with us, and they make life a little more comical, relaxed and less stressful. The math department is more strict and in my opinion has poor social skills. My favourite professor is a person who talks to me as an adult who is coming to school to learn. He respects us and we should respect him (Bob, 1st year).

The students had specific criteria that constituted a good professor as well as a bad professor. The most salient criterion for a good professor was clarity. A professor who could organize the material in logical sequence, who would either provide printed notes or write slowly and legibly on the blackboard, who would explain clearly in understandable language and dynamic presentation, and who would give students time to copy and digest the presentation, was considered the best. The students also identified a good teacher by his obvious enjoyment of sharing his knowledge and expertise with the students and by complementing the text, not just reiterating. Such a professor would be exciting and easy to

listen to and he would hold the students' attention. One reason why the upper-year students enjoyed their professors more than the first-year cohort did was that their professors were teaching their own specialties and were more excited about sharing their expertise.

Another important indication of a good professor was that he showed respect for his students by understanding the students' other academic commitments. Respect included arriving in class on time and treating the students as adults who were there for the purpose of learning, which included the professors' availability after class to clarify any questions or problems. A good professor would encourage and motivate the students and bring in outside expertise to add to his own.

Lots of the profs don't have much practical experience, but the ones who do are encouraging and motivating, up front and helpful. A good prof is a stimulating lecturer and someone who brings some outside experience into the classroom. Understanding scheduling and tailoring their schedules around your needs as well. But most of the profs in [department] value the teaching part of their job (Jeff, 4th year).

If clarity was the mark of a 'good' teacher, the most damaging quality for a professor was an inability to express himself or his topic in a manner that the students could understand. Albert (1st year) remembered a class where nobody appeared to understand, "so I asked the prof and he explained it.⁶ He was solving a problem without stating the problem. Nobody was questioning, because they thought they had missed something." A 'bad' professor would withhold some information, even after being questioned, and use it on a quiz, which the students thought was unfair:

Sometimes the professors don't know exactly what's going on. I know they understand what I'm asking and they just ignore the question and then, all of a sudden it pops up on a quiz. The easy stuff they go over in intense detail and then they go over the really hard stuff really quickly (John, 4th year).

Other times, it was a function of the professor's poor English language skills and being unfamiliar with Canadian education:

I've had instructors who just can't get the concept across. One was a language barrier, the professor had a very difficult time with the English language. When we asked questions, he didn't know what we were asking and he would go on in a different

⁶ Like Bob, Albert was an older first-year student and less afraid of 'losing face' by asking questions. Younger students appreciate that older students dare to ask (Anderson, 1994).

direction. It took us about a month to recognize that he didn't understand what we were saying (Marie, 4th year).

Where a good professor was dynamic and exciting, a 'bad' professor was monotonous and boring, and Amber, (1st year) found it "really hard to listen to people that have bad, monotone voices, they just kind of drone on and on and on." Where a good professor would be motivating and encouraging, a 'bad' professor would be condescending, discouraging and resentful, as Jeff, (4th year) explained: "There's one or two profs that are condescending and that is really discouraging. Some are really disorganized, and some are too geared toward the research side of their job." Jeff thought this was a matter of having generally poor teaching skills, not really wanting to teach, and therefore not organizing the lectures.

When I asked the students to identify good and bad professors, some of them took the time to relate 'horror' stories from their experiences as engineering students. While physics was the favourite first-year course, the first-year students indicated that calculus was their least favourite. Most of the complaints were against the mathematics professors.

I was harassed by professor [name] in the math department. We were in class the first day [of term two] and my friend and I sat up front. He asked us for an answer to a question, I worked it through and gave an answer. He laughed at us and said it was incorrect. He said 'if you were in my section last term you would have got the right answer.' The next class my friend and I sat quietly in the middle. Again he asked us, again we tried to give our best answer, nervous to give the wrong answer, because I don't have the background in math that other students have. The next class he asked us again; now this is three times in a row, and this is getting annoying, as I'm busy writing down notes.

The next class we sit at the back doing our work; the people behind us are talking and we're repeatedly telling them to be quiet. The professor looks up and says 'excuse me you people in the peanut gallery back there, what's the answer to this question?' and he's pointing at me and says 'yes you, in the peanut gallery.' And I looked at him and said 'excuse me, I find it offensive to be referred to as the peanut gallery, and I don't like it when people talk to me that way.' That's what I said across a class of 100 people, at which point he snidely said 'oh, I'm sorry to bother you, it was just a joke' (Bob, 1st year).

Bob had requested transfer to another section, and he believed this example explained why a number of students thought this particular professor to be very arrogant. As a former teacher, Bob thought the professor's behaviour was unprofessional; he had expected a higher level of professionalism from a university professor. One student who had left engineering and

earned a B.Sc. in mathematics and an M.Sc. in computer science, offered an explanation in defense of the mathematics department:

Some of the external profs have different attitudes about teaching engineering students than the engineering profs have. I don't think teaching engineering classes is a big thing for them to do. When I took my degree classes in the math department [the professors] were great, but the ones that have to teach the engineering classes seem like they don't want to be teaching engineers, and that's why they aren't good. I have been in a lot of classes with engineers since I quit and I have noticed that engineering students tend to group together in class and fool around more, and they tend to be quite disruptive (Matt, transfer student).

Upper-year engineering students who had declared their interests through their choice of departments, and who had more options in their course selection, still thought that their mathematics professors had been below par as teachers. However, aside from identifying one department as generally 'bad,' these students had more reasoned complaints against individual teachers. One graduating student stated: "There are definitely some professors in this college who should not be teaching. It is so painfully obvious that they don't want to be there and they don't want to teach" (Nicole, 4th year). The senior students, whose professors were teaching their own specializations, had more praise than complaints, and Marie (4th year) asserted that "the level of instruction goes up in third and fourth year."

Student Interactions with Professors and Peers

My observations in the classroom setting concentrated on voluntary seating arrangements and student interaction with professors and classmates. In the physics laboratory, partners were arbitrarily paired in alphabetical order and seated accordingly, while in the physics and the GE 131.1 lectures students seated themselves at random, and the seating arrangements varied from day to day. The drafting course offered the best opportunity for making seating observations because the students had to select seats that became permanent and were recorded for the purpose of monitoring attendance. I received the professors' seating plans for three of these sections. In all sections, it appeared that the female students preferred to sit near another woman and at the front of the room. In one section (n=67, women=17), one student needed to be near an electrical outlet and sat by herself. Four other women sat alone among the male students while six women clustered in two rows on both side of the

centre aisle. There were also three sets of two women together. In another section (n=51, women=15), there was only one woman sitting by herself, while six women sat in a two-row block, and two women sat in the row in front of a row of six women. In the third section (n=56, women=10), three women sat alone among the men, and the other seven were clustered together. I was able to observe the same seating pattern in the other two sections.

Similarly, in four of the five GE 131 tutorials, the female students were more likely to seat themselves in groups of two or three. In one particular section, three women sat side by side in the row directly behind another set of three women. It was obvious, by watching their interactions in class, that this arrangement was deliberate. Together they formed a group of six, which can be considered a critical mass in a class of roughly thirty students.⁷ The following year I was able to observe the same pattern in five sections of upper-year classes.

Later, during the interviews, eight women and seven men indicated that they preferred the front of the classroom or lecture hall; seven women and three men liked to be in the middle; four women and two men seated themselves in the back of the room, while five women and three men would sit anywhere. Some of the students stated that they were in groups of friends that had carved out a spot for the year. One man confided that he wanted to be near an exit so he could leave without being noticed if the lecture was uninteresting. Others avoided the rear of the room because it was noisy.

Personal interaction in the large lecture sections was negligible, and one female student remarked, "we are too busy taking notes to interact with anybody." The difference in interaction in a large lecture theatre and small tutorials was evident in the GE 131 course. The lecture sessions were quite formal with little opportunity for interaction, while the less formal tutorials invited interaction. Interaction between students and professors and among the students was also easier to observe in the smaller settings, such as the English course and the labs and tutorials. Although the students were usually busy taking notes, one English section

⁷ An upper-year student had told me that the women tended to cluster in the classroom. Similarly, my family physician related her experiences in medical school: 'I always wanted to become a doctor, but when I started, there were only six women in the class of 60. I couldn't handle it and dropped out. When I re-entered some years later, there were 16 women in the cohort, and I was comfortable with that critical mass.' Moreover, former Saskatchewan MLA Anne Smart once told me: 'Around the Caucus table in the Legislature, my two female colleagues and I were told it would be better if we did not sit together, as that would give us too much power.' Ms. Smart had been one of only three women among 23 men in her Caucus. Cited with permission.

almost always elicited good discussions and ideas about the literature in the syllabus, in contrast to the one-directional lectures in the large drafting and physics classes. In the labs and tutorials, the instructors did not lecture unless there appeared to be a general problem that would be better solved by addressing the entire class. The instruction was more informal, and because the instructors circulated among the students, there was better opportunity for individual questions and help. It is far less intimidating to ask for quiet, one-on-one assistance in a setting with more privacy than shouting out questions in a large lecture theatre, and the students are less likely to fear ridicule from classmates. The tutorials and laboratory session, consequently, encouraged more personal interactions both among the students themselves, and between students and instructors.

Interactions in the physics laboratories showed some differences depending on the gendered composition of the working pairs. The students were paired alphabetically and were mostly male. In one section there were three mixed pairs, in the other, three mixed pairs and one female pair. In the male pairs, the tasks involved in the experiments appeared to be equally and evenly shared between the partners who took turns performing 'active' and 'passive' tasks.⁸ Although they were working together, there was always a physical distance between the partners. Physical distance was also evident in the mixed pairs. However, if the female partners did not immediately take charge of setting up the exercise, they would most often record the results of the exercise while the male partner was the 'active' worker. A real difference appeared in the only female pair. As in the male pairs, the women shared 'active' and 'passive' tasks equally, but the physical distance between the partners disappeared. The female team was the only team that I observed coming into physical contact with each other, bumping into, brushing up against, and leaning closely over their work, heads together.

Formal Socialization Into the Engineering Profession

Education in a professional college is a process of socialization into a professional culture. As well, the course work is vocational in nature (Frehill, 1997b). Some of the

⁸ For the purpose of classification, I considered setting up and manipulating experiment variables as 'active' (tinkering) tasks, while calculating formulae and writing the report became 'passive' (academic) tasks.

professional colleges at the U of S require one or more years of pre-entry programs in general arts and science courses. The students who are accepted in these colleges accumulate an academic background and a proven proficiency record. In contrast, the College of Engineering is a direct access college without prerequisites other than high school courses and grades. The college is then able to start their formal socialization process in the students' first year, before they are influenced by any other university culture. During this process, female students learn to adjust to and identify with the professional engineering culture. As they learn to cope with the obstacles they encounter as they progress through this masculine and male dominated environment, they must also finally learn what engineers really do (Dryburgh, 1999), a common problem for engineering students (Frehill, 1997b).

Transition from high school to university can be difficult for many students, and the "Introduction to Engineering" course, GE 131.1 served the dual purpose of adjustment and socialization. The course had two separate components and required only a 'pass' grade. The cohort was divided roughly in half for weekly, one-hour sessions in a large lecture theatre where they were introduced to university policies, procedures and graduation standards and to information about the many aspects of the engineering profession. Each engineering department made presentations to the cohort about course requirements and employment opportunities in the respective specialty. The students saw this approach as an important strategy to start thinking like engineers about what engineers do. However, they thought the methods of presentation were uninspired and uninteresting.

In addition to lectures, there were 50-minute weekly seminars of approximately 25 - 30 students, the so-called 'small sections,' which were intended to make it easier for the students to get to know at least one professor and some of their classmates. One student compared it to the high school 'home room.' The students performed practical exercises related to engineering education and the engineering profession, such as résumé and memo writing, computer exercises, and time management. All the professors stressed the importance of keeping up with lectures, labs and homework lest they fall behind. Catching up, they advised, was much harder than keeping up. That particular year they also worked in teams on a small,

creative engineering task called the 'Challenge Project.'⁹ In a special section, 'mature students' who had returned to education after several years in the work force or in the home, discussed their specific problems or issues, such as work load and study skills.¹⁰ Although the workload was light in the course, students nevertheless had to pass a midterm and a final exam.

Most of the first-year students appreciated the opportunity in the small groups to make connections with other students and getting to know one professor as 'their own.' However, many students believed that the seminars could be improved by focusing more on engineering *per se* than on strictly student adjustment matters, not realizing the connection between mundane exercises, such as keeping track of their study and play time, and the real world of time management in the engineering workplace, where billing for time spent on a project and documenting processes and procedures are of the utmost importance.

The third-year Oral and Written Communication course, GE 390.3, was another major component in the process of socializing the students into the engineering profession. The course exposed the students to teaching approaches other than the lecture and problem-solving methods. In this course, the instructors required the students to write and to speak in the 'public' forum of their class. The students had written assignments, such as a report of a completed project; one section had an organized debate; and one section had to write a short in-class essay. They prepared oral presentations, sometimes using computerized PowerPoint visuals. These presentations followed a formal pattern of introducing and thanking the 'guest speaker,' tasks that were allocated on rotation basis among the students. The students also had to critique each other's presentations, in terms of both content and mode of presentation and generally act as the 'contractor' purchasing the project. Because there were students from several departments in each class, the students were forced to explain their presentations to an audience that was not completely familiar with their own specialization. Experiences the students gained in this class would be both useful and helpful in their engineering career. For

⁹ Each group was handed a file folder, which they were to manipulate so that it would be able to withstand as much pressure as possible. It could be folded and cut, but staples, glue or tape were not permitted. The 'structure' also had to have a space for a Ping-Pong ball. An instrument was brought in to test the pressure it could withstand. The project was designed to promote team work and encourage creativity.

¹⁰ During my M.A. research, several of my respondents had expressed an interest in such a seminar, where they could catch up on skills they had forgotten, or learn new skills they had never learned during their high school years (Anderson, 1994).

example, they had to present their projects with confidence and authority, which is sometimes difficult for women “who begin with the ‘handicap’ of being female in a field where the professional identity is associated with being male” (Dryburgh, 1999:674). Thus, the class was a practical ‘job training’ element of their engineering program.

The professors operated under the assumption that engineers are men and generally referred to both ‘professor’ and ‘student’ as ‘HE.’ During the 1996-97 academic year, neither of the two female engineering professors taught first-year courses, and even fourth-year students were unaware that there were female engineering professors in the college. However, the students had an opportunity to see some female role models when two young, female, practising engineers addressed lecture sessions of GE 131 about their work force experiences; as well, Electrical Engineering brought in a young, female graduate for their departmental presentation. In later interviews, some of the students thought the most interesting and valuable parts of the GE 131 lectures were the departmental presentations and the guest lectures by the young, female engineers.

Attending these courses provided a glance into engineering education and the required workload. Observing and listening in drafting and physics courses, I gained insight into some of the technical, theoretical and mathematical requirements of the engineering program, while the required English course provided a change of pace, shifting from numerical to verbal expression. Attending the GE 131.1 course through lectures and seminars was useful to understanding the induction into the engineering environment. Some of the sections of Eng 115.3 including one that I observed, as well as one section of computer science, had female instructors. One section of GE 390 had a female sessional lecturer with a M.Sc. in engineering. However, it is very possible for engineering students to go through their program without realizing that women can become university professors, in engineering or in any other discipline.

This section has focused on the students’ experiences in the classroom environment. Most of the first-year classes are large, and teaching can be impersonal, using mostly lecture and problem solving approaches to cover the material. While the professors in the courses I observed had a gentle demeanor, one particular professor was confrontational toward one of the older male students. The professor’s behaviour had made the climate so chilly for that

student that he had requested transfer to another section. The 'chilly climate' becomes evident in the next section, which discusses the student environment outside the classroom.

THE SOCIAL ENVIRONMENT

In the second part of this chapter, I examine the ways in which the masculine culture is both maintained and reproduced through a variety of strategies, both conscious and unconscious. The re-creation of this masculine culture produces a 'chilly climate' for women and for some men. The literature on the 'Chilly Climate' has established that the university setting is not particularly friendly to female students. Dagg and Thompson (1988), Hawkesworth (1990), Hacker (1989; 1990) and Levenson (1990) all give examples and evidence of the different levels of intensity within the chilly climate, ranging from sexist jokes and exclusionary behaviour vis-à-vis women to persistent harassment of women. The university environment can be hazardous to women, with the murders and injuries at L'École Polytechnique as the ultimate expression of the chilly climate. Although the perpetrator was not a student, he believed that women were occupying seats that he should have had. While such concepts as chilly climate, patriarchy, bias, sexism and misogyny existed long before the massacre, this event changed the reality of life for women in engineering. Because of the outrage and grief following that tragedy, it became possible to name the concepts and include them as part of the public discourse (Franklin, 1995). Such naming of the problem is required in order to correct and eradicate injustice. Following the unspeakable act by self-admitted misogynist Marc Lépine, who himself had *named* feminists and feminism as his enemies (Lacelle, 1991), and who believed that women occupied seats in engineering that *he* should have had, such previously taboo terms as discrimination, harassment and misogyny were brought into the open and claimed by feminists and non-feminists alike. Because sexism, harassment and discrimination are illegal, discrimination and harassment have become more subtle and often camouflaged, which makes it much more difficult to define and eliminate (Benokraitis, 1997).

Nijole Benokraitis has named three major forms of sex discrimination: blatant, covert, and subtle discrimination. Blatant sex discrimination is intended to be hurtful; it is visible, obvious and easily documented. It appears as gendered wage discrepancies whereby

occupations most often held by women are rewarded at a lower scale than men's occupations; it can also manifest itself as sexist language and sexual harassment and as physical violence against girls and women. It is illegal and can be prosecuted under both civil and criminal law, depending on the act of discrimination. Covert sex discrimination is hidden, purposeful and harmful and may include, for example, allocating the least desirable shifts or schedules to women in occupations that require shift work. Between open and hidden discriminatory practices lie the subtle forms of sex discrimination, which at times may appear rather 'natural' or go unnoticed, yet they reinforce stereotypical ideas of women's and men's roles in society and may even be passed off as 'tradition.' Benokraitis has named nine types of such subtle sex discrimination; they will be described further as they appear throughout the data. Similarly, Stalker and Prentice (1998) offer a set of "micro-inequities," depicting systemic discrimination of women in universities, which correspond to Benokraitis' (1997) categories of subtle sex discrimination. These definitions were especially helpful in seeing how the engineering college environment socializes the students to become not just engineers, but to become male engineers.

Subtle sex discrimination is frequently found in fields or occupations traditionally considered male domains, but where women have begun making inroads. One field or profession that is particularly prone to this type of discrimination is engineering and engineering education. Lisa Frehill (1997) gives examples of subtle sexism in women's perceptions of not being taken seriously by their engineering professors, who might "roll their eyes" (p.126) when a female student asks a question or simply refuse to respond. She also gives examples of male students' sexist behaviours toward their female classmates, such as assigning secretarial duties to them when writing up team reports (see an instance of this in a previous section of this chapter), and blatant catcalls like "look at the tits on her" (p.128). Frehill fears that such situations will persist for years, due to a lack of advocacy for women in male-dominated fields.

Until the efforts to recruit women into engineering and sciences started in the mid-1980s, engineering was the domain of male practitioners who were educated and practiced in a masculine culture. This culture includes "sexist student newspapers, crude initiation pranks and 'girly' pin-ups [as] integral parts of the education of engineers" (Franklin, 1995:3). Franklin is ambivalent toward acculturating women into this environment because "hardening [women]

against the chilly climate” demands that the unprivileged must change, and it does not change the problems within the engineering culture. In her view, “it is a question of structural, institutional and cultural changes—systemic changes that have to involve the elders of the engineering tribes as well as the majority of the traditional ‘average’ male engineers” (Franklin, 1995:3). Similarly, Frehill (1997) compares women in engineering to Fine’s study of female cooks and concludes that in settings where women are a significant minority, they have to become ‘one of the boys’ in order to be accepted.

In addition to sex discrimination—or sexism—, sexual harassment is a form of social control, which “does long-term damage to the self, to our dignity and self-respect” (Kadar, 1988:337). A formal definition by an organization directly involved in its eradication is helpful to understand exactly what sexual harassment entails:

Sexual harassment is any unwanted sexually based or sexually oriented practice which creates discomfort and/or threatens a woman’s personal well-being or functioning (mental, physical, or emotional). Sexual harassment includes verbal abuse, jokes, leering, touching, or any unnecessary contact, the display of pornographic material, the invasion of personal space, sexual assault or rape, or any threat of retaliation or actual retaliation for any of the above (Alberta Alliance Against Sexual Harassment [AASH], cited in Kadar, 1988:339).

As the definition indicates, sexual harassment is an occupational hazard that is harmful to a person’s health, both physical and psychological, and may result in long-term suffering in the forms of ulcers, insomnia and depression. Physical and/or psychological health problems may in the extreme affect employment performance, and thus could result in the victim’s loss of livelihood and income. As my data will demonstrate, both subtle sex discrimination and sexual harassment were present in the day-to-day lives of some of the female engineering students.

Women’s Ambivalent Status

One issue that had a poisoning effect on the college atmosphere was the idea that women were ‘favoured’ in the college and that some of them really ought not to be there. Both female and male students believed that women had advantages in the college that the men did not. First-year student Amber suggested: “I think if anything, women are favored, especially since government is promoting accessibility everywhere for visible minorities.” While Bill (4th year) believed that women were favoured in the work place, “I know there are

employment programs that target women,” other students, both female and male, suggested that women could be perceived to be favoured in terms of accessibility to the college and that female students received special treatment from the male students rather than the professors.

The profs have too many students to teach to have time to discriminate, but I do think the male students are more accommodating toward the female students. I have seen men asking other men for help and get the cold shoulder, but when a woman asks for help, she gets help. I think the men believe women have a lower level of knowledge (Bob, 1st year).

Other students were ambivalent and had examples of both favouritism and discrimination. “In class, NO. Socially, maybe. Both favored and discriminated” (Fiona, transfer student). One man came to his interview complaining of ‘reverse discrimination’ because a female classmate had been offered a position that he, too, had applied for, “even though she didn’t have [course] that I had.” The next day, Tanya, a transfer student, volunteered “my roommate just got a job that a male classmate had also applied for. She thinks *he* thinks she got the job because she was a woman, even though they had the same qualifications.”¹¹ However, even if there was a targeting of women in certain programs, favours were irrelevant if the student, or engineer, did not have the proper qualifications:

I am an extrovert so I’ll go and ask for help if I need it. Maybe it is because women who enter this male domain are stronger and not easily intimidated. On the other hand, women engineers are sometimes promoted much faster than the men. A company will lose in the long run if it promotes without proper experience or qualifications. I don’t think women were favoured or discriminated against. Either way, if I was, it didn’t bother me (Anne, 4th year).

These conflicting views of favouritism toward women indicate that gender has become one of the perceived variables used to explain ‘advantages’ and/or ‘disadvantages’ for individuals who are studying and working in highly competitive environments.

When engineering was an exclusively male preserve, gender would not have been an issue—although other factors would have come into play. For example, Dryburgh (1999) points out that while academics (a female strength) are highly valued in engineering education, the

¹¹ I have since met the woman in question who told me that when she asked her employer if her gender had influenced her appointment, she was told that the committee had simply been impressed with her skills and how she presented herself at her interview.

workplace prefers tinkering (a male strength). A workplace that requires high 'tinkering' skills would then favour employing a male candidate, while a woman may be better suited to a position that is not specifically tinkering oriented. As more women have entered the profession, and as some skills appear gender based, gender has been invoked as one of the signs predicting 'success' or 'failure.'

Does Gender Matter?

All of my respondents believed that women were needed in the profession, and working with women as engineers was a desire for both men and women. The question of gender relevance in engineering ranged from responses that dismissed gender as an issue to indications that women did bring many different qualities and aspects to engineering. There were tensions and diverging opinions both among and between the male and female students in their perceptions of women's place in and benefit to the engineering profession. Both men and women stressed their common education and training and believed that knowledge and skill outweighed any gender differences, and some women accepted as a fact that engineering was a masculine occupation: "I don't see why women as engineers should be an issue, even though it is still male-dominated" (Fiona, transfer student). Some were trailblazers, like Samantha, who had deliberately chosen engineering "because it was a man's field," and Erla, who admitted that she had broken many gender barriers and insisted that it was time to change the male domination in the profession.

While these women knew that they were different, others took an 'equal opportunity' approach, indicating that gender might not be an issue as long as the individual had the necessary skills to be a successful engineer. After all, "It shouldn't matter if you are male or female, I'm going to be an engineer" (Amber, 1st year). Implicit in Amber's statement is the rejection of any need for privileges or concessions in order to succeed in the field, a sentiment a female practising engineer also expressed to Dryburgh (1999:675): "I just go on expecting to be treated as an 'engineer,' not a 'woman engineer.'" Because it became generally accepted that the engineering profession was gender blind, many students believed that women would not contribute anything special or specifically feminine to the engineering profession: "I don't think they would contribute anything different. Something equal, perhaps" (Albert, 1st year).

Some of the fourth-year male students agreed with Albert and Amber: "I don't really know if women have a different perspective on engineering problems, but I don't think they do" (Dave, 4th year).

As far as rating and marks are concerned, they are treated like any one else, like a student. It's like, after they become engineers they sort of stop being women, they just become engineers. You bond with them like you would with guys; they become 'one of the guys' (John, 4th year).

The girls are just a student. They have to do the same amount of work. The girls I have been associated with have been smarter than the guys. But I see cases where girls are 'babied along' and being spoon-fed some of the information (Joe, 4th year).

Although Joe recognized some women's academic superiority, the female students had been rendered genderless, if not masculine, in engineering education. The idea that women are 'just engineers' or 'just students' who are forced to deny that they are also women, is one strategy for coping with gender in engineering. This strategy has long been a concern for female engineering educators (Geppert, 1995).

However, there were male students who, although they considered the female students equal and 'one of the guys,' admitted that the women both thought and approached problems differently. For example, John, who had just asserted that he bonded with women because "women are just engineers," continued "I don't know if they can contribute anything different, but I have found that women do approach problems differently" (John, 4th year). While John was hesitant in his comment on difference in approach, it was similar to some of the women's thoughts. Transfer student Diana, for example, expressed an individualistic attitude to a possible gendered difference in approaching engineering issues: "I know that men and women think differently, and I don't feel sexist saying that. It could be women just enjoy different sciences. I just feel I'm equal [to the other students]."

Some of the fourth-year students, who were the most familiar with engineering both in education and in the work place, and who in some cases also had other degrees, had opposing thoughts about gender differences. Men and women both believed that more female engineers would benefit and enrich the profession in general. A mature student with several years of teaching experience believed that:

We bring a different aspect to engineering. Women question why things have been done in certain ways. I don't know if that is because of gender or our generation. In

my classes it is usually the group of women in the front questioning everything.¹² Maybe we have an inquiring mind, it could be curiosity, or it could be the challenge. In the work force it may be difficult to be an engineer and a woman. As the only woman in a group of engineers I have been asked if I was the wife or the secretary. . . . When we give workshops for industry on how to handle [job] applications, we advise women to use initials only to avoid discrimination (Marie, 4th year).

Women have every right to be an engineer, just like men, but I don't think they should be pushed into it. Women should not be encouraged more than men, although engineering is work that mostly men do. I think you should study any field in university that would encourage you to enter engineering. . . . As long as people can work together well, gender shouldn't matter. I just want to work with people who are pleasant and skilled. But to be the only female engineer in a large firm I think would be uncomfortable. At one time I was the only girl of seven operators and I thought it was fine until one time there was another woman. I didn't realize how nice it was to have another woman there [to work with] (Betty, 4th year).

I think there should be more female engineers. The profession is so saturated with men that when engineers are referred to it is always as 'HE.' I would certainly like to see that mindset changed. The last few years I have had a female work and study partner and I enjoy working with her better than with many guys. I think engineering is teamwork, and there are more dynamics and different perspectives on things brought into the group when you mix genders (Jeff, 4th year).

What, then, are the qualities required of women in order to be successful in engineering? The women themselves, Holly, Anne, April, Betty and Nicole believed that they had to be "confident," "smart," and "competent." "You have to be confident to survive. You have to be yourself among men" said Holly, who had left engineering. Women also have to be "extra energetic" and "strong, not easily intimidated" to be successful. When Dr. Elizabeth Cannon, the holder of the NSERCC/PetroCanada Prairie WISE Chair, visited the U of S in 1997 she made the statement that it takes a special kind of person to be an engineer. I do not think of her remark as elitist, but rather that it requires special interests, skills and attitudes, as it does with any profession or vocation. Betty (4th year) affirmed "I do think engineers are special kinds of persons, whether male or female," a thought that other women echoed.

Obviously I think women are competent. A person should be hired for competence, not for gender. But women didn't have the same opportunities that men did, so the

¹² During the CBS Television program *Sunday Morning* (1999) a female engineering student indicated that she always sat in the front to hear well, to ask questions and be noticed, and not having to look at the sea of male heads in front of her.

gender issue is valid. I think it takes a certain personality to be a woman and an engineer. I didn't fully realize how male-dominated engineering was until I got here (Anne, 4th year).

I think it takes a certain personality type to be in engineering. I consider myself an extrovert, quite outgoing, but many engineers are introverts. I am interested in the managerial and educational side of engineering, where you need communication skills, whereas many introverts are geared toward design and research working by themselves or in small groups. I think women in engineering bring out the human aspect of engineering, not only the technical, and I think they are better communicators than men are. And yes, men and women think about the problems differently (Nicole, 4th year).

Nicole's comment confirms the perception that women think and approach engineering issues differently, although some of her peers disagreed. Her statement is also a comment on the different specialties the women choose in the college. As noted in Chapter Four, the women did lean toward departments that applied to human and environmental needs, while the men chose the more abstract disciplines. The choice of a specialty clearly indicates that gender matters in engineering.

What women could not be if they wanted to succeed in engineering was "timid." The successful women who coordinated recruitment and outreach committees (discussed in the next chapter) were adamant that "you cannot be timid, you have to fight back." Those women also thought they could spot the first-year students who would not succeed by judging their ability to 'give and take' and to fight back.

I think what makes a woman able to be an engineer is that she doesn't notice the things that are getting in her way. She ignores sexist comments or situations that could intimidate or offend other women (April, 4th year).

Henwood (1998) found similar attitudes in her research on differences between women who had chosen education in male dominated software engineering and those who had chosen the more traditional female course of personal assistant. It appears that the non-traditional women do learn to shrug off sexism and cope with the male dominated *status quo*.

Gender Blindness

In Chapter Five I alluded to one female student who left engineering when she became a parent and another whose husband made a career move that involved relocating the family. Marriage and children can have a negative impact on women's academic careers, especially in

the sciences where women are often considered less suited than men, and in graduate programs where they may even be threatened with expulsion if and when they marry or have children (Etzkowitz et al., 1994). In my survey of the first-year cohort, two women indicated that they had pre-school children living with them. In addition, I became aware of another woman who had school-age children. During informal conversation, these three women made it clear that they could not linger after classes but had to rush home to their families. These women, then, did not have equal opportunity to participate in student organizations or social events as their classmates. Within the masculine culture in engineering, these women's special needs were not taken into account.

Following a lecture in the 'ethics' course, one woman approached me to tell about her struggle to complete her program. Having started her education as a mature student, single parent with small children, and later giving birth while still a student, it had taken her six years plus a professional internship year to graduate. Aware of the gender imbalance in the college in general and her department in particular, Sandra called herself a "minority within a minority." "No woman who has a family has finished the B.E. to my knowledge. My 'Big Sister' was also a single parent, and she quit during third year and didn't come back" she insisted.¹³ For Sandra, responsibility for children was a barrier to her engineering education, which would follow Sandra into the labour market where, with any luck, she might find employment that would accept flexible working hours. Alternatively, she could opt for contract work and eventually consulting, which would allow the needed flexibility (Ranson, 1998; 2000).

As a mature student with multiple responsibilities, Sandra had found it difficult to divide her time between classes, homework, family care, and establishing and maintaining a romantic relationship that had led to marriage and her third child. She had considered giving

¹³ An earlier program of 'Big Sisters' was supposed to help 'Little Sisters' to adjust to the engineering education environment. New *female* students (Little Sisters) were paired with upper-year peers (Big Sisters) for academic and social support. The intent was to arrange special get-togethers for the women, such as pizza parties and bowling. However, the women who organized the EEE recruitment committee explained that, as a volunteer, student organized strategy through the Students' Society, there had been little funding, poor organization and waning interest for a project that was intended for women and did not benefit male students. It also became difficult to find Big Sisters for the increasing cohorts of female students. It appears to me that any incentive that would benefit women only had to be organized by the women themselves without support from the general student population. The program later became the co-educational 'Big Buddies.'

up her studies several times, especially while a single parent. During her first two years, Sandra had taken a light course load and worked a lot at home around her children, always feeling guilty that she had so little time for them. After the birth of her third child, she decided not to take maternity leave but to forge ahead in order to finish her program. Like Nettie (see next section), she could only think of completing her courses and leave the university. She felt fortunate that her husband understood her study needs, and that his home-based engineering business made it possible for him to provide child care while she was in class.

The real issue for Sandra was how to cope with breastfeeding her infant daughter when her husband brought the baby every day at noon. "There is no place in the college for mothers and nursing infants to have quality time," she said.¹⁴ Obviously, the college had not considered that female students might have children during their student years. Hoogensen (1997:96) had experienced the same dilemma when, as a Ph.D. candidate, she had tried breastfeeding her infant while teaching a seminar class. 'Helpful' friends had suggested that she should do so in the bathroom rather than in the classroom, to which she responded "when the toilet becomes the dining area of choice for the rest of society, I might relent and join in. Until then, I would rather be told that I am welcome to feed my son wherever I choose." The failure to address the needs of female students who are breast-feeding illustrates the ways in which the education process is gender blind. It is also an example of a structural issue wherein "society, organizations and institutions are arranged in favor of men for the preservation of their advantages" (Fox, 1998:203). In engineering, this observation is reinforced by the demanding workload, which assumes that students (traditionally young men) have no other commitments than their studies.

Should the university and the college expect that women, as students, might need to breastfeed infants during their university studies? Should new mothers expect the institution to accommodate their special needs? Social norms and mores have changed dramatically during the twentieth century, and breastfeeding is considered essential to infants' health. Moreover,

¹⁴ In the College of Engineering there are several small seating areas in the hallways overlooking the library. The areas do not provide any privacy, but this is where she would feed her daughter, rather than in the library (where no food is allowed) or in the washrooms. Sandra was painfully aware of the lack of mothering facilities in the college, yet she did not complain, she just stated the fact.

as more women attempt to combine education and family life, pregnant and nursing women may be a growing part of the student population. In Frize and the PEO recommendations for a 'woman-friendly' university (1996), one requirement is 'administrative leadership in response to women's needs and issues;' another is for 'support, services and security measures for women on campus.' Similarly, the CFUW believes that a 'woman-friendly' university is "a place where every woman feels comfortable living, studying, working and playing; a place where she can reach her full academic and personal potential" (Saunders et al., 1998:223). Thus, if a female student gives birth and decides to continue her studies while breastfeeding, it would not be outside the scope of a 'woman-friendly' university to wish for a comfortable place to do so.

Blatant Forms of Sexism and Harassment

The engineering culture may be no more masculine at the U of S than at other universities. For example, in the 1960s, female science students at MIT had to be able to "throw off derogatory comments" (Bix 2000:31). Yet, this was the late 1990s, and one might think that attitudes had changed. However, studies by Dryburgh (1999) and Dececchi et al. (1998) confirm that they have not. Based on the lived experiences of 1 male and 14 female engineering students in a Canadian engineering college, Dryburgh (1999) examined how students internalized the values and culture of the profession during their education. She found evidence of both sexism and harassment in the engineering environment and that, similar to the situation at the U of S, the students denied that harassment existed. The social environment was even more difficult for female students at the Royal Military College (RMC) (Dececchi et al., 1998).¹⁵ Their data indicate that sexism was prevalent both in the classroom and the social environment and that the women experienced the pervasive masculine cultures of both the military and engineering. At the RMC, Dececchi et al. report that the women would not permit them to use the word harassment. During my interviews, when I asked students about harassment, sexual or other, the male and female students had different responses to incidents of harassment and sexism, if they recognized it at all. Eighteen of 49 students (36.7%) were

¹⁵ This study included all the female students at the college but no male students.

adamant that women were not harassed, answering unequivocally “NO” to that question. However, that still leaves 31 students in my sample who believed they had experienced or witnessed some harassment or unwelcome sexist behaviour. For example, a mature female first-year student, who had taken some courses in the 1980s, called the prevailing culture in engineering ‘testosterone poisoning,’ hinting at the ‘macho’ attitudes and behaviours of her younger male classmates. Additionally, several of the transfer students, discussed in Chapter Five, both female and male, expressed how elements of the college culture had contributed to turning them away from engineering and into other fields. Students who were close to their graduation brought out examples of how they perceived male culture in the college.

The boys like to ‘psych’ you out. The men come to the college, and they’ve been ‘pumped up’ at home. A lot of them are very arrogant and conceited, and that’s probably where lots of the harassing starts. They feel, they’ve been told, that they are superior. But the women may be more serious about their studies here. I think it is important for the girls coming in to realize that they are just as good. . . . I would like to work with female engineers. The female students end up sticking together in this college, if that’s because we like each other or if we sense danger, I don’t know. When I walk into a room I automatically look for a girl to sit beside because there is safety in numbers (Christina, 4th year).

Christina’s comments draw our attention to the elitist attitude held by many of the male engineering students, the effect of which is to create a situation of ‘insiders’ (those who fit the engineering mould) and ‘outsiders’ (those who do not) (Becker, 1961). Harassment, in this context, operates as a form of social control either by policing the boundaries between the two groups, or by pushing the ‘outsiders’ to conform. In either case, harassment represents a form of intimidation, which Christina perceived as danger. In response, she coped by seeking the company of women to alleviate her discomfort, because there was safety in numbers. In contrast to Christina’s fear for her safety, the female students at RMC, where they represented 15% of the entire student population, felt completely safe on their campus and never feared the male students (Dececchi et al., 1998).

Nettie had experienced more than just discomfort while working with a male study partner. Their collaboration on assignments had been beneficial to both of them, and they had both increased their marks. However, two male classmates, one of whom she thought had a crush on her, had been making sexually suggestive remarks and were spreading vicious rumours that had made her life “a living Hell.” Both Nettie and her study partner were

bothered by these two men,¹⁶ but asking them to leave them alone had just made things worse. Filing a formal complaint was not an option, since it would bring both of them notoriety and label them as ‘troublemakers’ in the college. When Nettie returned to complete her B.E. after a year of internship, her study partner had graduated. Because most of the work in her program was done in study groups that had been formed during her year of absence, she was unable to find a new partner and was on her own. Being away had placed her in a different cohort and had hurt her cohesion with the other students in the department. To make matters worse, her previous harasser was still in the college and was “slowly and methodically destroying my reputation by telling stories about me that cannot be verified. I’m just getting through this as quickly as I can. I’m not happy here” (Nettie, 4th year).

Nettie’s experience is an example of blatant sexual harassment. The behaviour her tormentors displayed was definitely unwanted. The harassment was initially mediated by her working relationship with her study partner, but when she returned after a year’s absence, she had no protection against her harassers. Yet, as the victim, she was powerless, as *she* would be considered the troublemaker if she took action against them. In order to survive and complete her program, Nettie adopted an avoidance strategy (Dececchi et al., 1998:31) to minimize the level of conflict.

Nettie believed that being in a professional college made her feel like a professional; on the other hand, she had experienced sexist and chauvinist conduct in engineering. For example, while passing her in the hallway, one male student had told another “don’t look at her cunt.” She had coped by ignoring the comment then, but she had obviously not forgotten it. Had Nettie been in another discipline, she might have had recourse against the students who hampered her success, while the masculine culture in her profession and fear of retaliation caused her to refrain from taking action.

Openly hostile attitudes toward women in the past have left a legacy that still persists within the college. A recent incident is an example of such hostile attitude towards women:

On the eve of the Dec. 6 Memorial [of the Montreal Massacre] . . . while escorting a group of children . . . on the university campus, I encountered engineering students

¹⁶ The case of Nettie and her study partner is an example of how male students may harass other male students. In other words, male students also experience harassment in the college, both from other students and from faculty, as in Bob’s case in a previous section of this chapter.

chanting and marching. The leader shouted back: 'Don't hand out the *Red Eye*¹⁷ just now.' The rabble, dressed in red, marched military style. As the rear of the group came into contact with the young girls, one male yelled out, 'Oh, it's little bitches' (Readers' Opinion, *StarPhoenix* Dec. 12, 1999).

If the college sincerely desires to increase the number of female engineering graduates, this experience may well have intimidated some of the young girls and discouraged them from considering the study of engineering.

Subtle Sex Discrimination in Engineering Education

Subtle and not-so-subtle sex discrimination is evident in engineering and science faculties in numerous universities. A study of women's history in engineering and science at MIT tells of women being admitted as "special students," a status that severely restricted full access to education in their fields. Admission requirements for women were stricter than for men, MIT was called "an unsuitable place" for women (Bix, 2000:27), and female faculty fared not much better than the students. The 1990s have seen change, especially since female science faculty began comparing notes on their experiences (Bix, 2000). However, a study by three female faculty members at MIT in 1999 found glaring examples of bias against women, causing the president of MIT to admit that female faculty there had been mistreated for years. The study and the president's admission led to a meeting, sponsored by the Ford Foundation and the American Association for the Advancement of Science, where nine major American research universities agreed to collaborate toward a strategy to achieve three specific goals:

- "A faculty whose diversity reflects that of the students we educate"
- "Equity for, and full participation by, women faculty"
- "A profession, and institutions, in which individuals are not disadvantaged" (Cox, 2001).

This initiative should be welcome news for all women interested in science and engineering. When the presidents of research universities such as MIT, Yale, Harvard and others make specific commitments to better the environment at their institutions, there is hope that other universities and research facilities will implement their strategies post haste. Women now account for 38% of the undergraduate population at MIT and take for granted their right to

¹⁷ For information on the *Red Eye* please see Chapter Seven, fn. 5.

study at the institution (Bix, 2000).

Benokraitis (1997) explains that not everybody understands the various categories of subtle discrimination in the same way. What one person considers subtle, another may interpret as rather blatant. Benokraitis has cleverly named her categories as oxymorons to emphasize explicitly how these concepts may appear harmless on the surface, but that they intimidate or hurt the victim. Most women encounter one or more of these categories on a daily basis, yet not all will identify them in the same way. For example, Dryburgh (1999) found that her respondents reacted to sexist behaviour and harassment by denying that it existed in the engineering program and that, if it did, it was an exceptional incident rather than a systemic issue. However, some students who had participated in industrial internship programs had seen sexism at work in the workforce and were able to identify it as such in the college. Dececchi et al. (1998) also identified statements in their interviews that described harassing incidents, some of which appeared to be systemic. However, none of the women at RMC used the term harassment, nor would they allow the researchers to use the term. Dececchi et al. state that such behaviour is consistent with previous work by Julia Wood (1994), who realized that university women had experienced harassment behaviour but who did not report it because they could not or would not name it.

Friendly Harassment

Benokraitis (1997:16) describes *friendly harassment* as “sexually oriented behavior that, at face value, looks harmless and even playful. If it creates discomfort, embarrassment, or humiliation, however, it is a form of subtle discrimination.” In this study, the women had two choices for dealing with sexist comments: by ignoring them, or fighting back by responding in kind, that is, to respond as the men would do. While the men thought it was more fun when the women fought back, most of the women appeared to prefer the silent approach because they would suffer repercussions if they spoke up.

Within the co-educational situation in the college, flirting was bound to take place. The male students were generally happy with the population of female students in the college:

I think the college would be very boring without the girls; their physical beauty is a good thing. Some of my best friends are women, 75 percent of the friends I have made in engineering are women. They are as good at their work as any man and more fun to

work with because they are joking back and forth, being flirty and stuff (Dave, 4th yr).

First-year student Bob had also quickly discovered that “the boys flirt with the girls, and in return, the girls are flirtatious, they enjoy the attention they get.” A female student agreed: “Sure, there is flirting going on in the college, but I never thought of that as a form of discrimination or harassment” (Marie, 4th year). While flirting can be considered normal in this environment, it may also be considered as a ‘friendly harassment’ type of subtle sexism, as I believe it can lead to more unfriendly and more harmful forms of sexism, together with joking and accusing those who do not appreciate sexist jokes of having no sense of humour (Benokraitis, 1997).

Although most of the women did not perceive that they had been harassed, some, like Betty, had experienced at least discomfort:

I don’t think I have been deliberately harassed, but there was one incident that made me uncomfortable where some guys were bragging about their [sexual] experiences. I don’t think women are becoming masculinized, but if they are, it is probably because there are masculine things to do and know about [in engineering] (Betty, 4th year).

She dismissed her experience as something that could be expected in the masculine engineering environment, and in doing so, she admitted that the female students were, indeed, adopting masculine traits as a strategy for survival in the college. What the male students preferred, was feisty women who responded in kind (in other words, people like themselves):

Some girls fight right back; if you tell a girl ‘you have a nice set of breasts’ they’ll say ‘you have a nice ass.’ The girls who fight back are fun to listen to and be with. I really think harassment should be taught to first-year students, with fourth-year students showing examples of what is unacceptable behaviour. Some women might be reluctant to report cases of harassment or rude behaviour for fear of being labelled troublemakers (Joe, 4th year).

Joe’s comment touches at least three issues. First, at least for the male students, sexual play is normal and valued. Neither the men, nor the women who respond in kind, see this behaviour as harassment. Second, Joe, at least, is aware that harassment exists. I do not believe he meant that students should learn *how* to harass their classmates, but rather that there was a need for awareness of harassment and explanation of its manifestation, illegality, and damaging effects. Third, Joe appeared to be sensitive to gender issues and realized that women who ignored harassing behaviour feared the repercussions of objecting to harassing behaviour, if they did not

adopt the men's ideas of fun and games. He added:

We had a discussion about 'girly calendars' in offices, and the girls were saying that it is really disgusting and it makes women uncomfortable. One said to me 'I bet you have a different comment to that' and I said that a true professional won't have one [calendar in the office]. I really try to look at how it would feel from the other side (Joe, 4th Year).

Another strategy for dealing with harassment was to ignore it and keep quiet, as one way to avoid further attention and humiliation. Several women admitted that they would 'grin and bear it' if they felt harassed:

I don't think we are harassed in the college. However, the other day in class some girls had chosen a debate topic that somebody else had chosen, just for the sake of debate. When the prof asked if any team wanted to change their topic, one guy said 'why can't those bitches change to something else.' Hello, where did that come from? The women obviously believed in their topics. And if you try to stand up for females in the college, you risk being harassed so it's better to be quiet (Christina, 4th year).

These quotations are typical of many of the students' comments. They start their statement with a denial of a problem or an issue (I don't think there is . . . but let me tell you about . . .), and then proceed to give a personal example of the issue they have just denied. Initially, Christina had not interpreted her classmate's comment as harassing, yet when naming it during the interview, she queried it.¹⁸ In this case, the professor had done nothing to indicate that such language was unacceptable.

Dryburgh (1990:675) relates a similar incident of systemic sexism in her research. When a male student had made several offensive and sexist remarks in class the female professor had dismissed the student as an 'exception' by saying "you know, we all want to punch you right now, but we're not going to." Some of the women in the class had found him very offensive and thought he 'got off' with the professor's slight reprimand. The women also wondered how serious he was, and coped by brushing the incident off as 'exceptional' or 'friendly banter.' Dryburgh interpreted the discussion as a demonstration of the women's uncritical solidarity with their professional colleague and accepted the masculine culture as an undisputable given.

¹⁸ One might be suspicious of attitudes and values of a professor who permits such language in class.

Others students in my study admitted that harassment might be a problem for the female students, but drawing attention to male harassing behaviour would only escalate unwanted attention. In a previous section, Nettie had felt the consequences of speaking up. In this section there are several examples showing that unless the women toe the line, life as a female student in the College of Engineering can be rather unpleasant. Obviously, if the women do not want attention, they are forced to keep quiet.

Condescending Chivalry

Condescending chivalry is often meant to project well-intentioned assistance by strong, protective men toward weak and defenseless women (Benokraitis, 1997). Stalker and Prentice (1998) also stress this category as a signal that women are less important, powerful or competent than men, and maybe affording less academic competition. For example, in my study, Bob suggested that male students would be more willing to help female students with homework, thereby acknowledging that women were no threat to them. On the other hand, David, who had transferred to philosophy, was willing to offer physical protection to women if he perceived them to be uncomfortable in a flirting situation:

There is a very fine line between flirting and harassment. When I have seen girls becoming uncomfortable, that's when I intervene and divert the attention of the offender. The guys know that the girls have friends who will protect them and sometimes even teach them a lesson that could land them in hospital! I feel like a big brother to many of the women. Protective. But there are girls who would rather take care of the situation themselves, and then you don't mess with (David, transfer student).

Henwood (1998) described two types of masculine behaviour, the 'protector' and the 'aggressor,' that are apparent in this statement. It can be disputed if David is an example of condescending chivalry, of a 'knight in shining armour' (the protector) coming to the aid of a 'damsel in distress,' or if it is a serious willingness to use violence (the aggressor) to stand up for the rights of female students to study and work in an environment free of harassment. In either case, he was willing to use traditional male behaviour to deal with another male's aggression. David was, however, not the only male student who thought he knew where to draw the line between flirting/joking and harassment. Other men also volunteered that they would intervene if they witnessed a female student being uncomfortable in a harassing situation.

Supportive Discouragement

Benokraitis (1997:15) explains that *supportive discouragement* happens when women are encouraged to succeed in general, but their actual achievements are not rewarded because it may interfere with male interests. The concerted effort to attract women to engineering through a number of recruitment strategies is an example of supportive discouragement. However, once the women are in the college, there is little organized support for them as women. There is no retention officer in the college, and the 'Big Sister' strategy, which was intended to give the new female students, the 'Little Sisters,' a good start in the college, became the co-educational 'Big Buddies' (See footnote 6.13).

Although the professors would assist students who asked for help, some students complained that some professors were reluctant to help women and at times ignored them in class (see also Chapter Five). April (4th year) saw no advantages or encouragement for women. "The profs only notice you if you are missing from class, or if you need help. Our marks are no higher than the guys', and we don't get any more scholarships."¹⁹

The equivalent micro-inequity is the under-valuation of women's work. Women need to be 2.5 times as productive as men to achieve the equivalent peer rating as students or academics (Stalker and Prentice, 1998: 21). Sandra (4th year) was particularly annoyed when male students comparing their marks to hers became resentful that hers at times were better. Attributing her marks to 'lucky breaks,' and implying that the professors "favoured" or "privileged" her, the students displayed an 'aggressor type' masculinity because they perceived a competent woman as a threat (Henwood, 1998). However, Sandra knew that her marks were sometimes higher as a result of age and expectations of herself. She also believed her professors were reluctant to give her any "breaks" for her added family responsibilities.

After asserting that he had heard of "a few discriminatory type situations" but never personally seen them, Jeff related an example of supportive discouragement whereby a professor selected the work of a female group for a design competition, although he obviously did not believe they deserved the honour:

I had taken a lab in [department] and there is [sic] three girls that I kind of knew from

¹⁹ I counted the scholarships awarded in February, 2000. At that time, the proportion of women in the college was roughly 20%. The women took home 20 % of the awards.

first year in that class and they told me the situation where they have a big design project as well, and they present two times a week, and one of the professors made a comment to them that 'there is one group that basically represents the college at a big competition and he basically bluntly said to them that this is the best design over here but we're probably going to invite you guys [a team of women] because we kind of need the token females to come along to the competition.' He didn't say 'token' but he gave them that impression. The way they portrayed it was that probably the guys will have the best design but if we have a group of girls it makes us look good (Jeff, 4th year).

This incident is 'hear-say,' however, Jeff appeared to be aware of the gender differences in the college, having already remarked on the maleness of the engineering profession and that he believed that the gender dynamics in mixed-sex situations would be beneficial. Although many male students believed many women to be equal to, if not better than, men as engineers, and although the women themselves wanted to be 'just engineers,' I doubt the women felt that their professor supported their project. The professor's admission that the women would be selected in spite of their second-best effort in the design project is an indication of the hostility, condescending attitude and non-inclusion of women in the college.

Subjective Objectification

Subjective objectification tends to treat women as children, possessions or sex objects. Included in this group are sex-related messages, both public and private, that "glorify violence against women and exploitation of women's bodies" (Benokraitis, 1997:18). One poignant example of subjective objectification came to light during a private conversation that was not part of the recorded interviews. Kendra (4th year) related how her class was in the process of oral presentations, and one of the male students gave a talk on "*Picking up Chicks*." Kendra was perplexed that the professor accepted the topic since it had nothing to do with engineering. Instead, the presentation had been peppered with sexual and denigrating language, and Kendra, having self-identified as a 'chick,' felt embarrassed. But the class and the professor had all roared with laughter, while Kendra, feeling harassed, just wanted to hide, to become invisible. When I asked if she had complained about the impropriety of the presentation, she looked at me in disbelief and said: "Are you kidding? I was the only girl in that class."

In addition to feeling personally objectified through the language used both to describe young women and the process of adolescent dating strategies and practices, Kendra also felt

ridiculed by the experience. The only woman in the classroom, students and professor alike completely ignored her presence, while the students and the professor enjoyed themselves at her expense. Yet if she had dared to complain, she would be dismissed for not understanding harmless jokes and anecdotes (Stalker and Prentice, 1998). What stands out in Kendra's story, is what Dorothy Smith has called the "circle effect" where men engaged in activities which were of interest to them alone

What men were doing was relevant to men, . . . Men listened and listen to what one another said. A tradition is formed in this discourse of the past with the present. The themes, problematics, assumptions, metaphors, images--are formed as the circle of those present draws upon the work of the past (Smith, 1975, cited in Stalker and Prentice, 1998:23).

In the process of the circle effect, the lone female subject in the class became objectified and de-personalized as just another plaything. Kendra's story could also be interpreted as an example of another subtle sex discrimination: collegial exclusion.

Collegial Exclusion

Collegial exclusion is the most common form of subtle sex discrimination, whereby "women are made to feel invisible or unimportant through physical, social, or professional isolation" (Benokraitis 1997:23). As examples, Benokraitis suggests the lack of female role models, or being excluded from classroom discussions or activities. Stalker and Prentice (1998) call this the micro-inequity of "cocooning" women's contributions, especially when men ignore or appropriate women's ideas. There were numerous examples of exclusion of women and their work in the college. Even though both the female and the male students were adamant that the women were 'just engineers' because they all had the same education, the women noticed a difference in acceptance and inclusion while being the only woman working with groups of men.

One particular issue that bothered some of the women was that they became 'invisible' in class, and Kendra's story of wanting to be invisible could also fit here. One woman recalled, "one professor, I remember, ignored me. I asked a question and he didn't answer. Then I asked a guy to ask the same question, and the prof says 'that was a really good question.' That really bugged me" (Fiona, transfer student). Not only was Fiona's question ignored, not only

was the male student heard, he was even praised for appropriating her question. In the same vein, another woman believed that some professors gave the impression of not wanting to teach women: "You're a female, I don't want to teach you. They don't exactly say it, but you read their expression, the way they talk down to you, so you put it all together" (Lei, 1st year). Fiona and Lei had, obviously, not made a fuss over not being heard. However, Marie explained why speaking up was more of a disadvantage than help. "If a woman tries to take credit for a question or a suggestion by saying 'I brought that up five minutes ago,' she is labeled as not being a team player" (Marie, 4th year).

One of the main disadvantages for women in the college was a lack of access to both formal information and the informal network. While Joe (4th year) believed that teachers should be "accessible after class and going out with students once in a while," how would it be interpreted if a male professor 'goes out with' female students? According to April, it would be misconstrued as the student 'having an affair' with the professor:

The guys seem to have more connections to other guys. Every time I go to a prof or to a male student for any help, you always hear that there must be something romantic going on. The guys can have fun, close relationships with their profs. They can talk about social things and nobody thinks anything of it. But if I spent too much time in a prof's office they'd think I have a crush on him and the rumor mill gets going. The person I am studying with now is a married man. Camaraderie is natural for the men but unacceptable for the women (April, 4th year).

April's example can also be an illustration of the micro-inequity Stalker and Prentice (1998:20) call "excluding or impairing access to information." The gender disproportion in the college made male/female relationships between professors and students difficult. Gendered favouritism toward the male students worked to the detriment of the female students who felt excluded not only in the classroom but also from the informal knowledge network. In general, the female students got the impression that they did not belong.

The women were also ignored by their male classmates: "I remember an instance of morale boosting, and only two girls were involved, and [the rest of us] weren't asked to go along. It felt like sexism, and we got an apology [for being excluded], but I thought it wasn't fair" (Leanne 4th year). Leanne also remembered being excluded in the workplace. "Last summer, when I was working, my boss was telling some kind of joke so I went to listen and he said 'I don't think you should listen to this,' and there was a group of guys around him." In

such exclusionary practices, the women receive the message that they are outsiders. In the first case, it appears that two women were hand picked for the outing, making the rest of the female students feel more like second-class citizens. The second case, in the workplace, was a clear example of women not belonging to the group. Maybe they only wanted to shield Leanne from a sexually explicit joke, which in itself has no place in the workplace. Or, the joke was used as a mechanism for male bonding, the effect of which is to exclude women in the workplace.

In previous sections I explained how women became labelled as ‘troublemakers’ and ‘poor sports’ if they protested or spoke up in their own defense, and therefore avoided the issue for fear of retaliation. Despite that risk, Marie believed that women, in some instances, had to speak up to draw attention to behaviours that interfered with learning. She elaborated on one particular professor’s behaviour:

There could also be a difference in attitudes among the various departments, especially those that don’t attract or appeal to women, like Mechanical. The cultural background of some professors might influence their attitudes toward women. I don’t think the male students notice ‘cause it’s not something that affects them. One professor would tend to avoid even recognizing that female students asked a question, whereas if a fellow asked, it would be promptly dealt with. After a few classes a few of us went ‘do you notice this is what happens in our classes?’ and the guys went ‘we don’t notice that’ and once it was brought to their attention they did, but they hadn’t because *their* questions were being answered; they didn’t seem to be missing out (Marie, 4th year).

Marie’s example illustrates how culture influences the learning environment. In this case, men who had grown up in a Canadian culture were not aware that some other cultures do not hold women in the same esteem as men and may not respond to women’s queries. At the same time, the exclusion of women cannot be reduced to simply ‘cultural’ differences. In ‘Canadian’ culture (i.e., white, Anglo-Saxon) the exclusion of women is well documented. In this case, ‘Canadian-born’ students attended to the incident of discrimination because it was enacted by a racialized, immigrant professor. The attention highlighted *his* own ‘otherness,’ as a man who did not understand issues around women’s equality while leaving other forms of discrimination, such as being ignored when asking questions by Canadian-born professors, either invisible or dismissed as ‘natural.’

While attending engineering courses, I did not detect any particularly ‘chilly climate’ in the classroom. However, I rarely interacted with the students in class. In the smaller classes,

the professors appeared to involve male and female students equally, and in the large sections it was difficult to hear any student comments. There were, however, times when some women appeared to be excluded by their male peers. In the Challenge Project in GE 131, the two male students in a team of three completely ignored the single female team member. On the other hand, she did not make any particular attempt to be included. In another case, two women sitting together in a 'small section' appeared to have voluntarily withdrawn from the group. When I asked, they told me that they were simply marking time. They had already decided to transfer out of engineering and were only interested in having credit for the course.

As the students' statements indicate, the college atmosphere is rife with both hostility, sex discrimination and sexualized language, for example, 'reconsider your career,' 'flirting,' 'bitches,' 'cunt,' 'nice breasts,' 'nice tits,' 'nice ass.' Some women, like Nettie and Kendra, were uncomfortable with this kind of language while other women had responded to sexist comments with their own sexist comments, for the male students' "enjoyment." Similarly, Dryburgh (1999:676) found that some of her respondents did the same and considered such language "kind of good banter." In order to be accepted as a 'valid' colleague and sometimes as a supervisor, the women had to play along and respond in kind to sexual language. This use of sexual language is an ingrained part of masculine engineering culture where "the phallus is an obvious symbol of engineering" (Dryburgh, 1999:677), possibly because women for so long were scarce in the profession. This is the culture and the profession into which the female students are socialized. Subtle and not so subtle sex discrimination or sexism thus appears to be part of the 'natural' atmosphere in the college (Dryburgh, 1999).

The data in this chapter provide ample evidence that the full inclusion of women in engineering is, so far, an illusion.²⁰ Male dominance forces many women and some men to deliberately separate themselves from the majority, not only by sticking together in the college, but also completely removing themselves from the college by transferring to other disciplines. Other coping strategies for women are to internalize the masculine culture and become 'one of the guys,' or for women to sit in the front of the classroom in order to be seen and heard and to

²⁰ The concept "Illusion of Inclusion," taken from Jacqueline Stalker and Susan Prentice' (1998) edited work "The Illusion of Inclusion. Women in Post-Secondary Education," becomes stronger and more pronounced throughout this research.

avoid “look[ing] at the sea of male students’ backs” (CBS, 1999). April’s statement about visiting a professor’s office suggests a passive resistance toward sexism and possible harassment. However, ignoring the issues does not make the issues disappear. Standing up and speaking up for themselves means naming the sexism that exists in the college, thereby rejecting it and forcing it out.

DISCUSSION

Engineering is defined as “application of science to the design, building, and use of machines etc.” (Oxford Dictionary of Current English, 1992). By definition, the educational curriculum must rely heavily on giving the students the necessary knowledge and skills required to apply the principles of science and mathematics to the practice of engineering. The pedagogy applied to this curriculum was the typical ‘instruction’ paradigm, where the teachers were the active instructors and students mainly passive recipients of knowledge. As is true also in other colleges, the students were nonetheless able to distinguish between ‘good’ and ‘bad’ professors. The best-liked professors had respect for the students, conveyed enthusiasm for the subject matter and presented the material in a dynamic way. The obverse was true for professors who were disliked.

Within Rosser’s (1988) scheme for including women in science, the instruction in science and mathematics falls into stage one, where women are not only missing, but where it is not even recognized that they are missing. At the upper-year levels a higher, although not the highest stage prevailed. Students themselves insisted that the teachers were to provide information for the students to “take notes”, i.e., accumulate, not to ponder over or think about the subject matter, while others thought there should be more opportunity for discussion. In contrast to the mathematically based engineering courses, women’s presence was noticed and even highlighted as ‘problems’ in the ‘ethics’ course. Similarly, in the English course, the syllabus included female authors as well as a variety of female characters in the literature, and the instruction, which emphasized individual interpretation and discussion of the texts and their actors, could then be considered at a higher, more gender-inclusive level. There were several opportunities for discussion throughout the engineering courses, yet the students appeared unwilling to participate, especially in ‘ethics.’ Unfortunately, the students did not exactly embrace these courses but rather regarded them as useless.

Although male and female students study and learn the same curriculum, becoming an engineer entails different experiences for women than for men. Women in the engineering college face barriers unknown to, and unnoticed by, most men. As the data indicate, the men did not notice when women were not acknowledged in class, nor were they aware of the absence of breastfeeding facilities in the college. As a result, the women had to 'become one of the guys' and forget their feminine gender in order to be accepted as equals. Throughout the interview data, there is ample evidence of both denial of gender and sex discrimination. Because it appears that there is no willingness in the college to change this behaviour, it has become 'part and parcel' of the masculine culture in engineering and of the socialization into the gendered, i.e., masculine engineering profession. Ergo, both male and female students become professionally socialized to reproduce that masculine culture. However, this phenomenon is not exclusive to the U of S, as both Dryburgh (1999) and Dececchi et al. (1998) demonstrate.

Dececchi et al.'s (1998) and Dryburgh's (1999) studies confirm that many of the same issues are at work at other Canadian universities. Although these studies mostly ignore the thoughts and experiences of the male students in these institutions, they confirm the masculine culture in engineering education. Dryburgh, particularly, emphasizes the fact that the female students, in order to survive, are forced to uncritically accept the masculine culture and define sexist behaviour as exceptional rather than embedded in the institutional and professional culture.

The interview data illustrate that several of Benokraitis' (1997) categories of subtle sex discrimination are present in both the classroom and the more informal, social environments in the college. There are illustrations of friendly harassment and its corollary, condescending chivalry, where students fail to understand that when women are uncomfortable with flirting and use of sexualized language they are experiencing sex discrimination. Female students experience subjective objectification where they feel humiliated by the behaviours of their male classmates and at least one professor. In addition, the data showed evidence of supportive discouragement of women in an environment that is not prepared for women's needs. While some of the female students had children, and one was a nursing mother, there was no child-

care available in the college,²¹ and no private space for breastfeeding. Finally, collegial exclusion was evident when women were ignored by professors in class and by male classmates outside the classroom. Exclusion happened in a variety of ways: Male students were praised when they appropriated women's ideas and questions. Female students were deprived of information and privileges male students take for granted, such as freely discussing any issue with male professors. For the female students, long visits in a professor's office would jeopardize their reputation.

The social environment for women studying in the College of Engineering is fraught with ambivalence and contradictions. On the one hand, gender is a category the students draw upon to explain differences in success as denoted by higher marks, attaining good jobs and promotions, as well as women's contributions to the profession. On the other hand, some men and women alike denied the impact of gender. As a result of these tensions, female students are forced to negotiate this gendered landscape where the terrain is continually shifting.

The other major issue in this chapter is the women's own denial of gender, as well as the men's un-gendering of the women. For the women, there was tension between knowing they were different from men, yet wanting to be treated the same as their male colleagues (Henwood, 1998). They wanted to be accepted by the majority, and therefore resorted to being 'one of the boys' (Dececchi et al, 1998). On the one hand, one can argue that both men's and women's belief that women as engineers are 'just engineers' and 'one of the guys,' is an indication of the men's complete acceptance of women engineering graduates as their professional equals and thus a sign of full inclusion in the profession. On the other hand, this acceptance is on male terms, not on women's terms or on terms of equality. In the musical *My Fair Lady*, Professor Higgins sings: "Why can't a woman be more like a man?" The reverse, "Why can't a man be more like a woman?" did not occur as relevant or agreeable to the students, although some male respondents admitted that some women might be better engineers than some men. Ursula Franklin lives in the hope that engineering will some day be fit for women, rather than women being fit for engineering. Women's caring and reluctance to being aggressive and pushy are not

²¹ The university in general lacks adequate child-care facilities for students, staff and faculty.

values that are unacceptable in engineering. She admonishes women that

women engineers are not mere substitutes or emulations of their male peers, but bring—as women—different perspectives and experiences to their work. All considered, it is certainly not yet plain sailing for women engineers. . . . Secondly, don't forget your feminism and your solidarity with other women. Feminism is not an employment agency for women; feminism is a movement to change relations between people to more egalitarian, caring, and non-hierarchical patterns. Feminism provides a way of life that our society, I feel, desperately requires and that we need to practice (Franklin, 1995:7).

Franklin is not the only woman engineer concerned about women's experiences and perspectives not being encouraged and nurtured in engineering colleges. In an interview with eight professional women who were academic engineering faculty and senior industrial managers, Linda Geppert (1995) discussed the forces that caused female engineering students to deny their gender. As a consequence of the dearth of female mentors and role models and the denigration of women, Geppert found that women often believe that to be accepted in the masculine engineering profession they must adopt as many masculine traits as possible. While women in other professions and disciplines can assert that they can be both female and professionals, “women in engineering have successfully made themselves genderless. . . . They don't even recognize that they can say they have a gender, both to themselves and to others”(Geppert, 1995:44). Moreover, these attitudes developed in colleges and universities where “professors from overseas . . . from cultures where women have historically stayed home and raised children . . . are downright denigrating” to female students (Geppert, 1995:42-43). When faculty members ignore or belittle female students it is small wonder that “women are not fully accepted by their male peers” (Geppert, 1995:43), and that the male students have a tendency to harass their female classmates. Women are forced to deny their gender in such non-inclusive environments in order to survive. In their training or education they adapt to and adopt the attitudes and values of the masculine professional culture.

CHAPTER SUMMARY

In this chapter I have documented parts of the process of engineering education through observing classroom actions and interactions at the first, third and fourth year level of

instruction. In addition, I listened to what first-year and fourth-year students told me about their personal experiences and observations in the college. Attending first-year courses as an observer gave me an appreciation for both the workload and some of the course content in a first-year engineering program. I came to realize that pedagogy in engineering focused on information and testing and less on exploration and understanding of concepts.

The purpose of engineering education, in addition to teaching the students the skills and knowledge required for a professional engineer, is to socialize the students into the professional engineering culture. Pedagogy in the technical courses in engineering reflect stage one in Sue Rosser's (1988) schema of science education, where women are not present or even noticed as being absent. The workload left little room for social interaction outside the university community, limiting students to interactions in the masculine culture of the college. In contrast, in the liberal arts English course the instruction was at a higher level. Here, there was a number of female faculty, the syllabus reflected female authors and female actors in the literature. The students, both male and female, took part in interpretation and discussion of the curriculum.

The narrative data demonstrate that the atmosphere in the College of Engineering was not particularly inviting to the female students. Both in the classroom and otherwise, the female engineering students experienced a 'chilly climate,' being ignored when they asked questions in class, considered troublemakers if they claimed credit for their questions or answers, and harassed by their male classmates both inside and outside the classroom. They had become sex objects and were taunted by male students. The women were victims of sexual innuendo and catcalls, which they either chose to ignore or decided to throw back at the offender. They became victims and further harassed if they said STOP. In response, some of the women reacted to sexism with their own sexist jokes. The women admitted to responding to sexism or harassment in kind, claiming that they could give as much as they took. However, the data do not show how pervasive the issue of harassment or sexism might be or how many incidents any single student had experienced.

The male students came to understand and recognize that their female classmates were just as talented as many of the men and that some women would probably be better engineers than many men. However, in order to fit in and be accepted by their male peers, the women

had to deny their feminine gender and become 'one of the guys,' a problem that concerned a sample of professional female engineers both in industry and the academy. Throughout the data, there is evidence that both male and female students are actively and continually negotiating gender barriers. In West and Zimmermann's terms, these students are "doing gender" on a daily basis

This chapter has discussed the chilly climate and multiple expressions of sexism women experience in the College of Engineering. The women who remained in the college had to develop strategies to survive in their engineering education. In general, they decided to ignore all sexism and play deaf. Otherwise, the climate became even chillier. To compensate for the predominant, male culture in the college, many female students sought niches and situations where women were the majority, such as the outreach and recruitment committees, and where they were in control of the situation. They participated in one aspect of college activities that was not tainted by the sexism of the chilly climate. This will be the focus for the next chapter, which will discuss the student organizations in the college.

CHAPTER SEVEN
“ORGANIZING” THE ENGINEER
(The Extra-Curricular-Environment)

In the preceding chapter I discussed the engineering students' experiences that emerged in the classroom and the social environments in the College of Engineering at the University of Saskatchewan (U of S). In those environments, the male and female students had varying, and sometimes contradictory, gender-related experiences. However, there is a third environment in the college, which I call the organizational environment of college-related extra-curricular activities of the students. If the classroom and social environments were considered un-gendered, the organizational environment was marked by a gendered division of labour.

THE GENDERED DIVISION OF LABOUR

The ratio of women in the paid labour force has increased from 18.5% in 1941 to 45% in 1991 (Armstrong and Armstrong, 1994). However, in contemporary North American society there is a gendered division of labour. There is a wealth of evidence which suggests a persistent industrial and occupational segregation; women earn less than men; women tend to work in part-time, non-unionized jobs, etc. At the same time, despite women's entry into the labour force, many women are still the primary care-givers and perform most of the domestic labour in the home. Care-giving and family were important issues for female engineers, who deliberately sought or maintained employment in organizations that would accommodate women's concerns, such as maternity leave, flex-time or part-time work. In contrast, male engineers did not change their approach to workplace practices and continued full-time work (Ranson, 1998; 2000).

In 1997, women earned on average 80 cents for every \$ 1 that men earned. A study of factors affecting this wage gap between men and women revealed that in addition to education, major field of study, occupation and industry of employment, women's lower wages were

influenced by less work experience and lower job responsibilities, as well as reasons that are not yet understood (Statistics Canada, 1999). Thus, in the late 1990s

Women earned an average of \$14.38 an hour in 1999, up 2.3% from 1998. Men made an average of \$17.77 an hour, 2.7% higher than in 1998. Weekly salaries for women averaged \$484.52 in 1999, compared with \$470.64 in 1998, a 2.9% increase. The average weekly wage rate for men was \$698.53, up 2.6% (Statistics Canada, 2000).

One reason for the wage gap is the occupations where many women find employment, many of which are at the lower end of the scale of occupational prestige. In the USA the gendered wage gap ranged from 38.1% for graphic designers to 1.3% for registered nurses, while female postal clerks had a 2.4% edge on their male counterparts (Eitzen and Baca Zinn, 1994). Even as attorneys, physicians, university professors and engineers, who in many cases have the same educational background, the male practitioners earned more than their female colleagues.

The gendered division of labour also appears to affect participation in student organizations in the College of Engineering. Within the students' organizations in the college, a majority of male students presided over the executive body of the student society, while the women became the caretakers of the nurturing arm of the college's outreach and recruitment programs.

STUDENT ORGANIZATIONS AND EXTRA-CURRICULAR ACTIVITIES

It is common in universities and colleges for students with shared interests to organize in student societies or clubs. Such organizations give students an opportunity to come together to discuss issues of interest to the group from a discipline or profession-based point of view, as well as social interactions for enjoyment and relaxation. In addition to college or specialty student societies, there may be groups sharing cultural, charitable, age-related or other interests. Extra-curricular groups usually have a committee or executive that assumes the responsibility for arranging meetings and social events. In general, student societies are important for generating college pride and cohesion among students, and they serve as opportunities for making friends in a less overwhelming environment than within the entire student population of any given institution. In the College of Engineering at the U of S, the various engineering specialties have their student societies. Membership in these societies gives all the students in the separate departments an opportunity to participate in their own field of

engineering, both academically and socially. Collectively, the engineering students are also organized in their Saskatoon Engineering Students' Society (SESS).

In addition to the specialty societies and the SESS, the College of Engineering has a recruitment and outreach strategy which is an important part of the social environment in the college. The Encouraging Enrollment in Engineering (EEE) Committee is the umbrella committee for recruiting students to the college. When I attended a EEE Committee meeting during the observational phase of my research, I discovered that all the committee members at that time were women. Although proportionately more female (36%, n=21) than male (27%, n=43) students in my survey of the first-year cohort in November 1996 had indicated an interest in becoming involved with the SESS, male students dominated the SESS executive while the female students administered the outreach committees. There was obviously a gendered division of labour in these organizations, and the recruitment strategies had become 'women's work.'

Some of the answers to my fourth research question about social experiences in the college came during a meeting with a group of six female students who were executive members of the EEE, Student Activity Fund (SAF), Discover Engineering and Sci-Fi committees. The women spoke about their reasons for participating in the committees and explained the benefits they derived from the activity. However, before turning to the interview data from the group meeting I will give a brief overview of the purpose and work of the SESS and describe the mandate of the recruitment committees.

The SESS

In Chapter Five I alluded to the Saskatoon Engineering Students' Society (SESS), which arranges the annual 'Hell Week' and publishes the college paper the *Red Eye*. The SESS is part of a longstanding masculine tradition within engineering education and the engineering profession. It has a hierarchical structure of administration with a nine-member elected Executive and a Council, on which the professional societies, the outreach committees, the yearly cohorts and specialty departments have seats as affiliated groups. The volunteer executive, elected by the student body, has been dominated by the male students. With less than 25% female enrollment in the college, the probability of a woman being elected to any

position of real power is minimal (Table 7.1).

Table 7.1 Gender Composition on Saskatoon Engineering Students' Society (SESS)

	1993-94		1994-95		1995-96		1996-97		1997-98	
	M	F	M	F	M	F	M	F	M	F
President	0	1	1	0	1	0	1	0	1	0
Executive	5	3	5	3	7	1	6	2	6	2
Total	5	4	6	3	8	1	7	2	7	2

Source: Joelene Mackey, 1997/98 coordinator of the EEE Committee.¹

As the table shows, women are not well represented numerically within the SESS executive, although they might be serving in auxiliary capacities on sub-committees. However, the proportional representation corresponds with the approximately 22% proportion of women in the college. In 1993/94, when a woman, for the first time, was president, there was a gender balanced executive, although women were then proportionately over-represented.²

The EEE organizers explained that women were generally elected to positions within the SESS executive by default when there were no male candidates for specific positions. They also stated that the SESS was in a deficit position when the woman was president. She had to practice fiscal restraints, and thereby earned the nick-name 'the bitch.' Other women, who were students at the time, have contradicted these statements, adding that she had been a well respected leader who was genuinely interested in student government.

According to the 2000/01 president, the purpose of the SESS is "to provide for the academic and social needs of undergraduate students." Among the activities, SESS arranges an annual Pi(e) Throw³ for charity, participates in several other fund-raising community

¹ When full names are used, the persons cited have given permission to use their names. I am grateful to Ms. Mackey for her archival efforts to provide me with the numbers for this and other tables. She did not explain why she did not have data prior to 1993.

² Although I completed my data collection in 1998, I am aware that the SESS president during the 1999/2000 academic year was female. Recent data indicate a more numerically equal distribution of male and female student on the SESS executive since 1998, although the 2000-2001 executive again had a 7:2 male composition.

³ *Pi(e) throw* (in algebra, $\pi = 3.14$, is a concept and a number necessary for calculating the area and the circumference of a circle) is a charitable fund-raiser in the college whereby a cream pie is planted in the face of the recipient. Pies can be declined, bought, redirected for a fee or accepted 'in the face.' In 1999/2000, the engineering students raised \$ 26,000 for various charities. In 2000/01 SESS collected close to \$ 10,000 to the end of the calendar year (StarPhoenix, December 27, 2000, p. A3, Art Robinson column).

activities as well as collecting food for the local Food Bank. In addition, the IEEE (Institute of Electrical and Electronic Engineers) student society organizes the annual, fund raising "High Voltage" street-hockey tournament. The SESS also participates in the annual December 6 Memorial for the victims of the 1989 Montreal Massacre.

On an academic level, the SESS has participated in regional and national competitions for engineering students. In 2000, the U of S representatives placed first in first- and second-year team designs; first in extemporaneous debate; and second in corporate design (fourth-year) at the Western regional competition. As well, the first- and second-year design team placed first, and the U of S team was declared overall winners at the National competition. In addition, since 1959 SESS has organized a triennial *Spectrum*, a public exhibition, which requires an all-out effort of both faculty and students. This event relies disproportionately on the work of the female students: for the 1998 exhibition, a male coordinator assisted by 18 female and 24 male students worked to prepare the extensive program, with additional student help during the show itself.⁴

Despite its stated purpose of serving all engineering students, many of the SESS activities create and reinforce a masculine culture in the college. For example, in the past, the SESS has published a very sexist and racist college paper, the *Red Eye*,⁵ which has offended many. A major activity in the early fall is Hell Week, featuring the *Red Eye* Stomp and the E-Plant event, pub crawls and other beer nights. The Lady Godiva Ride, where a woman rides scantily clad on a horse, and which was a part of the Hell Week activities, was discontinued by the university administration in 1989, and the *Red Eye* was forced to tone down its sexism.

⁴ During the 2001 exhibition, a female student was the chief organizer.

⁵ In the 1980s, the *Red Eye* faced a Human Rights complaint that, in the end, was dismissed by the Supreme Court. During my research, I found that the *Red Eye* still published sexist and pornographic material. 'Hell Week' is a week of concentrated fun, games and beer drinking to create community spirit in the college. The *Red Eye* Stomp consists of red-clad and red-painted students running through other buildings on Campus, making noise and attracting attention to their superiority as engineering students while distributing their college paper. During the E-plant, the engineering students 'capture' a member of the agriculture students society, the 'Agros,' strip him down to his underwear and tape him with duct-tape to a large E. Blue-painted agriculture students then rush to his 'rescue,' during which a 'battle' ensues. The weapon is spray cans of shaving cream liberally aimed in all directions. During this 'battle' there is an attempt to strip clothes off the male combatants in a process called 'panting.' Girls are never 'panted.' The 'Agros' win if they manage to release their E-planted member; however, this does not happen very often. This E-plant battle is a general university 'entertainment' event watched by large numbers of 'neutral' students.

Recruitment and Outreach Initiatives at the University of Saskatchewan

The pressure to include more women in science and technology education, combined with declining enrollment and human rights legislation, has given rise to various recruitment strategies at the College of Engineering at the U of S. The College of Engineering has in the past few years arranged an annual "What is Engineering?" day where faculty, students and invited speakers present the many facets of engineering to invited high school students and their teachers from across Saskatchewan. In collaboration with the University of Regina, this has been a one-day effort by the college itself to recruit students to their programs and to impress upon both teachers and students the importance, multiplicity and opportunities of the engineering and technology fields. The program is also presented in Regina.

The initial recruitment strategy started in 1988 with the inauguration of the Encouraging Enrollment in Engineering (EEE, or E-cubed) Committee. The committee has its funding from the Office of the Dean of Engineering⁶ and a mandate to present and promote the academic side of engineering education and the engineering profession to high-school students around the province. Originally a strategy to attract specifically female students, the focus soon changed to general recruitment of new students for the college and by extension, new members of the profession. The focus for the committee has again shifted, now to northern and aboriginal students.

In 1991 the EEE committee expanded its mandate with a Sci-Fi Summer Camp program for grades 4 to 9 under a separate committee. In 1993, the committee received approval for yet another program, the Discover Engineering weekend conference for grade 8 girls. The fund-raising SAF is responsible for soliciting funding from industry for the student-run programs such as the Discover Engineering, Sci-Fi and Spectrum.⁷ However, the organizers of all these volunteer committees are female students who cooperate for the general purpose of enticing young girls and boys to engineering and to recruit new students for the college.

While the female students were numerically under-represented as executive members of

⁶ The 2000/01 President of the SESS has informed me that the funding comes from the university's base budget to the College of Engineering.

⁷ The Spectrum committee is the affiliated group within the SESS that is responsible for the exhibition.

the SESS, they had concentrated their efforts on the recruitment committees. In contrast to the college operated “What is Engineering?” day, the EEE Committee is student run. Compared to the well-established SESS, the recruitment initiative is a relatively new venture. While the student body elects the SESS executive in annual elections, students who are interested in the positions in the EEE Committee must apply in writing to the incumbent committee, whose members select their own successors. Other than the Sci-Fi, the recruitment work, as well as the SESS executive, is voluntary and carries no monetary remuneration, although the women admitted that as executive members they received a ‘free lunch’ when they met twice yearly with their Faculty Advisory Board. Because the program involves travelling, both within and outside the city, drivers receive mileage reimbursement, but at a lower rate than faculty and staff.

The Sci-Fi co-ordinator, who usually is female, and the instructors’ positions are paid college employment for students, and because it has proven beneficial to the children, the college attempts to have both a female and a male instructor in each classroom. Therefore, there is as close to gender balance as possible for these paid appointments. In 1996/97 and 1997/98, the two years for which I received information, the co-ordinator was a female engineering student.

Committee Membership

Participation on the recruitment and outreach committees has become an activity for the female students in the college, and they carry a disproportionate load on these committees. Table 7.2 and Table 7.3 show the gender distribution on the recruitment committees.

Table 7.2 Participation in EEE Recruitment Committee

	1996-97		1997-98	
	Male	Female	Male	Female
Coordinator	0	1	0	1
Executive	0	8	1	7
Total	0	9	1	8

Source: Joelene Mackey, 1997/98 coordinator of the EEE Committee.

Table 7.3 Participation in Discover Engineering Camp for Grade Eight Girls

	1994/95		1995/96		1996/97		1997/98	
	Male	Female	Male	Female	Male	Female	Male	Female
Coordinator	0	1	0	1	0	1	0	1
Executive	3	5	2	5	0	7	1	6
Total	3	6	2	6	0	8	1	7

Source: Joelene Mackey, 1997/98 coordinator of the EEE Committee.

While only one male student had been an executive member of the umbrella nine-member EEE Committee (Table 7.2), there had been up to three male members on Discover Engineering between 1994/95 and 1997/98 (Table 7.3), and the women indicated that they expected four male members the following year. As for the lone male student that year, the women stated that “he does not impede our progress.”⁸ In other words, the women have found an enclave where they feel safe and where they can be the decision makers. While the Sci-Fi summer employment positions, funded by the college and registration fees, had not yet been announced for 1997-98, the 1996-97 season had four female and two male instructors plus one female and two male head instructors.

Programs and Activities of the Outreach Committees

Following the general recruitment drive for women into science and technology, the original intent of the recruitment strategy in the College of Engineering was to encourage high-achieving high school girls to enter the field of engineering. This was one recommendation the Canadian Committee on Women in Engineering (CCWE) proposed in its 1992 report. Therefore, the original target for the EEE Committee was the provincial high schools, particularly the graduating class. The main EEE program has a three-pronged approach, consisting of High School Promotions, On-Campus Tours and On-Campus Days. During high school promotions a team of two or three students, both female and male, make a

⁸ Current update indicates that both in 1998/99 and 1999/2000 the distribution has been the same: female coordinator and only 1 male member on the executive. It is possible that the women have “marked their territory” to the extent that the men feel excluded from this work, similar to the exclusion of the women in the college in general.

presentation consisting of information pamphlets, a video and a computerized PowerPoint program. The students stress that engineering may not be an option for everybody, but that it could be suitable for someone who enjoys certain activities, such as sciences and mathematics. In the early years, the committee showed a video produced by the CCWE through the NSERC/Nortel Women in Engineering Chair at the University of New Brunswick, but the EEE Committee has since produced its own video, featuring local students, many of them women, and the local specialty departments. Although female students chair the committees and organize the high school visits, it is never difficult to enlist both female and male volunteers to take part in the school presentations. The female students then demonstrate that there are female students in the college and act as role models to show that engineering is an occupational option for women.

The recruitment and outreach programs of the EEE Committee became a rewarding work experience for the female engineering students because it aimed at promoting the academic aspects of engineering to the public at large. One of the women in the first-year cohort stated during her interview, "I chose to work with EEE because I thought it was the best organization to reach the general public all over the province" (Lei, 1st year). Other students' statements also give an indication of their dedication to the cause:

This year has been the best ever, we have been almost all over the province. When it first started it was to get more female students, but our mandate has changed. We are there to educate the general public in what engineering is. We are producing a new video showing what students, professors and workers are doing in the field, and there is a really good mix of men and women (Leanne, 4th year).

I think the promotion programs are good, especially for girls who really need the exposure and to see positive female role models. It is important in remote areas where students don't see engineering as an option. But they have to be realistic when doing their presentations—it [engineering] is not suitable for everybody, and it is a lot of hard work (April, 4th year).

EEE encourages both men and women to enroll in engineering, especially high school students and older, where Sci-Fi is geared toward grades 5-8. We tell students 'if you like science, then engineering might be for you'"(Nicole, 4th year).

The frequent references to women as targets of recruitment, as well as role models, indicates that encouraging women into engineering remains a high priority, although the

focus for the school promotions has officially shifted to general recruitment and particularly Northern and aboriginal populations. Another aspect of the EEE Committee's work is for its members to serve as guides for On-Campus Tours for interested high school groups touring the college. During On-Campus Days, students may attend first-year lectures, take part in lab demonstrations, and generally experience the workload and other demands and activities in the College of Engineering.

The first expansion of the outreach and recruitment program took place in 1991, with the introduction of the Sci-Fi camps. These are week-long, co-educational day camps for children from grades four to nine. They are offered during July and August and attract a large number of youngsters who learn to apply scientific principles to making age-appropriate items. In contrast to the voluntary aspect of the EEE and Discover Engineering committees, teaching the Sci-Fi camps is paid summer employment for engineering students, and the coordinator's position is also paid.

Discover Engineering is a weekend conference for grade eight girls which was started in 1993. The purpose is to expose young girls to engineering programs early enough for them to make proper course selections in high school. The camp accommodates 85 girls who work, sleep and eat on campus without boys being present. During this conference, the girls tour the college and attend seminars and workshops, which introduce them to hands-on applications of science and technology in a non-competitive environment. There are lectures and guest speakers as well as recreational programs. There is friendly collaboration among the girls, and they work at their top level. The almost totally female atmosphere keeps the girls interested and focused on the topic at hand. By inviting only girls to the camp, the girls do not have to compete with boys for attention or for hands-on experiences, and they are comfortable asking questions. However, one of the organizers volunteered that whenever a male student instructor conducts a lab or workshop, the girls tend to "dumb down" (act less intelligently) and show more interest in the lecturer than in the lecture. For this program, the EEE committee won an award from the Memorial Grant Fund, which was established to

commemorate the 1989 massacre of women at the École Polytechnique in Montreal.⁹

Funding

In addition to some direct funding from the Dean's office, the recruitment and outreach strategies depend on external funding. For that purpose, the college established the SAF as the umbrella fundraising committee, to solicit contributions from industry for student projects in general. Prior to the establishment of the SAF, the students had done well fundraising for individual projects. When the EEE Committee now proposes a new activity or program, the organizing group must present a budget to the SAF, which coordinates, collects and distributes all funds among the outreach groups. That committee, too, most often had a female student as its head.

The school presentations receive funding entirely from the Dean's Office. The EEE Committee sets the expense budget for travelling, printing, postage etc., which requires the approval of the Dean's Office. Any budgetary shortfall must be thoroughly justified before additional funding will be approved. The Discover Engineering and Sci-Fi committees receive their operating funds from the SAF as well as from registration fees. In the case of Discover Engineering, the committee receives \$ 50.00 per registrant. For this weekend camp for grade eight girls there are five bursaries available to applicants from Northern and inner city schools in order to encourage and provide opportunities for these particular populations.¹⁰

Success Rate

The college's enrollment records show that the EEE Committee has fulfilled its original mandate to increase female as well as general first-year enrollment: the ratio of female first-year students has grown since the EEE program started from a low of 4.8% in 1987 to a high of 24.4% first-year women in 1995. However, recent university statistics indicate that the

⁹ According to Ms. Joelene Mackey, at most universities, the Students' Society operates committees such as the Discover Engineering and EEE. Therefore, award money is given to the student society. However, at the U of S the student society and the outreach committees are separate organizations, and the SESS would not transfer all the money to the Discover Engineering committee, although the committee *per se* won the Memorial Fund Award.

¹⁰ Information provided by Ms. Joelene Mackey.

proportion of first-year female enrollment has stalled at roughly 21% annually (See Figure 4.1).

The EEE Committee advertises by mailing information pamphlets to all high schools in the Province with the offer to make a presentation to the students. However, both the extent of the committee's work and the success of the program depend on which schools and which teachers invite the committee to make its presentation. Without an invitation, there is no visit. With that in mind, in my survey of the first-year cohort in 1996, the EEE Committee had made in-school presentations to 27.2% (60 of 220 students) and had influenced 31.7% (n=19) of those 60 students to enter engineering. However, that was only 8.6% of the total survey sample.

In 2000 the College of Engineering conducted a survey of the first-year students; the survey showed an increase in contacts since my survey in 1996. Nine percent (22 of 244 students) had attended a Sci-Fi camp, compared to 5.5% (12 of 220 students) in my 1996 sample. Of the women, 3.7% (3 of 81) had taken part in Discover Engineering (a question that was not included in my survey). The EEE Committee had visited 30.1% (75 of 249) of the students, a three percent increase since 1996. In addition, 27% (67 of 248) of the students had visited the EEE program during On Campus Days. In total, the outreach strategies had made 167 contacts with the 249 first-year students; however, some of the students had made multiple contacts. Accounting for repeat contacts, 47.5% (116 individual students) had been exposed to some of the strategies, and 54.3% (n=63) of those indicated that this contact had influenced their decision to study engineering (College of Engineering, 2000). Those 63 students constitute 25.3% of the 249 respondents. That is a remarkable increase over the results of my 1996 survey.

In spite of the achievements of the EEE Committee and the women who have made it happen, there were contradicting opinions about its prestige relative to the SESS. The faculty advisor for the EEE Committee has indicated to me that this committee was absolutely essential to the recruitment of new engineering students and that it performed an invaluable service to the college. The increase in female enrollment over the years had justified the present general recruitment strategy instead of targeting female students. The fine-tuning of the school presentations and the skills the women had developed and honed over the years, including the students' own production of a new video, had exceeded the college's

expectations. According to the advisor, the work of this committee outranked the efforts of the SESS both in profile and prestige.

Despite the advisor's glowing assessment, not all students agreed. One female engineering graduate did not hesitate to place the SESS in a more prestigious position than the outreach committees. Another female graduate, now a practicing engineer, suggested that where the SESS had more clout within the college and the university, the EEE Committee had higher prestige in the community. A third female graduate, also a practicing engineer, believed that the two were equal, because "if you are involved, it doesn't matter how you are involved."

Reasons for Involvement

While the SESS has traditionally been a male enclave, the EEE Committee has become a niche for women. Why do the women, with a limited voice in student politics, concentrate their efforts on outreach committees? One of the committee members remarked, "If I don't do it, who will? Very few people in the college are willing to do all the [unpaid, non-academic] work that's involved." Another woman stated that the recruitment activities had become such an integral part of their daily lives that as they were graduating, "we don't know what to do when it's over." One graduating woman, who was not a committee member, explained during an interview:

I think women are probably taking charge of more committees than ever. But I was thinking that it is now possible to be an apathetic female in the college. There was a time when every single woman in the college felt like she had to take part in things. I don't think it's like that anymore (April, 4th year).

All of the committee members (n=6) expressed their loyalty and dedication to their college and to their work. The women believed that their volunteer work made a difference to the college by bringing in new students, and that the recruitment programs were needed. They believed that because the committees had been established, it was up to the students to keep them functioning. They insisted that they were not excluding male students' participation, but they could not force the men to work on the committees. Thus, it was a type of work whose reproduction was left up to the female students. Yet, at the group meeting, the women were concerned that, although they never had difficulty finding volunteers, female or male, for a single project or a single school visit, "after us, there are [sic] nobody lined up to take over" the

day-to-day work of what they considered an essential service to the college.

Benefits and Disadvantages

Being involved with the EEE Committee was a very positive experience for the women. They felt needed, knowing they were performing an important service to the college. They were recognized by the college administration, not because they were working within the college, and not because they took part in engineering competitions, but because they represented the college to the general public. They were also recognized by new students who would approach them to ask questions and indicate they remembered them from having visited their schools or guided their campus tours. "That gives you such a good feeling" one woman added. It was proof that her efforts were important and added to her self-esteem.

Through their committee work, the women acquired and developed skills which they realized they could not learn in the classroom. Among these skills were assertiveness as well as team work and cooperation to achieve their goals, such as enlisting their male classmates' support for the existing school visits and for establishing any new outreach programs. Through cooperation, they became friends and collaborators rather than competitors. They were able to develop communication skills because their work involved contact with individuals outside the engineering profession. One woman illustrated the importance of communication skills by relating that her husband, also an engineering student, had become so isolated within his course work that he could communicate socially only with engineers. For her, communicating with non-engineers had broken that isolation:

It is hard for all of us, and especially for the women, to maintain 'a life' or even normal relationships. The longer you're here, the more isolated you become within your field. If it wasn't for this committee work, we wouldn't know how to behave among 'normal people.'

The skills the women developed through their committee work would transfer well to their future working lives. Aside from the management of the day-to-day work, they learned the importance of practical, organizational skills such as completing projects and meeting deadlines. They learned accuracy in cost estimating and budgeting and how to present their projects for approval and funding. Because each committee had a single purpose, they learned to focus on the task at hand. These were all work place skills that were vital to their future

work and that would make them valuable employees. The women were particularly pleased to hear the guest speaker at the college's *C.J. Mackenzie Banquet*¹¹ stressing these skills as essential to success as engineers.

The women believed that although they were not paid for their work, their personal benefits would be life-long. They also believed that the skills they had acquired through their recruitment and outreach work would, in time, benefit society in general. One woman believed that the committee activity had shown them the value of volunteering. She expected that during their lifetimes they would contribute their experience and expertise to charitable, community and professional organizations. The women also realized that although an SESS executive position might provide more 'glory,' the 'gut' work of their committees was as good as glory.

Although the women took great pride and pleasure in their volunteer work, performing it came with a significant personal cost. In addition to receiving no money for their services, they had taken the longer and more costly five-year course option to complete their programs. The time and effort involved in recruitment strategies were 'stolen' from their academic work, which after all is the 'real' work in the college, and had often resulted in lower grades.¹² These lower grades were detrimental to them when seeking employment. "After Spectrum was over, my grades improved by 10%. Doing this work has compromised my grade point average. How will that affect my employment prospects?" asked one woman who was graduating at the end of the term. She continued:

I had a job interview with [company], they were mean! It was intimidating, there was one of me and four of them: one female Human Resource officer and three male engineers. The first two engineers asked questions relating to my extra-curricular activities, and the third was so horrific. He threw my résumé on the table, leaned back in his chair and said 'I can't believe we are interviewing you! Look at your marks, you are such an oxymoron, all this extra-curricular activity, and your marks are just terrible.' He asked the others why they were interviewing me, 'this is insane.' I told him that my extra-curricular activity was important and that I learned more from that than I did in class. I explained that the skills I had in management, organization and

¹¹ The *C.J. Mackenzie banquet* is the opportunity for the *Mackenzie* lecture, arranged by the College of Engineering and featuring distinguished graduates. The 1998 guest speaker was Mr. Art Dumont, President and CEO of Western Rock Bit Co. Ltd., a 1968 graduate of Mechanical Engineering.

¹² I understand that the students involved in the SESS also complain about the same issue.

communication were applicable to any situation, while some of my courses were so specific that they couldn't be applied to just any job. When it was my turn, I asked why this marvelous company would condescend to interview me if all they looked for was marks. . . . One of the other men admitted that he had once been required to withdraw, and not because of extra-curricular work. I never was required to withdraw! . . . I finally got up and left, I am not prepared to be belittled. I want to be valued for my skills. I took the next train home!

This woman was angry. About to graduate, she had passed all her courses and, in addition, given of her time and talent to benefit her college. Somebody within the organization had obviously seen the value of her particular skills because they had invited her to interview for the position. However, one interviewer had only contempt for her non-technical communication skills, skills that are considered 'soft' and 'feminine' and can thus be devalued, ignored, or dismissed outright. This gendering of skills and the denigration of the feminine stand in sharp contrast to the male interviewer who had been 'required to discontinue.' It was quite acceptable for a man to fail, yet become successful, while lower marks were detrimental to a woman's career in spite of her other skills and abilities.

DISCUSSION

Declining enrollment, governmental desire for greater female participation in engineering and science, and increased awareness of human rights issues had led the College of Engineering to encourage higher female enrollment. To that end, the college depended on female students already in the college to perform the necessary outreach and recruitment work. This move gave the college high visibility in the community, and the female student presenters created the illusion that there was a large peer group of women in the college. The strategy was very successful and effective, with minimal cost to the college administration

In comparing the two major student organizations—the students' society (SESS) and the outreach and recruitment EEE Committee—it is clear that they are gendered in terms of composition, the structure of the work, the purpose of their activities, their funding, the prestige of the organizations, and how the participants were rewarded for their efforts. Within the two types of organizations, the SESS operated in a male sphere of production, while the EEE Committee functioned within a female sphere of reproduction.

The gendered composition of the SESS executive board was heavily weighted in

favour of the male student population. Granted, among the nine board members, there was always at least one woman (and at one time four women), meaning that the female students usually had a 20% representation on the executive, corresponding to their proportion within the student body. In contrast, for the two years that I received membership numbers for the nine-member EEE Committee, only one male student had participated, hardly proportional to the male student body. Male participation was slightly better in the committee organizing the engineering weekend camp for grade eight girls, which saw a male participation of between none and three men over a four year period. Thus, there was clearly a difference in the students' choices when allocating their spare time to extra-curricular activities in the college.

Although the female students were proportionately represented within the SESS executive they had little influence within that body. Moreover, they experienced the masculine culture in the college with its gender-denying characteristics. By accident or by design, the female engineering students had created a niche for themselves in the EEE, a comfort zone within a masculine environment. Within this safe place the women felt free to exercise the characteristics more often associated with feminine qualities, for example friendship and communicative collaboration. The women cited the adage that "birds of the same feather flock together." The continuation "not as a luxury but out of necessity" (Berger, 1963:101-102) was even more evident for this group. In Chapter Six I discussed how the women demonstrated the necessity of togetherness both verbally and by deliberately seeking out other female students with whom to work and to sit beside in class. They had discovered that while they might be 'insignificant' separately, when they, through necessity, worked together on the committees, they became powerful as a critical mass, of which the EEE is a typical example. These actions and strategies show the structural determinants for women's choice in extra-curricular activities.

The two organizations were structured differently. The SESS had a hierarchical, three tiered pyramidal structure of student body, Council and Executive. The student body held annual elections for the executive positions. As in any election campaign, positions could be either acclaimed or contested. The Council consisted of representatives from the various specialty departments, the yearly cohorts, and from other interest groups in the college. Thus, the EEE Committees were members of the Council. The president and the executive were the

overall decision makers. As opposed to the hierarchical structure of the SESS, the EEE Committee and its Discover Engineering and Sci-Fi sub-committees echoed a 'feminine' culture with a lateral and more egalitarian structure. The women were nurturing the social, communicative, co-operative outreach function for the college, where each member had a particular responsibility as part of a whole, and where decisions were made by consensus for the general benefit of the project. The method for filling the available positions also differed from the SESS: interested students had to apply in writing for a seat on the committees, and the incumbents filled the positions with the applicants they deemed best qualified.

The purpose of the SESS, according to its 2000/2001 president, is "to provide for the academic and social needs of undergraduate students," that is, the SESS worked for the student body by *producing* 'fun and games' and relaxation for the students during the school year. Several fund-raising activities for community charities were also part of the 'fun and games,' and the student body in general took part in these arrangements. Similarly, the entire student body always rallied to make the triennial *Spectrum* exhibition a success. However, the SESS also promoted a number of sexist activities that reflected the masculine culture in the college. With an almost 80% male student body, and a predominantly male executive board, some of the activities in the college did not appeal to the 20% or so female students, although they did participate in the fundraising projects and 'Hell Week' events. Even though the SESS was forced to discontinue some of its more obviously objectionable activities, it remains largely a male enclave.

In contrast to the productive intentions of the SESS, the purpose of the EEE Committee was to *reproduce* the student population year over year. The members performed this reproductive work on behalf of the College of Engineering, not for the benefit of engineering students. The College of Engineering knew the benefit of marketing themselves, and the university recognized the importance of the recruitment strategies by funding it through its base budget. In this way, the EEE Committee became the official recruitment arm of the college rather than simply a student organization. In other words, they were working for the college and the university. Drawing on metaphors of women's reproductive labour, the committee increased the engineering 'family' by reproducing the profession through their recruitment of new, prospective students. Moreover, the Discover Engineering and Sci-Fi sub-

committees exemplify 'women's work' at the level of financing. As volunteer work, the efforts of those committees were largely unpaid and also under-funded, as the students themselves had to procure outside funds for some of the programs through the fundraising SAF committee. The SESS, on the other hand, had secure funding by assessing membership fees in the organization. The funding through membership fees also reflects the purpose of working for the students. However, the women enjoyed the work, and in the EEE recruitment and outreach committees they had found and established a niche to work for the benefit of their college.

Another difference between the work of the SESS and the EEE committee is the difference in prestige and value of the organizations. Many students regarded the activities of the SESS as more prestigious than those of the EEE committee. In part, the higher prestige of the SESS appears to be linked to its charitable fundraising activities, which enhance the college's status in the larger community. In its fundraising, the SESS members used their labour power to produce concrete amounts of money, in exchange for the prestige associated with their generous donations to charitable organizations. Through the "illusion of male drama and heroics" (Fiske et al., 1998:26) the SESS can then document and quantify their productive effort, and the gifts of this money would be considered valuable contributions to social life. Thus, the male SESS president's public 'thank you' in the local daily newspaper to all the participating students for their successful efforts in aid of volunteer organizations—which in 1999/2000 amounted to \$26,000.00 and to the end of 2000 had brought in \$10,000.00—reinforced that prestige.¹³

In contrast and comparison, the work of the EEE committee had low status among the students, and the skills they acquired appeared to have little value for employability in the work force. Neither the women nor the College of Engineering advertised the EEE Committees' equally 'heroic' recruitment and outreach efforts, which convinced 63 tuition-paying young women and men (54.3% of n=116) to study engineering, and which translates to about one fourth of the approximately 250 students who responded to the college's first-year

¹³ There was no recognition of the EEE Committee's work. At a recent awards ceremony in the college, which I attended as a scholarship presenter, the president repeated his praise for the fundraising. Again, the women's efforts were ignored.

survey. The reproductive tasks the EEE committee performed, and the low status in which the committee was held, provide insights into the ways in which gender relations are subtly reproduced in the College of Engineering. The college is, in effect, exploiting the women's labour through *benevolent exploitation*, defined as

taking advantage of people because it's 'good for them,' because they care about or respect us, or because we persuade them that the work is critical to the organization. . . . Women are often assigned to committees which are considered less critical to the university's mission. Ironically, they are often committees which involve large amounts of time (Benokraitis, 1997:20; 21).

The definition very aptly describes the work of the recruitment committees. Similarly, benevolent exploitation corresponds to the micro-inequity of 'administrative pimping,' which is exploiting women through imposing a heavier workload on them and invoking their loyalty, especially in times of financial crisis (Milne, cited in Stalker and Prentice, 1998:21).

The responsibility for the success of the recruitment program rested solely on the shoulders of the female committee members. Although male students took part in the visible work of the committee, such as the public presentations, the women did all the invisible planning and necessary scheduling of school visits, much like women's often invisible domestic labour. Thus, the women spent untold hours on their committee work without remuneration other than a 'free lunch' of sandwiches. Even their direct expenses, such as mileage for their travels, were not reimbursed at university rates. While the women themselves found it rewarding and beneficial to gain the experiences that managing the recruitment strategies entailed, the work was 'greedy' for the women's time as well as being considered less prestigious than the SESS. Although the committee is critical to maintaining and increasing enrollment in the college, its work can be considered part of the domestic labour within the college.

In addition to being exploited, the women were subjected to *considerate domination*, where women tend to adhere to gender expectations of being self-sacrificing and cooperative (Benokraitis, 1997). These attitudes were clearly evident in, and part of the ethos of the recruitment committees. The women retained a sense of loyalty to the college, and especially to the new generations of female students. The college and the university were

able to exploit the women's labour, time and energy by affirming the importance of their work to the institution. At the same time, the university did not compensate the women financially for their time, thereby contributing to the devaluation of this work, particularly within the university environment.

The literature on recruitment and retention (Daniels, 1988) recommended that engineering schools employ salaried and professionally trained recruitment and retention officers with a background in human resource management. This suggestion is in stark contrast to the U of S exploitation of the female students' volunteer efforts to do necessary, reproductive labour. In effect, the women in the EEE were saving the college the cost of a professional position and its necessary support staff and supplies, which might exceed the highly valued charitable donations raised by the SESS.

CHAPTER SUMMARY

In this Chapter I have described and discussed the difference between the Saskatoon Engineering Students' Society (SESS) and the Encouraging Enrollment in Engineering (EEE) Committee and its sub-committees in the College of Engineering. The mostly male SESS has as its purpose to produce entertainment and diversions for the student body, whereas the almost exclusively female run recruitment committees provide a valuable, reproductive, volunteer service to the College of Engineering. The women's work on the recruitment and outreach committees has coincided with the increased number of women enrolling in engineering education, and the EEE Committee performs at very little cost work which at other universities (e.g. Dryburgh, 1999) warrants a special, paid position within the faculty of engineering.

Unlike the students who had discontinued their engineering education (Chapter Five), all the committee women stated that there was no place they would rather be than in the College of Engineering and the engineering profession. They also agreed with other students I had interviewed that women definitely had a place in engineering. Although their committee work was time consuming, jeopardized their academic performance and extended their educational programs, the intrinsic rewards for the work compensated for possibly lower grades and might make them valuable team players in a profession where

team work is a necessity. The practical skills they developed have long been recognized as necessary in the work place. Employers have lamented that college graduates have not been taught these skills in sciences and engineering; yet some industry recruiters apparently give little credit to students who have acquired them.

The activities of the outreach committees, while valuable, require the students to raise significant external funding for some of their activities, yet are simultaneously undervalued, for example, the 'free lunch' consisting of sandwiches. This gendered division of labour perpetuates the denigration of women's work in society, which often falls into the reproductive sphere. The niche the women had carved out for themselves in the EEE Committee can be seen as an example of 'voluntary exclusion' because, much like the 1800-1900 turn-of-the-century girls' and women's schools and colleges, the committees provided a safe environment to which the women could retreat, and where they could practise the more feminine skills of co-operation and communication. Through their recruitment and outreach work the women had found a source of friendship and community, and while they might be considered 'insignificant' separately, they gained power when they worked together as a critical mass.

CHAPTER EIGHT
“COMMISSIONING” THE ENGINEER
(Conclusions and Recommendations)

Until the 1980s there has been an under-representation of women in the sciences in general, and specifically in the engineering profession. Government responded to this problem by establishing special university scholarships for gifted students in these disciplines, with the provision that half the awards be allocated to female students. Universities, among them the University of Saskatchewan (U of S), responded by designing recruitment strategies to encourage women to consider the study of engineering. At the U of S, the Encouraging Enrollment in Engineering (EEE) Committee was established even before the creation of the NSERC/NORTEL national chair for Women in Engineering (WIE). As a result of these strategies, the proportion of female engineering students has increased from below ten per cent of enrollment to between 20 to 21% at the U of S and 20 and 25% nationally.

In this study I have investigated three important phases of engineering education: why students choose engineering as a profession; why they decide to discontinue engineering education; and the students' social, pedagogical and cultural experiences during their years of study. Because a longitudinal study of one single cohort was not possible within the time frame of a doctoral program, a cross-sectional study of three distinct sub-populations of engineering students has allowed me to study the breadth of engineering education in a compressed mode while attending courses at the first, third and fourth-year levels of the program. In each of these phases of engineering education, it became apparent that gender relations partially mediated both women's and men's perceptions, experiences and responses to the engineering program. Although male and female students study and learn the same curriculum, becoming an engineer entails different experiences for women than for men.

An Illusion of Inclusion¹

“To be or not to be [a female engineer], that is the question.” During the analysis of the research data, I have come to realize that the “female engineer” may not exist and may even be an oxymoron, or at least a paradox. Judith Lorber (1994:7-8) has identified numerous “paradoxes of gender,” for example “Why does gender simultaneously construct difference and sameness?” “Why are most of our cultural images of women the way men see them, not the way women see themselves?” and “Why do societies established for equality . . . still exhibit substantial inequality?” Moreover, Lorber questions “Why, since gender is socially constructed, is it [inequality] so difficult to eradicate or even minimize?” These questions are indeed important for women who decide to study the male-dominated field of engineering. Throughout their years of education, the women who enroll in engineering education experience continuous tension because of their gender as well as their sex. They enter engineering education as idealistic, enthusiastic high school girls and emerge as jaded women who have struggled with contradictions that cause some to deny their gender while others confront the gender challenge and fight back.

It is common knowledge that women now constitute at least half of all university students, and it appears that women are included as part of the student population. However, research has demonstrated that there is systematic exclusion of women on university campuses (Stalker and Prentice, 1998). The illusion that female students are included is particularly evident in engineering colleges. The data from this study show that the female students were excluded in a variety of subtle and not so subtle ways, ranging from being invisible and ignored in the classroom environment to exclusion from formal and informal discussions with their male professors. In the social environment some of the women experienced a hostile climate of jealousy and sexual and disparaging remarks and objected to extra-curricular activities that generally appealed to male students.

The findings from my survey of the first-year cohort and subsequent interviews were consistent with the literature, which had indicated that women and men had different reasons

¹ Taken from the title of an anthology edited by Jacqueline Stalker and Susan Prentice (1998), *The Illusion of Inclusion. Women in Post-Secondary Education*. Halifax: Fernwood Publishing.

for choosing engineering as a profession. Most of the students in my study had parental encouragement and approval to pursue engineering, some had the added benefit of knowing engineering role models, and some had been urged to study engineering because of women's minority status. There was a gender difference in the students' decision, as the women lacked the men's "tinkering experience," for which they compensated by entering with high academic credentials. While the women took particular pride in their mathematics and physics skills, the male students appeared to take such skills for granted. The students' choices of specialization were also gender based. Following a national trend, and confirming previous studies, most of the women chose departments with a social or environmental focus, while showing less interest in the 'tinkering' based departments. In contrast, the majority of the men chose mechanical and electrical engineering, thanks to their 'tinkering' interest in making and constructing objects while staying away from the social and environmental specializations.

Attrition has been a central issue in this research. Students were admitted to the College of Engineering on the basis of their final high school marks, and male and female students were equally well prepared academically, especially in mathematics and the sciences, the building blocks in engineering education and gatekeepers to the culture of engineering (McIlwee and Robinson, 1992). In other words the 'building material' for the 'construction' of engineers at the U of S is 'Grade A,' with equal possibility for success in their courses. Because the deficit model of education did not apply to the students in the research, it also does not explain the high attrition rate, especially for women. In spite of their high school preparation, some engineering students realized that they had made a wrong choice and decided to transfer to other fields. The literature, and especially Baignée's (1993) study, found that difficult subjects and a heavy course load were major impediments to completing an engineering education. Such information was gathered mainly from surveys with limited response options. When I discussed attrition directly with the students who had transferred to other fields, it was clear that the major reason for such transfers was the heavy workload, especially in the first year of study. Yet others had more individual reasons for leaving, for example family responsibilities. Moreover, some women complained about incidents relating to a "chilly climate" for women, including sexualized language, name-calling and a feeling of exclusion. There was a generally hostile environment in the engineering culture, which they

found offensive, puerile, and not conducive to feeling included. This finding is a crucial addition and a new dimension in the study of attrition.

Exclusion was not only an issue for those who left but also a problem for those who remained. Some female students were excluded from full participation in the classroom while others felt excluded from social activities. The women who stayed experienced the paradox of being at the same time equal to and different from their male classmates (Lorber, 1994). On the one hand, they were 'equal' by learning the same concepts in the same courses, causing the men to consider them 'one of the guys' and 'just engineers.' On the other hand, they were 'different,' as some male students had noticed that women tended to approach problems differently and changed the dynamics of the classroom, which did not prevent the male students from calling them 'bitches' in a certain class. They were also unequal by not being able to spend time in professors' offices, lest they be considered 'having a crush' on him. Unequal access to information is a matter of exclusion, which works to the women's disadvantage.

Rarely acknowledged (until recently), and even less understood, are the ways in which patriarchal values inform, mediate and shape engineering education. Although it is difficult to draw definite conclusions from this small, self-selected sample, my research has revealed that, both in the classrooms and in the social environment, there is no doubt that some students, both female and male, experienced a chilly, if not arctic, climate in their social relationships. Some of the incidents the informants retold reveal a level of hostility toward female students (mostly by their male peers) that is disturbing. In addition, the women experienced the paradox of always being judged through the male students' eyes and perceptions. They were considered both inferior to (spoon-fed), yet possibly better engineers than the male students. They were vain, yet smart. They were sexual objects with whom flirting was fun, yet they were subjected to suggestive remarks about their biological features and sexual organs, causing the men to offer protection, either valiantly or violently. Although they were 'just engineers,' some of the men nevertheless viewed them as unfair competition for employment and possibly scholarships. Although they were equal and 'one of the guys,' they were 'troublemakers' if and when they pointed out any inequalities. In Canadian society, where women have been 'persons' and in theory equal to men since 1929, one might ask with Lorber why full equality is not part of women's reality in engineering.

In addition to demonstrating the paradoxes women experience in engineering education, my findings illustrate the inadequacies of the deficit model of women's education, which dominates the explanations for women's under-representation in engineering. The deficit model assumes that women's under-representation in science and engineering courses is due to their failure to study mathematics and science in high school. It further places the onus on girls to ascertain that they study these crucial courses, and if need be, enroll in enhancement courses, lest they be excluded from many fields of post-secondary study. Offering extra courses and special scholarships would encourage girls to take care of this science deficit. Otherwise, once they became part of the educational pipeline that leads to post-graduate degrees, senior research positions and university faculty appointments, the girls would 'leak' out of the educational pipeline and be eliminated from these coveted positions.

The model of a 'leaky pipeline' in science and technology infers that women who do not complete their education in science and engineering are 'waste' products. However, the model should apply equally to men who change their interests from science to other fields. Furthermore, students who voluntarily opt out in spite of solid pre-requisites and performances in these disciplines, should not be considered 'waste.' This model constructs those who leave engineering in negative terms, and it blames attrition from engineering on the individual. Instead, my data suggest that the masculine culture in engineering and the structure of the education are, at least partly, responsible for making engineering education less attractive to many women and some men.

In addition to the 'waste' metaphor, the leaky pipeline model considers only one point of entry, at the lowest, most elementary level. This model does not consider the many other points of entry into engineering education at higher levels or the students' range of talents and abilities. Nor does it account for occasional 'trickles' of re-entry students into science and engineering education. Ironically, present recruitment strategies are based on attempts to introduce the college as more inclusive and welcoming to prospective students, especially women. Yet, the leaky pipeline metaphor tends to reinforce elitism within the engineering profession by creating a dichotomy of insiders (those who made it) and outsiders (waste products).

From the above discussion, it is clear that the model of a rigid, one-directional pipeline

is a poor metaphor for attrition. I have suggested other, more positive and appropriate metaphors to describe students' deliberate movements between disciplines and fields of study. My preferred metaphor is a corridor of educational opportunities that is not restrictive, and which may more appropriately depict how students make choices in post-secondary education. The talented students in my study who withdrew from engineering found engineering education and the masculine engineering culture unsuitable and other disciplines more worth their while. These students had, as Stalker and Prentice (1998) warned, withdrawn their time and interest and denied engineering the privilege of their participation.

In addition to the inadequacies of the deficit model, the findings in this study illustrate the ways in which the deficit model obscures the social and cultural practices that shape the transmission of knowledge. Generally, engineering education is conceptualized as the transmission of knowledge and skills necessary for engineers to carry out their work. Embedded in this view of knowledge is the assumption that it is value free and objective. But as a former president of the National Academy of Engineering, Robert M. White (1991:v), has indicated, "engineering is . . . a social enterprise" and "social needs and pressures shape what engineers do as much as engineering and technology shape the nature of society." White draws our attention to the dialectical relationship between engineering and society, which starts at the educational level. Although White focuses on social needs and technology, this analysis can be extended to human needs. After all, societies exist through human relationships. Therefore, it is necessary for engineers to consider the human elements of society and teach new generations of engineers the importance of human relationships, both in theory, in practice and by example.

Studies of male workplaces and educational environments point to the existence of masculinist culture. In the College of Engineering, both male students and some faculty reproduced the masculine culture. This culture manifests itself in "looking, talking and acting male" (McIlwee and Robinson, 1992; Stalker and Prentice, 1998). It refers to the propensity for engineers to behave aggressively, competitively, and excelling in hands-on competence (McIlwee and Robinson, 1992). The masculine culture rests on the assumption that the university itself is men's business and that those who 'count' in the university setting are male (Drakich et al., 1991, in Stewart, 1994).

This study also shows that engineering education is embedded in gender relations. As

the students themselves commented, their education reflected the dominance of 'masculine' values, which emphasize "working hard and playing hard" (Dryburg, 1999), and are expressed in the engineering profession through a heavy workload and in the curriculum itself. In addition, male dominance is evident in the makeup of the faculty; there were no female role models in the college after the two female engineering professors left the university. The gendered and hierarchical feature of engineering was also evident in the male and female students' choices of specializations. One fourth of the female students chose the Department of Civil Engineering. This department is concerned with infrastructures that influence the human environment, such as transportation and habitation. Another 30% of female students favoured Chemical Engineering and Agricultural and Bioresource Engineering, departments that are directed toward issues in the human environment, for example, water quality and waste disposal. In contrast, over 25% of the male students at the U of S chose Electrical Engineering as their specialization, only exceeded by Mechanical Engineering. There was a corresponding low female choice of these two departments, and the male students' almost dismissed Chemical and Agricultural and Bioresource Engineering. The processes that lead to the construction of some fields as "human oriented" and others as "abstract" are uncertain, but it appears that they are linked to the gendering of engineering education. This question is not unique to engineering but can also be found in such professions as medicine and law, where men and women are under- and over-represented in certain specialties.

My study supports Henwood's (1998) finding that indicates the existence of at least two masculine student cultures and possibly more. In the College of Engineering there was a dominant male student culture which celebrated machismo and policed the boundaries of gender through discrimination and power. As Chapter Six demonstrated, sex discrimination is one of the barriers female students experience in engineering education. The students' social environment was rife with sexualized language, and the women who complained about rude language and unacceptable behaviour were harassed, and even called 'bitches' in class. On the other hand, the male students were not totally safe from harassment by professors, as one particular male student revealed. Following Benokraitis (1997), there was evidence of both blatant and subtle forms of sex discrimination in the college. While there was strong evidence of a misogynist subculture among the students, this was not true for the male faculty. With the

exception of a few isolated incidents, the male faculty did not engage in overt sexist or discriminatory behaviour toward the female students, nor did the students complain about this issue. However, male faculty were blind to gender issues and dynamics. Some faculty were unaware of gendered patterns of socialization (for example, eliciting students' opinions, in conversations, etc.). At an institutional level, the male faculty were engaged in subtle forms of sex discrimination through their benevolent exploitation of female student labour. The college's recruitment and outreach committees—staffed almost exclusively by women—performed an invaluable service to the college. At the same time, these committees cost the women extra tuition and loss of academic standing, although they did have the benefit of an enclave in which they could be safe.

However, as in Henwood's research, there was also a small group of male students who, according to their interview statements, enjoyed working with intelligent and skilled female students and were less willing to go along with the overt forms of sexism. These men were willing to stand up for the women if and when they believed someone had crossed the line of unacceptable behaviour. Furthermore, the data show subtler differences in the expression of masculine identity between engineering and mathematics as well as between the engineering specializations, where the women preferred the more societal and human disciplines to the 'hard' mechanical and electrical departments. The nuances of male sub-cultures within engineering colleges require further study. In addition to further studies in engineering, there are likely other populations of students in science and mathematics who may experience many of the same problems as the engineering students do. A comparison of the masculine cultures in engineering and mathematics may be worthy of a study. A comparison with men's and women's specialty choices in law, medicine and education would add to our understanding of the gendered division of labour in society. Explanations of power relations between and among these sub-cultures will provide insight into the perpetuation of male dominance, as well as resistance to it.

Women's Responses to the Illusion of Inclusion

Despite the insistence that male and female students study and learn the same curriculum, women in the engineering college face barriers unknown to and unnoticed by most

men. The women responded to engineering education in several ways, the most prominent being the women's own denial of gender, as well as the men's un-gendering of the women. During the education process, all students become socialized into the gendered, i.e., masculine culture of the engineering profession, and by daily negotiation of gender dynamics through 'doing gender' (West and Zimmermann, 1991), female and male students alike become professionally socialized to reproduce that masculine culture. In their training or education they adapt to and/or adopt the attitudes and values of the masculine professional culture. For the women, there was the paradoxical tension between in some cases knowing that they were different from the men, yet wanting to be 'just students' and wanting equal treatment as their male colleagues (Henwood, 1998; Lorber, 1994). They resorted to being 'one of the boys' and forgetting their feminine gender—or denying their gender—for acceptance by the majority (Dececchi et al., 1998), yet sought women's company for safety. The phenomenon is not exclusive to the U of S, as both Dryburgh (1999) and Dececchi et al. (1998) demonstrate.

The un-gendering of women has been troublesome for female engineering educators and researchers. Ursula Franklin (1995), for example, was concerned that if women engineers become mere emulations of male peers, rather than bringing feminine perspectives of caring and non-aggression to their work, it would be a loss to the engineering profession. Similarly, Geppert (1995) was appalled that women would not recognize and admit that they were feminine, gendered individuals. Geppert blamed faculty who ignored or denigrated women for contributing to and perpetuating the un-gendering of the female students.

In addition to denying their own gender, and similar to Geppert, my data indicate women believe that they must also adopt masculine traits in order to be accepted in the masculine engineering profession. Therefore, the women realized that they had to be able to protect themselves both physically and verbally. They were aware that they could not complain about harassing or unwanted behaviours for fear of escalating harassment and made a point of responding in kind to sexual jokes and communicating with the men on their own terms. In general, they managed to 'grin and bear it,' although they were unhappy with the way they were treated.

On the one hand, one can argue that both men's and women's belief that women as engineers are 'just engineers' and 'one of the guys' is an indication of the men's complete acceptance of women engineering graduates as their professional equals and thus a sign of full inclusion in the profession. On the other hand, this acceptance is on male terms, not on women's terms or on terms of equality. Small wonder, then, that a few women sought out a separate space through the EEE Committee, which served as a kind of voluntary separatism or exclusion and gave them an outlet where they could practise their 'feminine' skills and cultivate friendships without repercussion. The EEE provided a safe space for women who had accepted engineering as their vocation and prevailed in their desire to enter the engineering profession. However, the space was constructed within the parameters of acceptable femininity; that is to say, that the recruitment committee performed domestic labour for the college. In contrast, and as a last resort if the culture became too oppressive, there was the opportunity for both men and women to transfer to other disciplines, where the culture might be more attuned to the students' personalities.

The results of this study reinforce the view that gender is performed on a daily basis at the micro-level and requires the active participation of all the actors in the environment, men as well as women. Because this environment is foreign to most women, they are at a disadvantage in how to negotiate the necessary subtleties. As a result, many women adopted survival strategies and responses discussed above. Throughout this research, my primary focus has been on the female student population. However, by including men in the research and listening to their concerns and ideas it is obvious that the men are gendered individuals too, and that there is a need to pay more attention to the men in the college and to soften and eradicate the gender inequalities.

Solutions for Inclusion

The results of this study demonstrate the complexity of gender relations in the College of Engineering, necessitating a variety of responses at different levels. Clearly, the first step is to enforce already existing zero-tolerance policies for overt forms of discrimination and harassment. The second step would be to create a positive educational environment for women. Appointing more female faculty will ensure that both male and female students have

role models who provide important forms of mentorship as well as reinforcing the idea that *woman* and *engineer* are not oxymorons. However, given the dearth of women in doctoral programs in engineering, increasing the representation of women among the faculty must be a long-term goal. Thus, the creation of a positive educational environment rests with the existing male faculty and administration.

While the majority of male faculty does not have expertise in feminist pedagogy, they clearly need to raise their level of awareness about gender issues, relations and dynamics. This is particularly important in the classroom setting, but also in the social environment. For example, Linda Briskin (1994) calls attention to a number of contradictions that women bring to the classroom. The mere fact of being a woman implies being socially devalued. Similarly, there is a contradiction between attractiveness, which is a criterion for successful women, and intelligence, a sign of masculinity. Intelligent males are powerful; beautiful women are powerless (Briskin, 1994). My data show examples of power versus beauty in statements that the female students' beauty was good for the college, yet their perceived vanity implied a lesser intelligence.

Ignoring female students' questions is sexist and reinforces both marginalization and stereotyping of women. Rubin and Cooper (1998:161) are distressed that some teachers consider gender equity issues "tangential to the process and outcome of education and should be addressed only as a special interest topic, if at all." They argue that the sooner male and female students are treated equally at all educational levels, the easier it will be for all workplace employees to accept each other as both co-workers and supervisors in an increasingly competitive global environment. Rubin and Cooper therefore recommend that, in order for female university students to have truly equal opportunities, professors must be trained in the importance of gender neutral pedagogy. Briskin goes one step further by arguing that teaching implies leadership, and that only by leading and teaching by example will students realize the difference between non-sexism and anti-sexism. While the need for female students to deny their gender to be accepted as equals is an example of non-sexism, Briskin argues that non-sexism is not good enough and that it should be replaced with a strategy of anti-sexism, which "makes gender an official rather than an unofficial factor in classroom process and curriculum" (Briskin, 1994:455). In contrast to non-sexism, which proposes that with proper preparation

women can do anything, anti-sexism would elucidate the barriers that stand in the way of achieving this 'anything' and how collective strategies can tear down some of these barriers (Briskin, 1994).

In addition to the students being gendered individuals, so also are their teachers. Thus, male faculty need to learn not only about creating a positive educational experience for women but learn to recognize patterns of gendered interactions that disadvantage women, intentionally or otherwise, and make women feel uncomfortable and excluded.

While much responsibility for changing the culture in engineering education must rest with faculty and administration, there are limits to which they can control the misogynist activities of the dominant male student culture. However, since this culture is not homogeneous, faculty and administration should identify students who appear sensitive to or cognizant of gender issues and work with them to develop strategies to undercut the dominant male sub-culture.

The college has acted upon some of the recommendations of its own attrition study, for example the strategies for spreading the four-year curriculum over five years, which has become increasingly popular with the students. Another recommendation, to allow engineering students to take other science or mathematics courses equivalent to the courses offered in engineering, has not been implemented. Ursula Franklin's (1993:15) statement "If it is not appropriate for women, it is not appropriate," has its corollary in *whatever is good for women, benefits all*. On that basis I offer some practical recommendations for the College, some of which are suggestions for improvement that students offered during the interviews.

- Make the study of engineering a five-year program, including one year pre-engineering courses in the College of Arts and Science. The attrition study's finding that students with transfer credits from other university programs were more successful than direct entry students supports such a strategy.
- Make it easier to study engineering on a part-time basis. This becomes particularly important for women and older students who may have a problem balancing studies with their obligations to family and/or paid work.
- Pay more attention to issues relating to engineering and society. Students experience the many dimensions and contributions of engineers from the point of view of the fine

arts, humanities and the social sciences, as well as from the technical and ethical sides. These aspects should be highlighted throughout the engineering program and could with a little imagination be integrated into a number of courses, following Weasel et al. (2000).

- As an alternative, develop a social science and humanities course for engineers, which examines the relationship between engineering and society, including emphasis on gender issues. This course could fulfil the required six credit units in social science and humanities disciplines. The first three-units should be introductory, while the next three units would move to an upper year level, giving engineering students a survey course of non-engineering disciplines.
- Provide more social support for women. Nayyar Javed (1988) reported that the college needed retention programs to combat the high attrition rate. Such retention programs are still missing.
- Examine other successful programs for retaining students and increasing gender awareness among students. One such program is the Women in Engineering program. The Prairie Chair for Women in Science and Engineering at the University of Calgary might be able to assist in establishing the program, which would provide students with an outlet, or a safe place, for programming and discussion of issues that relate to women as a minority in engineering.
- Place more emphasis on the application of engineering in a variety of domains. Hacker's (1990:137) comment that "responsible engineering education must teach the students how social relations at work are built into technological systems" could help making the study of engineering more relevant to women. "Boring math" and "plugging formulas" may make sense if the outcome of the math and physics would demonstrate not only how machines etc. are built and function, but also how appliances can make life easier in the home, or how the construction of prostheses aid amputees.
- Employ a Human Resource counsellor. In spite of realizing the importance of the EEE Committee to the women, I recommend that the College of Engineering takes responsibility for its recruitment strategy by either employing a Human Resource counsellor to perform the administrative and planning work of the EEE Committee or

compensating the women for their expertise and their services, for example, funding as teaching assistants, as well as secretarial help with the 'grunt work.' I also recommend that the EEE Committee be retained in an advisory position so that the women's collective knowledge would not be wasted. In addition to the recruitment function, a Human Resource officer, preferably female, would develop a retention strategy within the college to counteract the loss of qualified students to other disciplines. Other duties could include arranging gender sensitivity workshops for students, faculty and staff and act as an advocate and ombudsperson for students' problems and issues, especially gender related issues.

- Construct the engineering program based on the assumption that every student will graduate.
- If student attrition is still a concern, there has to be some monitoring of students who withdraw from the program, preferably through exit interviews either in person or by telephone.
- There are likely to be other issues that are in need of study, both in the College of Engineering and in the university as such. For example, although the college surveys their first-year cohort about the performance of the recruitment committee, this issue needs an in-depth study, especially in light of my suggestion to replace the committee of volunteers with a paid staff position. One issue that needs to be addressed is the lack of female engineering faculty. Since other institutions have a number of female faculty members, I urge the college to make a concerted effort to find female professors for their departments. It is important that students, both male and female, realize that women are capable academics, and that without women, engineering is missing a vital element of its profession. This is a very timely topic for further study.

This research has attempted to find answers to a number of questions that have been of concern to women in engineering, to administrators in engineering schools and to leaders in industry. In spite of a concerted effort to increase the numbers and proportion of women in engineering to approximate the proportion of women in society, there is still a long way ahead for gender parity in the profession.

My recommendations are intended to improve the climate for all students in engineering, but especially for the women. Students and faculty owe each other mutual respect. The female students must be treated with respect for their individual and particular concerns without feeling patronized. In order to make engineering education as pleasant as possible, colleges of engineering must make the educational environment inviting for the entire student population. That does not mean that female students should have special academic privileges, but they do have the right to a climate that is free of sexual harassment and jealousy. In other words, they have the right to a feeling of well-being and a possibility of finding a woman-friendly school or college with such features as those described in Chapter Six.

I close by re-stating the hope that the initiative by nine American research universities will lead to a better and warmer climate for all women in science and engineering (Cox, 2001). Lillian Dyck (1998:105) cites the surviving Dionne quintuplets' advice to children: "Never be afraid to speak out against injustice. Never be afraid to fight for what is right." Dyck hopes that women in science will be able to be themselves in their work and not be forced to be tough because that is what science requires. I hope that women who study engineering, at the University of Saskatchewan and elsewhere, will experience a place of study that affords women a safe environment, free of harassment and of unacceptable and derogatory language both within and outside the classroom. I hope that the women will not be afraid to name the injustices and repercussions they suffer when they speak out against sex discriminatory treatment. I hope that the full inclusion of women as equals to men in engineering, on their own terms, will become reality and cease to be an illusion.

REFERENCES

- Abdal-Haqq, Ismat. 1998. Constructivism in Teacher Education: Considerations for Those Who Would Link Practice to Theory. ERIC Digest, ED426986
- Alper, Joe. 1993. The Pipeline Is Leaking Women All the Way Along. *Science*, Vol. 260, 16 April, pp: 409-411.
- Anderson, Doris. 1991. *The Unfinished Revolution. The Status of Women in Twelve Countries*. Toronto: Doubleday.
- Anderson, Inger J. Tveten. 1994. *Per Ardua ad Astra: Challenges and Strategies in Educational Experiences of Mature Female University Students*. Saskatoon: University of Saskatchewan, Unpublished M.A. Thesis.
- Armstrong, Pat and Hugh Armstrong. 1994. *The Double Ghetto. Canadian Women and Their Segregated Work..* Toronto: McClelland & Stewart Inc.
- Association of Professional Engineers of Saskatchewan, (A.P.E.S.) 1993. *Saskatchewan Women in Engineering. Our Firsts!* Poster, October.
- Babbie, Earl. 1986. *The Practice of Social Research*. Fourth Edition. Belmont, CA:
- Baignée, Alison. 1993. Attraction and Retention of Women in Engineering - Undergraduate Survey of Engineering Students at the Universities of Ottawa and Manitoba. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 692 - 700. Toronto: Ontario Women's Directorate.
- Barinaga, Marcia. 1993a. Is There a 'Female Style' in Science? *Science*, Vol. 260, 16 April, pp: 384-391.
- _____. 1993b. Feminists Find Gender Everywhere in Science. *Science*, Vol. 260, 16 April, pp: 392-93.
- _____. 1992. Profile of a Field: Neuroscience. The Pipeline is Leaking. *Science*, Vol. 255, 13 March, pp: 1366-67.
- Baum, Eleanor. 1989. Why So Few Women in Engineering? *Engineering Education*, July/August. pp. 556-557.
- Beal, Philip E. and Lee Noel. 1980. *What Works in Student Retention*. The Report on a Joint Project of the American College Testing Program and the National Center for Higher Education Management Systems.
- Becker, Howard S., Blanche Greer, E.C. Hughes and A.L. Strauss, 1961. *Boys in White; Student Culture in Medical School*. University of Chicago Press.
- Belenky, Mary Field, Blythe McVicker Clinchy, Nancy Rule Goldberger and Jill Mattuck Tarule. 1986. *Women's Ways of Knowing. The Development of Self, Voice and Mind*. New York: Basic Books, Inc.
- Benokraitis, Nijole V. 1997. *Subtle Sexism. Current Practice and Prospects for Change*. Thousand Oaks, CA: Sage Publications

- Berger, Peter L. 1963. *Invitation to Sociology. A Humanistic Perspective*. New York: Anchor Books.
- Bix, Amy Sue. 2000. Feminism Where Men Predominate. The History of Women's Science and Engineering Education at MIT. *Women's Studies Quarterly*, 2000, 1 & 2, pp 24 – 45.
- Bowen, J. Ray. 1988. The Engineering Student Pipeline. *Engineering Education*, May. pp. 733-734.
- Brainard, Suzanne. 1993. A Successful National Women in Engineering Initiative. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 570 - 578. Toronto: Ontario Women's Directorate.
- Brandell, Gerd. 1996. Gender in Engineering Education. Contribution to GASAT (Gender and Science and Technology) 8. <http://www.wigsat.org/gasat/55.txt>
- Brinkerhoff, David B. and Lynn K. White. 1991. *Sociology*. Third Edition. St. Paul, MN.: West Publishing Co.
- Briskin, Linda. 1994. Feminist Pedagogy: Teaching and Learning Liberation. In Lorna Erwin and David MacLennan (eds.) *Sociology of Education in Canada. Critical Perspectives on Theory, Research and Practice* pp.443 - 478. Toronto: Copp Clark Longman Ltd.
- Canada Scholarships. n.d. Pamphlet.
- Canadian Committee on Women in Engineering (CCWE). 1992. *More Than Just Numbers: Report of the Canadian Committee on Women in Engineering*. Fredericton, NB: University of New Brunswick.
- Canadian Engineering Memorial Foundation. 1995. *Memorial Foundation Promotes Engineering Through Awards Program*. Ottawa.
- Cannon, Elizabeth. 1997. Presentation to Students and Faculty. Saskatoon: University of Saskatchewan, College of Engineering. December 5.
- Cannon, M. Elizabeth and Judy L. Lupart. 2001. *Gender Differences in Grades 7 and 10 Students Toward Science, Math Computers and Future Career Choices*. Presented at NAMEPA/WEPAN 2001 Conference/April 21-24, Alexandria VA.
- Carter, Ruth and Gill Kirkup. 1990. *Women in Engineering: A Good Place to Be?* Houndmills and London: Macmillan Education Ltd.
- CBS Television. 1999. *Sunday Morning* (Sunday, March 14, 1999).
- Chair for Women in Science and Engineering (CWSE), 1999. *Undergraduate Female Students in Engineering Programs by Province, 1991-1997*.
<http://www.geomatics.ucalgary.ca/cwse/Univers.html>
<http://www.carleton.ca/cwse-on/enrolment1.gif>
- City of Saskatoon. 2000. http://www.city.saskatoon.sk.ca/org/quick_facts/index.asp
- Cockburn, Cynthia. 1988. *Machinery of Dominance: Women, Men, and Technical Knowhow*. Boston: Northeastern University Press.
- Cockburn, Cynthia and Susan Ormond. 1993. *Gender and Technology in the Making*. London: Sage Publications.

- Cohn, Carol. 1990. "Clean Bombs" and Clean Language. In J. B. Elshtein and S. Tobias (eds.) *Women, Militarism and War: Essays in History, Politics, and Social Theory*, pp. 33-59. Savage, MD: Rowan and Littlefield.
- College of Engineering, Office of the Dean. 2000. First Year Student Survey (Excerpt). Saskatoon: University of Saskatchewan.
- _____. 1995-1999. Annual (Internal) Registration Statistics. Saskatoon: University of Saskatchewan.
- _____. 1995. *Retention Study. First Year Student Progress*. July. Saskatoon: University of Saskatchewan.
- Connell, R.W. 2000. *The Men and the Boys*. Berkeley and Los Angeles: University of California Press.
- Cove, Patrick G. and Anne Goodsell Love. 1996. Enhancing Student Learning: Intellectual, Social and Emotional Integration. ERIC Digest, ED4007-41.
- Cox, Ana Marie. 2001. 9 Research Universities Pledge to Treat Female Scientists Better. *Chronicle of Higher Education, January 31*.
<http://chronicle.com/daily/2001/01/200101310ln.htm>
- Cukier, Wendy. 1993. Equity Curriculum for Engineering Students: A Pilot Project. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 570 - 578. Toronto: Ontario Women's Directorate.
- Cumming, Sally M and Martha L. Hendriks. 1993. Recruiting Females Into Physical Science and Engineering Programs at the University Level: A Literature Survey. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 602 - 610. Toronto: Ontario Women's Directorate.
- Dagg, Anne Innis and Patricia J. Thompson. 1988. *MisEducation: Women & Canadian Universities*. Toronto: OISE.
- Daniels, Jane Zimmer. 1988. Women in Engineering: A Program Administrator's Perspective. *Engineering Education, May*. pp 766-68.
- Davis, Cinda-Sue and Carol Hollenshead. 1993. Marian Sarah Parker Scholars: A Pipeline Program for Undergraduate Women in Engineering. In Haggerty, Sharon and Ann Holmes (eds.) (1993). *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference, pp. 721 - 729. Toronto: Ontario Women's Directorate.
- Dececchi, T., M. E. Timperon and B. B. Dececchi. 1998. *Journal of Gender Studies, Vol. 7, No. 1*, pp. 21 -38.
- Dench, Sarah J. and Karen B. Levine. 1993. Mentoring in Engineering: A Case Study. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 570 - 578. Toronto: Ontario Women's Directorate.
- DeVault, Marjorie L. 1999. *Liberating Method. Feminism and Social Research*. Philadelphia: Temple University Press.

- Donaldson, E. L. and E. A. Dixon. 1995. Retaining Women Students in Science Involves More Than Course Selection. In *Canadian Journal of Higher Education, Vol. XXV-2* pp 29 – 51.
- Dryburgh, Heather. 1999. Work Hard, Play Hard. Women and Professionalization in Engineering—Adapting to the Culture. *Gender and Society, Vol. 13 No. 5*, October, pp. 664 - 682.
- Dyck, Lillian E. 1998. Stages in the Path to Equity for Women Faculty in Science Departments. In *Women in the Workplace: Achieving Harmony*. Contributions to Canadian Coalition of Women in Engineering, Science and Technology Conference, Vancouver, BC, pp 99 - 106. May.
- _____. 1998b. An Analysis of Western, Feminist and Aboriginal Science Using the Medicine Wheel of the Plains Indians. In Lenore A. Stiffarm (ed.) *As We See . . . Aboriginal Pedagogy*, pp. 87 – 101. Saskatoon: University of Saskatchewan, University Extension Press.
- Easley, Brian. 1995. Patriarchy, Scientists, and Nuclear Warriors. In S. Ruth (ed.) *Issues in Feminism*. 3rd Edition, pp. 70 - 82. Toronto: Mayfield. Reprinted from Michael Kaufman, 1987, *Beyond Patriarchy*. Toronto: Oxford University Press.
- Eichler, Margrit. 1991. *Nonsexist Research Methods. A Practical Guide*. New York and London: Routledge.
- _____. 1986. *Sitting Between Two Chairs and Loving It: Reflections of a Feminist Sociologist*. Lecture at OISE, January.
- Eisenhart, Margaret and Elizabeth Finkel. 1998. *Women in Science*. Chicago: University of Chicago Press.
- Eitzen, D. Stanley and Maxine Baca Zinn. 1994. *Social Problems*. 6th Edition. Boston: Ellis, Dormer.
- Ellis, Dormer. 1986. Educating a Growing Minority—Canadian Women Engineers. *Interchange*, vol. 17, no. 4, pp. 52 - 62.
- _____. 1983. *These Women are Engineers*. Ottawa: Canadian Council of Professional Engineers.
- _____. 1983. *Women Engineers: Their Careers, Their Workplace*. Ottawa: Canadian Council of Professional Engineers.
- Etzkowitz, Henry, Carol Kemelgor, Michael Neuschatz and Brian Uzzi. 1994. Barriers to Women in Academic Science and Engineering. In Willie Pearson and Irwin Fletcher (eds.) *Who Will Do Science? Educating the Next Generation*. Baltimore: Johns Hopkins University Press.
- Finch, Janet. 1993. 'It's Great to Have Someone to Talk to': Ethics and Politics of Interviewing Women. In M. Hammersley (ed.) *Social Research: Philosophy, Politics and Practice* pp. 166 - 180. Newbury Park: Sage.
- Finnie, Ross, Marie Lavoie and Maud-Catherine Rivard. 2001. Women in Engineering: The Missing Link in the Canadian Knowledge Economy. *Education Quarterly Review, Vol. 7, no 3*, pp. 8 – 17. Statistics Canada – Catalogue no. 81 – 003.
- Fiske, Jo-Anne and Carolyn Mufford. 1998. Hard Times and Everything Like That: Carrier Women's Tales of Life on the Trapline. In Jo-Anne Fiske, Susan Sleeper-Smith and William Wicken (eds.) *New Faces in the Fur Trade. Selected Papers of the Seventh North American Fur Trade Conference, Halifax, NS. 1995*. East Lansing, MI: Michigan State University.

- Flax, Jane. 1997. Postmodernism and Gender Relations in Feminist Theory. In Sandra Kemp and Judith Squires (eds.) *Feminisms*, pp. 170 – 178. Oxford/New York: Oxford University Press.
- Fox, Mary Frank. 1998. Women in Science and Engineering: Theory, Practice, and Policy in Programs. *Signs*, 24, 1, pp. 201 - 223
- Franklin, Ursula. 1995. *Looking Forward, Looking Back*. Address to the “More Than Just Numbers” Conference. UNB, Fredericton, NB, May 10.
http://www.ccwest.org/english/word/looking_speech.html
- _____. 1993. Letter to a Graduate Student. *Canadian Woman Studies/Les cahiers de la femme*, 13(winter), 2 pp. 12 - 15.
- _____. 1992. *The Real World of Technology*. CBC Massey Lecture Series. Concord, ON: House of Anansi Press Limited.
- Frehill, Lisa M. 1997. Subtle Sexism in Engineering. In Nijole V. Benokraitis, 1997. *Subtle Sexism. Current Practice and Prospects for Change* pp. 117 - 135. Thousand Oaks, CA: Sage Publications.
- _____. 1997b. Education and Occupational Sex Segregation: The Decision to Major in Engineering. *The Sociological Quarterly*, 38, 2 pp. 225 – 249.
- Freire, Paolo. 1985. *The Politics of Education. Culture, Power and Liberation*. South Hadley, MA: Bergin & Garvey Publishers.
- _____. 1970 (1992 edition). *Pedagogy of the Oppressed*. New York: Continuum.
- Frize, Monique. 2001. Statistics on Women in Engineering. <http://www.carleton.ca/cwse-on>.
- _____. 1996. Women in Engineering: Recruitment and Retention. *Nortel/NSERC Women in Engineering Chair Newsletter. Spring*. <http://www.unb.ca/web/wie>. Site discontinued.
- _____. 1994. Personal communication.
- _____. 1993. Women in Engineering in Canada: A National Perspective. In *Transforming Science and Technology: Our Future Depends On It*. GASAT 7 Proceedings, pp. 921-929. Sharon Hagerty and Ann Holmes, editors. Waterloo, ON: University of Waterloo.
- _____. n.d. *Engineering Education: The Changing Needs*. Paper presented at the 8th Canadian Conference on Engineering Education.
- Gaskell, Jane S. and Arlene Tigar McLaren. 1991. *Women and Education. Second Edition*. Calgary, AB: Detselig Enterprises Limited.
- _____. 1987. *Women and Education. A Canadian Perspective*. Calgary, AB: Detselig Enterprises Limited.
- Geppert, Linda. 1995. The Uphill Struggle. No Rose Garden for Women in Engineering. *IEEE Spectrum*, May, pp. 40 - 50.
- Gilbert, Melissa Kessler. 1997. Transforming the Classroom. Teaching Subtle Sexism Through Experiential Role Playing. In Nijole V. Benokraitis (ed.), *Subtle Sexism. Current Practice and Prospects for Change*. pp. 245 - 263. Thousand Oaks, CA: Sage Publications Inc.
- Gilbert, Sid and Alan Pomfret. 1995. *Gender Tracking in University Programs*. Ottawa: Industry Canada. <http://strategies.ic.gc.ca/SSG/ra00054c.html>.

- Government of Canada. n.d. *Canada's Fourth Report on the International Convention on the Elimination of All Forms of Discrimination Against Women. (CEDAW)*.
<http://www.pch.gc.ca/ddp-hrd/english/cedaw/dw4fed.htm>
- Government of Saskatchewan. 1996 Census.
<http://www.gov.sk.ca/bureau.stats/pop/pop1.htm>
- Hacker, Sally. 1990. *Doing it the Hard Way*. Boston: Unwin Hyman.
- _____. 1989. *Pleasure, Power, and Technology. Some Tales of Gender, Engineering, and the Cooperative Workplace*. Boston: Unwin Hyman.
- Harding, Sandra. 1991. *Whose Science? Whose Knowledge? Thinking from Women's Lives*. Ithaca, NY: Cornell University Press.
- _____. 1990. Feminism, Science, and the Anti-Enlightenment Critiques. In Linda J. Nicholson (ed.) *Feminism/Post-modernism*. New York: Routledge.
- _____. 1987. Introduction: Is There a Feminist Method? pp 1 – 13, and Conclusion: Epistemological Questions. pp 181 - 190 In Sandra Harding, (ed.) *Feminism and Methodology*, Indianapolis: Indiana University Press.
- _____. 1986. *The Science Question in Feminism*. Ithaca, NY: Cornell University Press.
- Hartsock, Nancy. 1997. The Feminist Standpoint: Developing the Ground for a Specifically Feminist Historical Materialism. In Sandra Kemp and Judith Squires (eds.) *Feminisms*. Pp. 153 – 160. Oxford/New York: Oxford University Press.
- _____. 1998. *The Feminist Standpoint Revisited & Other Essays*. Boulder, CO: Westview Press.
- Hawkesworth, M.E. 1990. *Beyond Oppression. Feminist Theory and Political Strategy*. New York: Continuum.
- Henwood, Flis. 1998. Engineering Difference: Discourses on Gender, Sexuality and Work in a College of Technology. *Gender and Education*, 10, 1, pp 35 – 49.
- _____. 1996. WISE Choices? Understanding Occupational Decision-making in a Climate of Equal Opportunities for Women in Science and Technology. *Gender and Education*, 8, 2, pp. 199 – 214.
- Hicks, Esther K. 1991. Women at the Top in Science and Technology Fields. Profile of Women Academics at Dutch Universities. In Veronica Stoltke-Heiskanen (Ed.), *Women in Science. Token Women or Gender Equality*. pp. 173-191. Oxford, U.K.: Berg Publishers Ltd.
- Himmelfarb, Alexander and C. James Richardson. 1982. *Sociology for Canadians. Images of Society*. Toronto: McGraw-Hill Ryerson Ltd.
- Hoogensen, Gunhild. 1997. Baby-Sitting, Breast Feeding and Deterrence Theory. In Inger J. Tveten Anderson and Cassandra Phillips Pugh, (eds.) *Changing the Climate: Western Canada in a Changing World*. Proceedings of the 1996 Conference for Graduate Students in the Social Sciences and Humanities pp. 94 - 100. Saskatoon: University of Saskatchewan.
- hooks, bell. 1984. *Feminist Theory from Margin to Center*. Boston, MA: South End Press.
- _____. 1989. Teaching Adults: Is It Different? ERIC Digest No. 82, ED305495.
- Inch, Jeanne and Monique Frize. 1991. In Their Own Words: Stories by Women Engineers About Themselves. *Women's Education des Femmes* Vol. 9 # 2, Fall.
<http://www.carleton.ca/wise/ownwords.htm>

- Jaggar, Alison M. 1988. *Feminist Politics and Human Nature*. Totowa, NJ. Rowman & Littlefield Publishers, Inc.
- Jary, David and Julia Jary. 1991. *The HarperCollins Dictionary of Sociology*. New York: HarperCollins.
- Javed, Nayyar S. 1988. *Female Engineering Students: Reflections and Perceptions*. Saskatoon: University of Saskatchewan, Unpublished M.Ed. Thesis.
- Judd, Charles M, Eliot R. Smith and Louise H Kidder. 1991. *Research Methods in Social Relations. Sixth Edition*. Fort Worth: Holt, Rinehart and Winston, Inc.
- Kadar, Marlene. 1988. Sexual Harassment as a Form of Social Control. In Arlene Tigar McLaren (ed.) *Gender and Society. Creating a Canadian Women's Sociology*. pp. 337 - 346. Toronto: Copp Clark Pitman Ltd.
- Kahle, Jane Butler. 1986. From One Minority to Another. In Jan Harding (Ed.) *Perspectives on Gender and Science*. pp. 63-79. London, U.K. and Philadelphia, U.S.A.: Falmer Press.
- Keller, Evelyn Fox. 1990. Gender and Science. In Joyce McCarl Nielsen (ed.) *Feminist Research Methods. Exemplary Readings in the Social Sciences*. Boulder, San Francisco, and London: Westview Press.
- Kemp, Sandra and Judith Squires. 1997. *Feminisms*. Oxford/New York: Oxford University Press.
- Kerka, Sandra. 1993. Women, Human Development, and Learning. ERIC Digest ED358379. Columbus, OH: ERIC Clearinghouse on Adult Career and Vocational Education.
- Kirby, Sandra and Kate McKenna. 1989. *Experience, Research, Social Change. Methods from the Margin*. Toronto: Garamond Press.
- Kuhn, Thomas S. 1962, 1970. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- Lacelle, Nicole. 1991. The Political is Personal. In Louise Malette and Marie Chalouh, (eds.), *The Montreal Massacre*. (Marlene Wildman, translator). Charlottetown, P.E.I.: gynergy books.
- Lang, Christine. 1997. The Evolution of Women in Engineering: Participation and Acceptance. *Engineering Dimensions, September/October 1997*, pp. 30-36.
- Learmont, Jeanette and Jennifer Lindley. 1993. Beyond Beginnings; An Australian Perspective. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 652 - 660. Toronto: Ontario Women's Directorate.
- LeBold, William. 1983. Engineering Education's Three-Edged Sword. *Engineering Education*, November. pp. 68-78.
- Lerner, Gerda. 1993. *The Creation of Feminist Consciousness. From the Middle Ages to Eighteen-seventy*. New York: Oxford University Press.
- Levenson, Nancy G. 1990. Educational Pipeline Issues for Women. <http://www.ai.mit.edu/people/ellens/Gender/pipeline.html> (04/14/95).
- Lewis, Sue V. 1993. Gender in Higher Education Science and Engineering Courses. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It*. Contributions to the Seventh International Gender and Science and Technology Conference. pp. 662-670. Toronto: Ontario

Women's Directorate.

- Lodge, Colleen M. J. 1998. The Access Program For Women in Science and Engineering, Past, Present and Future. In *Women in the Workplace. Achieving Harmony* pp 23 - 26. CCWEST (Canadian Coalition of Women in Engineering, Science and Technology) conference in Vancouver, B.C. May 1998. Vancouver, B.C.: Conference Contributions.
- Lorber, Judith. 1994. *Paradoxes of Gender*. New Haven and London: Yale University Press.
- Martin, Robert M. 1994. *The Philosopher's Dictionary*. Second Edition. Peterborough, ON: Broadview Press.
- McIlwee, Judith S. and J. Gregg Robinson. 1992. *Women in Engineering. Gender, Power, and Workplace Culture*. Albany, NY: State University of New York Press.
- Mendoza, Elaine M and Kathryn O. Johnson. 2000. *Land of Plenty. Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development.
- National Science Foundation. 1999. Women, Minorities and Persons with Disabilities in Science and Engineering: 1998. Arlington, VA: NSF 99-338.
- Nicholson, Linda J. 1990. *Feminism/Postmodernism*. New York: and London: Routledge.
- Nielsen, Joyce McCarl. 1990. Introduction. In Joyce McCarl Nielsen (ed.) *Feminist Research Methods. Exemplary Readings in the Social Sciences*. Boulder, San Francisco, and London: Westview Press.
- Noble, David F. 1992. *A World Without Women. The Christian Clerical Culture of Western Science*. New York: Alfred A. Knopf, Inc.
- Oakley, Ann. 1981. Interviewing Women: A Contradiction in Terms. In Helen Roberts (ed.) *Doing Feminist Research*. pp. 30 - 61. London: Routledge & Kegan Paul.
- Olesen, Virginia L. 2000. Feminisms and Qualitative Research at and into the Millennium. In Norman K. Denzin and Yvonna S. Lincoln (eds.) *Handbook of Qualitative Research*. Thousand Oaks: Sage.
- Oxford Dictionary of Current English*. Second Edition, 1992. Della Thompson, ed. Oxford University Press.
- Pascal, Charles E. and Seymour Kanowitch. 1979. *Student Withdrawals from Canadian Universities: a Study of Studies*. Toronto: Higher Education Group OISE.
- President's Advisory Committee on the Status of Women. 1993. *Reinventing our Legacy*. Saskatoon: University of Saskatchewan.
- Ranson, Gillian. 2000. The Best of Both Worlds? Work, Family Life and the Retention of Women in Engineering. In *New Frontiers, New Traditions. Conference Proceedings*. St. John's, NF: WISE (Women in Science and Engineering) Newfoundland & Labrador.
- _____. 1998. Retention of Women in Engineering: Good News and Bad News from Alberta. In *Women in the Workplace: Achieving Harmony. Proceedings*, pp. 27 - 34. Vancouver, BC: DAWEG (Division for Advancement of Women in Engineering and Geoscience) and CCWEST (Canadian Coalition of Women in Engineering, Science and Technology).
- Reinharz, Shulamit. 1992. *Feminist Methods in Social Research*. New York and Oxford: Oxford University Press.

- Rich, Adrienne. 1979. *On Lies, Secrets, and Silence. Selected Prose 1966-1978*. New York: W.W. Norton & Company, Inc.
- Ritzer, George. 1992. *Sociological Theory. Third Edition*. New York: McGraw-Hill, Inc.
- _____. 1988. *Sociological Theory. Second Edition*. New York: Alfred A. Knopf.
- Rosenau, Pauline Marie. 1992. *Post-modernism and the Social Sciences: Insights, Inroads, and Intrusions*. Princeton, NJ: Princeton University Press.
- Rosser, Sue V. 1988. The Relationship between Women's Studies and Women in Science. In Ruth Bleier, (ed.) *Feminist Approaches to Science* p.p. 165-180. New York: Pergamon Press.
- Rubin, Beth and Christine L. Cooper. 1998. Women Don't Count in Our Classrooms. In Jacqueline Stalker and Susan Prentice (eds.) *The Illusion of Inclusion. Women in Post-Secondary Education*. pp.154 - 164. Halifax: Fernwood Publishing.
- Ryerson Polytechnic University. 1994. *Discover Engineering. A Summer Camp for Young Women*.
- Saarinen, Aino. 1988. Feminist Research: In search of a New Paradigm? *Acta Sociologica*, 31 (1), pp. 35 - 51.
- Sadker, Myra and David Sadker. 1994. *Failing at Fairness. How America's Schools Cheat Girls*. New York: Charles Scribner's Sons.
- Saskatchewan Education, Training and Employment. 1996. *Saskatchewan Education Indicators Kindergarten to Grade 12*.
- _____. 1995. *Student Records System data*. Regina.
- _____. 1988. *Learning and Leadership: Women's Participation in Education. A Discussion Paper*. Regina, SK.
- Saskatchewan Women's Secretariat. 2001. Education. Statistical Update. Regina, SK.
- Saunders, Mary, Margaret Therrien and Linda Williams. 1998. Creating the "Woman-Friendly" University: A Summary of the CFUW Report. In Jacqueline Stalker and Susan Prentice (eds.) *The Illusion of Inclusion. Women in Post-Secondary Education*. pp.216 - 230. Halifax: Fernwood Publishing.
- Schiebinger, Londa. 1999 *Has Feminism Changed Science?* Cambridge, MA: Harvard University Press.
- Schmitz, Janet A. 1994. *Between the Shadow and the Hum: Feminist Perspectives on Computer Education, Gender and Research*. Saskatoon: University of Saskatchewan, Unpublished M.Ed. Thesis.
- Schultz, Katherine, Kelley Main and Judith Huebner. 1998. In Pursuit of Science: Factors Affecting the Success and Retention of Women in Science. In *Women in the Workplace. Achieving Harmony* pp 35 - 41. CCWEST (Canadian Coalition of Women in Engineering, Science and Technology) conference in Vancouver, B.C. May 1998.
- Schuyler, Gwyer. 1997. A Paradigm Shift from Instruction to Learning. ERIC Digest, ED414961.
- Schwartz, Howard and Jerry Jacobs. 1979. *Qualitative Methodology: A Method to the Madness*. New York: Free Press.
- Seidel, John, Susanne Friese and D. Christopher Leonard. 1995. *The Ethnograph v4.0: A Users Guide*. Amherst, MA: Qualis Research Associates.

- Sheahan, Bonney H. and John A. White. 1990. *Quo Vadis, Undergraduate Engineering Education?* *Engineering Education, December*, pp. 1017 - 1022.
- Shepherd, Linda Jean. 1993. *Lifting the Veil. The Feminine Face of Science.* Boston and London: Shambhala.
- Shuster, Marilyn and Susan van Dyne. 1984. Placing Women in the Liberal Arts: Stages of Curriculum Transformation. *Harvard Educational Review, vol 54, no.4* pp. 413 - 428.
- Simon Fraser University. 1995. Canada Science Scholarships may go with the budget. In *The Peak Student Newspaper Vol. 89, No. 7.* <http://www.peak.sfu.ca/the-peak/95-1/issue7/scol.html>
- Singleton, Royce Jr., Bruce C. Straits, Margaret M. Straits and Ronald J. McAllister. 1988. *Approaches to Social Research.* New York: Oxford University Press.
- Skidmore, Linda, et al. 1993. Recruitment and Retention of Women in Science, Engineering, and Technology. In Haggerty, Sharon and Ann Holmes (eds.). 1993. *Transforming Science And Technology: Our Future Depends On It.* Contributions to the Seventh International Gender and Science and Technology Conference. pp. 1074 - 1075. Toronto: Ontario Women's Directorate.
- Smith, Dorothy E. 1990. *The Conceptual Practices of Power. A Feminist Sociology of Knowledge.* Toronto: University of Toronto Press.
- _____. 1988. *Feminism and the Malepractice of Sociology.* Lecture or address, Spring. N.p.
- _____. 1988b. Institutional Ethnography: A Feminist Method. In Arlene Tigar McLaren (ed.) *Gender and Society. Creating a Canadian Women's Sociology.* pp. 62 - 79. Toronto: Copp Clark Pitman Ltd.
- _____. 1987. *The Everyday World as Problematic. A Feminist Sociology.* Toronto: University of Toronto Press.
- Stalker, Jacqueline and Susan Prentice. 1998. Introduction. In Jacqueline Stalker and Susan Prentice (eds.) *The Illusion of Inclusion. Women in Post-Secondary Education.* Halifax: Fernwood Publishing.
- StarPhoenix. 2000. Art Robinson column (p.A3). Saskatoon, December 27.
- _____. 2000. *Plant Research Lab Adds Space, Jobs* (p. A1). Saskatoon, July 1.
- _____. 1999. Readers' Opinion. Saskatoon, December 12.
- Statistics Canada. 2000. <http://www.statcan.ca/Daily/English/000724/d000724b.htm>
- _____. 1999. <http://www.statcan.ca/Daily/English/991220/d991220a.htm>
- _____. 1996 Census. Population 15 years and Over by Highest Degree, Certificate or Diploma. <http://www.statcan.ca/english/Pgdb/People/Education/educ41b.htm>
- _____. 1996 Census. Population 15 years and Over by Highest Level of Schooling. <http://www.statcan.ca/english/Pgdb/People/Education/educ43b.htm>
- _____. 1996 Census. Population by Aboriginal Groups and Sex, Showing Age Groups, for Provinces and Territories. <http://www.statcan.ca/english/census96/jan13/sask.htm>
- _____. 1996 Census. Population by Ethnic Origin. <http://www.statcan.ca/english/Pgdb/People/population/demo28b.htm>
- _____. 1996 Census. Visible Minority Population. <http://www.statcan.ca/english/Pgdb/People/population/demo40b.htm>
- _____. 1995. *Women in Canada. Third Edition.* Catalogue 89-503E. August 8.

- Stewart, Penni. 1994. Finding their Way: The Experiences of Undergraduate Women in University. In Lorna Erwin and David MacLennan (eds.) *Sociology of Education in Canada. Critical Perspectives on Theory, Research and Practice* pp.220 -234. Toronto: Copp Clark Longman Ltd.
- Theodorsen, George A. and Achilles G. Theodorsen (1979). *A Modern Dictionary of Sociology*. New York: Barnes & Noble Books.
- Thomas, Kim. 1990. *Gender and Subject in Higher Education*. Bristol, PA: Society for Research in Higher Education and Open University Press.
- Tobias, Sheila. 1993. The "Problem" of Women in Science: Why Is It So Difficult to Convince People There Is One? In *A Hand Up: Women Mentoring Women in Science*. pp. 150 - 159. Washington, D.C: AWIS
- Tobias, Sheila. 1990. *They're Not Dumb, They're Different. Stalking the Second Tier*. Fifth Impression, 1994. Tucson, AZ: Research Corporation.
- _____. 1990b. They're Not Dumb, They're Different. A New "Tier of Talent" for Science. *Change*, July/August, pp.10 -30.
- Toohy, R.P. and J. Whittaker. 1993. Engineering Women: A view from the Workplace. In *Journal of Management in Engineering, Vol. 9, No 1*, (January) pp. 27 - 37.
- Tovell, Dorothy R. and Helen M. Madill. 1993. So What Did You Do with Your Science Degree? A Preliminary Study of Career Patterns. In *Transforming Science and Technology: Our Future Depends on it*. GASAT 7 Proceedings, pp. 1040-1049. Sharon Hagerty and Ann Holmes,(eds.) Waterloo, ON: University of Waterloo.
- Tovell, Dorothy et al. 1998 Attracting Females to Science Careers: How Well Do Special Initiatives Work? . In *Women in the Workplace: Achieving Harmony*. Contributions to Canadian Coalition of Women in Engineering, Science and Technology Conference, Vancouver, BC, pp 64 - 69. May.
- Tripp-Knowles, Peggy. 1998. Women and Post-Secondary Science Education. A Case for Curriculum Transformation. In Jacqueline Stalker and Susan Prentice (eds.) *The Illusion of Inclusion. Women in Post-Secondary Education*. pp.146 - 153. Halifax: Fernwood Publishing.
- University of New Brunswick. 1995. *Worlds Unbound. Engineering and Science Summer Program*. Information Brochure.
- University of Saskatchewan. 1999. *1999-2000 Awards Guide for Continuing Students*. Office of the Registrar.
- University of Saskatchewan. 1998. University Calendar.
- University of Waterloo. n.d. *University of Waterloo Programs. Summary for the Women's Access to Training/Education Group*. Information Sheets.
- University Studies Group. 1999. Statistics XXV. Saskatoon: University of Saskatchewan.
- _____. 1997. *Statistics Vol. XXIII*. Saskatoon: University of Saskatchewan.
- _____. 1994. *Statistics Vol. XX*. Saskatoon: University of Saskatchewan.
- _____. 1993. *Statistics Vol. XIX*. Saskatoon: University of Saskatchewan.
- _____. 1992. *Statistics Vol. XVIII*. Saskatoon: University of Saskatchewan.
- _____. 1990. *Statistics Vol. XVI*. Saskatoon: University of Saskatchewan.
- _____. 1999. *Statistics Vol. XV*. Saskatoon: University of Saskatchewan.

- Van Dyne, Susan and Marilyn Shuster. 1985. Education: Transforming the Liberal Arts. In Mary Q. McFeely (ed.) *The Women's Annual, No 5 1984-85*, pp. 7 - 21. Boston: G. K. Hall & Co.
- Wajcman, Judy. 1991. *Feminism Confronts Technology*. University Park, PA: Pennsylvania State University Press.
- Wallace, J.E, V.A. Haines and M.E. Cannon. 1999. *Academic Choices of Engineering Undergraduates*. Calgary: University of Calgary.
- Weasel, Lisa H., Melissa Honrado and Debbie P. Bautista. 2000. The Forgotten Few: Developing Curricula on Women in the Physical Sciences and Engineering. *Women's Studies Quarterly*, 1 & 2, pp. 251 – 263.
- West, Candace and Don H. Zimmerman. 1991. Doing Gender. In Judith Lorber and Susan A Farrell, (eds.). *The Social Construction of Gender*, pp. 13 - 37. Newbury Park, CA.: Sage Publications. First published in *Gender and Society* 1 (1987):125-51
- White, Robert M.. 1991. Preface. In Hedy E. Sladovich (ed.). *Engineering as a Social Enterprise*. Washington, D.C.: National Academy Press.
- Whitehead, Alfred North. 1927/1957. *The Aims of Education and Other Essays*. New York: The Free Press. A Division of Macmillan, Inc.
- Whittaker, John D. 1994. *Female Students and the Engineering Culture in Canadian Universities*. Research Proposal/Application for SSHRC Strategic Grant. Edmonton: Department of Mechanical Engineering, University of Alberta.
- Women in Science: The Response. 1992. *Science*, Vol. 256, 19 June. pp: 1610-1615
- Wood, Julia T. 1994. *Gendered Lives. Communication, Gender, and Culture*. Belmont, CA: Wadsworth Publishing Company.



APPENDIX "A"

**UNIVERSITY ADVISORY COMMITTEE
ON ETHICS IN HUMAN EXPERIMENTATION**

(Behavioral Sciences)

NAME AND EC #: Dr. C. L. Biggs (Inger Anderson)
Department of Sociology

For Reference: 96-120

DATE: December 23, 1996

The University Advisory Committee on Ethics in Human Experimentation (Behavioral Sciences) has reviewed your study, "The Social Construction of Female Engineers" (96-120).

1. Your study has been APPROVED.
2. Any significant changes to your protocol should be reported to the Director of Research Services for Committee consideration in advance of its implementation.
3. The term of this approval is for 3 years.

Michael Owen

Michael Owen, Secretary
for the University Advisory Committee
on Ethics in Human Experimentation, Behavioral Science

Please direct all correspondence to:

Michael Owen, Secretary
UACEHE, Behavioral Science
Office of Research Services
University of Saskatchewan
Room 210 Kirk Hall, 117 Science Place
Saskatoon, SK S7N 5C8

APPENDIX "B"

SECTION A

THE FIRST SET OF QUESTIONS EXAMINES YOUR HIGH SCHOOL ACTIVITIES AND ACHIEVEMENTS

(a) = YES, (b) = NO, (c) = NOT APPLICABLE

N=220 Female=58 Male=158 No Gender=4

	TOTAL YES	FEMALE		MALE		MISSING
		N	%	N	%	
1 Was calculus offered in your high school?(yes)	200	51	88	145	92	4
2 Did you take calculus in high school?	170	44	76	122	77	4
3 Were you encouraged to take calculus in preparation for Engineering?	151	37	65	111	71	3
4 If you took calculus, was it well taught?	136	34	59	98	62	4
5 Did you play on a school or community sports team during your high school years (e.g. baseball, football, hockey, soccer)?	160	39	67	118	75	3
6 If you answered yes, are you still playing?	74	13	23	59	37	2
7 Did you participate in any individual sport during your high school years (e.g. ballet/dance, bowling, figure skating, golf, track & field)?	137	34	59	100	63	3
8 If yes, are you still participating?	55	12	21	42	27	1
9 Do you play any musical instrument(s)?	116	40	69	72	46	4
10 If yes, are you still playing?	44	16	28	27	18	1
11 Did you play or sing in a school or community musical band/group?	71	31	53	37	24	3
12 If yes, are you still participating?	13	3	5	9	6	1

PLEASE SELECT THE OPTION THAT APPLIES TO YOU

13	How many students were in your high school graduating class?					
	(a) Fewer than 25	47	17	29	30	19
	(b) Between 26 and 50	30	8	14	22	14
	(c) Between 51 and 100	25	2	3	22	14
	(d) Between 101 and 200	40	7	12	30	19
	(e) More than 200	75	24	41	51	33
14	Did you have a job - part time or full time - during high school?					
	(a) Part time during the school year.	80	28	48	50	32
	(b) Part time during the summers.	18	3	5	15	10
	(c) Full time during the school year.	7	2	3	5	3

	(d) Full time during the summers.	53	11	19	41	26	1
	(e) I helped on the farm all the time.	19	4	7	14	9	1
	(f) I never worked during the school year or summers.	14	2	3	12	8	
	(g) I worked occasionally.	27	8	14	19	12	
15	What was your final high-school average?						
	(a) Less than 70%	8	2	4	6	4	
	(b) Between 70 and 75%	15	5	9	9	6	1
	(c) Between 76 and 80%	22	3	5	19	12	
	(d) Between 81 and 85%	57	12	21	45	29	
	(e) Between 86 and 90%	58	13	23	44	28	1
	(f) Between 91 and 95%	52	19	33	31	19	2
	(g) 96% and over	6	3	5	3	2	

FOR THE NEXT SET OF QUESTIONS PLEASE INDICATE IF YOU
a = 'STRONGLY AGREE', b = 'AGREE', c = 'UNDECIDED', d = 'DISAGREE', e = 'STRONGLY DISAGREE',
f = 'NOT APPLICABLE'

		TOTAL		FEMALE		MALE		MISSING
		a+b	%	a+b	%	a+b	%	N
16	It was important to me to achieve high marks in high school.	182	53	91	125	79		4
17	I had to work hard for my grades.	72	27	41	45	29		
18	I really had to discipline myself.	36	10	17	26	15		
19	My grades in university are about the same as in high school.	18	2	3	16	10		
20	My grades are higher than in high school.	17	2	3	15	10		
21	My grades are somewhat lower than in high school.	145	39	67	104	66		2
22	My grades are much lower than in high school.	93	23	40	67	43		3
23	It concerns me that my grades have dropped since high school	108	27	48	78	50		3
I CHOSE ENGINEERING BECAUSE:								
24	I like to take things apart and put them back together.	140	25	44	112	72		3
25	I like to invent or make things.	161	27	47	131	84		3
26	I like to work with machinery.	136	21	36	111	70		4
27	I like to design and build things.	175	31	54	140	88		4
28	Engineering opens up many opportunities.	196	51	88	141	89		4
29	Engineering is a well-paid profession.	167	46	79	118	74		3
30	I enjoyed what I learned in Science/Engineering Camp.	12	2	5	9	6		1
	Not Applicable	184	52		128			2

31	I grew up in an engineering family.	30	3	5	26	17	1
32	I was inspired by progress and accomplishments in science and tech.	95	18	32	75	48	2
33	I was inspired by women's accomplishments in science and Technology (e.g. Roberta Bondar).	26	21	33	5	3	
34	I was good in math and sciences.	201	55	95	142	90	4
35	I like problem solving.	184	52	90	128	82	4
36	I needed a career change.	38	12	21	25	16	1
	Not Applicable	135	38		97		

SECTION B
THIS SECTION CONCERNS YOUR LIFESTYLE AS A UNIVERSITY STUDENT.
PLEASE CHOOSE THE OPTION THAT BEST DESCRIBES YOUR SITUATION

	TOTAL	FEMALE		MALE			
		N	%	N	%		
37	What kind of living arrangements do you have?						
	(a) I live at home with my family.	79	21	36	57	36	1
	(b) I live in residence on campus (e.g. Saskatchewan Hall).	33	8	14	25	16	
	(c) I live in student housing (e.g. student high rises).	8	3	5	5	3	
	(d) I have room and board in the city.	4	1		3		
	(e) I share apartment/house with siblings/relatives.	28	8	14	19	12	1
	(f) I share apartment/house with friend(s).	45	12	20	31	20	2
	(g) I have an apartment/house by myself.	14	1		13	8	
	(h) I live with a spouse/partner.	7	2	3	5	3	
	(i) I live with my spouse/partner and children.	2	2	3			

FOR THE NEXT QUESTIONS PLEASE INDICATE IF YOU
a = 'STRONGLY AGREE', b = 'AGREE', c = 'UNDECIDED', d = 'DISAGREE', e = 'STRONGLY DISAGREE',
f = NOT APPLICABLE

	TOTAL	FEMALE		MALE			
		a+b	%	a+b	%		
38	I make sure my assignments are on time.	199	56	97	139	88	4
39	I think the assignments are easy to do.	41	20	15	21	13	
40	I didn't know there was so much homework in engineering.	59	11	14	47	30	1
41	I hate Engineering; I think I'll quit and study something else.	8	3	5	4	3	1
42	It is difficult to be away from home and my friends.	46	12	20	33	21	1

43	I am making new friends in the University.	189	50	86	135	86	4
44	I would like to become involved with the SESS.	65	21	36	43	27	1
45	I take part in most of the SESS activities.	64	16	28	47	30	1
46	The "Big Buddy" concept is very helpful.	78	24	41	53	34	1
47	I appreciate the GE 131.1 concept.	120	30	52	87	55	3
48	I thought the GE 131 CHALLENGE PROJECT was fun.	112	21	37	87	55	4
49	I am happy to be in the College of Engineering.	169	42	74	123	80	4

PLEASE SELECT THE OPTION THAT BEST DESCRIBES YOUR SITUATION

	TOTAL N	FEMALE		MALE		
		N	%	N	%	
50	Engineering is a direct access college, but students also transfer from other colleges or programs or return after some absence.					
	(a) I entered directly from high school.					
	149	41	71	105	67	3
	(b) I entered directly, but have been out of high school a year or more.					
	24	8	14	16	10	
	(c) I have been admitted with credit for courses from another college.					
	10	4	7	5	3	1
	(d) I am trying Engineering for the second time.					
	6	2	3	4	3	
	(e) I have transferred from another college/university.					
	16	1	2	15	10	
	(f) I already have another degree.					
	5			5	3	
	(g) I have been in the work force for several years.					
	9	2	3	7	5	

FOR THE NEXT FEW QUESTIONS, THE OPTIONS ARE (a) YES, (b) NO, (c) N/A

	TOTAL YES N	FEMALE		MALE		
		N	%	N	%	
51	I attend all my classes.					
52	136	44	76	89	56	3
53	I attend all the labs.					
53	207	56	97	147	93	4
54	I spend several hours studying every day.					
54	140	42	72	97	61	1
55	I prefer to study alone at home.					
55	136	40	69	92	52	4
	I prefer to study with classmates.					
	118	34	59	80	51	4

FOR EACH OF THE NEXT THREE QUESTIONS,

- 56 My most important source of funding is:
 57 My second most important source of funding is:
 58 My third most important source of funding is:

THE CHOICES ARE

- (a) Scholarships.
- (b) Student loans.
- (c) My parent(s) pay my expenses.
- (d) My spouse/partner is paying my tuition.
- (e) I have saved money for my education.
- (f) I plan to work part time.
- (g) I expect to find summer employment.
- (h) Other.

TOTAL

1 2 3
 12/29/31
 65/17/08
 90/54/38
 00/02/03
 36/52/23
 03/14/11
 09/34/54
 05/04/10

FEMALE %

1 2 3
 06/12/08==10/22/16
 14/05/02==24/09/09
 25/11/05==43/20/10
 00/01/01==
 07/14/06==12/26/12
 01/04/05==02/17/10
 03/07/18==05/13/38
 00/00/04==

MALE %

1 2 3
 06/17/22==04/12/18 1/0/1
 51/12/06==32/08/05
 62/43/32==39/29/26 3/0/1
 00/01/02==
 28/36/17==18/24/14 3/2
 02/10/05==01/07/04 1/0/1
 06/25/35==04/17/28 3/2/1
 03/04/06==

PLEASE SELECT THE OPTION THAT BEST DESCRIBES YOUR SITUATION

59 How long does it take you to get to the University (daily commute)?

(a) Less than 15 minutes.	108	26==46	79==50	3
(b) 15 - 30 minutes.	81	23==40	57==36	1
(c) 30 - 45 minutes.	23	6==11	17== 2	
(d) 45 - 60 minutes.	5	2== 3	3== 2	
(e) More than one hour.	1		1	

60 In what kind of engineering do you intend to specialize

(a) Agricultural/Bioresource.	11	7==12	3== 2	1
(b) Chemical.	22	8==13	14== 9	
(c) Civil.	19	5== 9	14== 9	
(d) Electrical.	21	3== 5	18==12	
(e) Engineering Physics.	8	2== 3	6== 4	
(f) Geological.	8	3== 5	5==.3	
(g) Mechanical.	31	3== 5	28==18	
(h) Combined programs.	29	6==10	21==13	2
(i) I haven't decided yet.	63	20==35	42==27	
(j) Other.	7	1==.2	6==.4	

61 Where do you expect to find employment?

(a) Municipal/provincial/federal government.	14	2==.3	12== 8	
(b) Provincial/federal crown corporation.	7	1== 2	6== 4	
(c) Oil industry.	26	7==12	19==12	
(d) Mining.	6	1== 2	5== 3	
(e) Communication industry.	7	1== 2	5==.3	1

(f) University teaching/research.	3			
(g) Private industry, (e. g. manufacturing).	42	7==12	3==2	
(h) Consulting/self employment.	10	2==3	34==22	1
(i) Other.	19	2==3	8==5	
(j) I haven't thought about it.	85	35==60	15==10	2
			50==32	

62 Did the *Encourage Enrolment in Engineering* Committee visit your school?

(a) Yes N=60--FEMALE: 17(29%)--MALE: 40(26%) MISSING: 3

(b) No N=153--FEMALE: 40(69%)--MALE: 112(71%)MISSING: 1

63 If Yes, did the Committee's presentation influence your decision to study Engineering?

(a) Yes N=19--FEMALE: 04(7%) --MALE: 13(8%) MISSING: 2

(b) No N=53-- FEMALE: 14(29%)--MALE: 38(25%)MISSING: 1

(c) Not Applicable N=143--FEMALE: 40(69%)--MALE: 102(66%) MISSING: 1

SECTION C

THE FINAL QUESTIONS ASK ABOUT YOU AND YOUR FAMILY
FOR THE NEXT THREE QUESTIONS THE ANSWERS WERE WRITTEN IN THE IDENTIFICATION SECTION OF THE OPSCAN SHEET
AND CODED POST HOC

	TOTAL	FEMALE		MALE		MISSING N
		N	%	N	%	
64 What is your father's occupation? Please give all, if more than one.*						
a) Professional, not teacher.	42	10	17	31	20	1
b) Teacher.	17	4	7	13	8	
c) Manager, administrator.	17	3	5	14	9	
d) Sales.	4	1		3		
e) Clerical.	5	3	5	2		
f) Craftsman, mech, tech.	45	12	21	31	20	1
g) Farmer.	47	12	21	34	22	1
h) Service worker.	5	1		4	3	
i) Self employed.	20	9	16	11	7	
j) Other.	14	3	5	11	7	
*16 students gave father's occupation as "engineer", with or without sub-discipline						
65 What is your mother's occupation? Please give all, if more than one.						
a) Professional, not teacher.	29	9	16	19	12	1
b) Teacher.	30	8	14	21	13	1
c) Nurse.	23	3	5	19	12	1
d) Sales.	13	2	4	11	7	
e) Clerical.	21	5	9	16	10	
f) Homemaker.	41	7	13	33	21	

g) Farmer.	6	3	5	3	2	
h) Service worker.	22	10	18	12	8	2
i) Self employed.	9	3	5	6	4	
j) Other.	23	6	11	17	11	

66	What is your ethnic or racial origin?*	N	%
	Canadian, WASP, white.	92	41.8
	Indigenous, Metis.	6	2.7
	Oriental.	16	7.2
	Asian (East Indian)	5	2.3
	African, Afro-American.	1	0.5
	Hispanic, S.American.	1	0.5
	Ukrainian, Slavic & mixed.	18	8.2
	German & mixed.	29	13.2
	British Isles & mixed.	32	14.5
	French.French Canadian	8	3.6
	Scandinavian	15	6.8
	Philippine	3	1.4

**Any student who indicated 'Metis' is included as 'Indigenous'. Of the 'Oriental', all but one are Chinese.

PLEASE CHOOSE THE OPTION THAT BEST DESCRIBES YOUR SITUATION

67	In which year were you born?	TOTAL	FEMALE		MALE		MISSING
	(a) 1979.	N	N	%	N	%	N
	(b) 1978.	4	2	3	2	1	
	(c) 1977.	129	37	64	89	56	3
	(d) 1976.	45	11	19	33	21	1
	(e) Between 1971 and 1975.	11	2	3	9	6	
	(f) Between 1965 and 1970.	20	4	7	16	10	
	(g) Before 1965.	4	1	2	3	2	
	(h) Later than 1979.	4	1	2	3	2	
		1			1	1	

PLEASE CHOOSE THE OPTION THAT BEST DESCRIBES YOUR SITUATION

What is your father's level of education?

(a) Less than grade 12.	40	11	19	29	13	
(b) Completed grade 12.	30	03	5	26	17	1
(c) Some career college, vocational, or trade school.	23	09	16	14	9	
(d) Career college, vocational, or trade school certificate.	31	09	16	22	14	

	(e) Some university.	13	03	5	10	6	
	(f) University graduate, (e.g. BA, BSc, BEd, MD etc.).	48	14	24	32	20	2
	(g) University post-graduate degree (Master's Degree, Ph. D.).	22	05	9	16	10	1
	(h) I don't know.	11	04	7	07	5	
66	What is your mother's level of education?						
	(a) Less than grade 12.	21	06	10	15	10	
	(b) Completed grade 12.	49	11	19	37	24	1
	(c) Some career college, vocational, or trade school.	24	06	10	18	12	
	(d) Career college, vocational, or trade school certificate.	31	07	12	24	15	
	(e) Some university.	18	07	12	09	6	2
	(f) University graduate, (e.g. BA, BSc, BEd, MD etc.).	63	18	31	44	28	1
	(g) University post-graduate degree (Master's Degree, Ph. D.).	06	01	2	05	3	
	(h) I don't know.	07	02	3	05	3	
70	Are you						
	(a) Female 58 (b) Male 158						
71	How many girls, including you, are there in your family?						
		<u>N</u>	<u>F</u>	<u>M</u>	<u>MISSING</u>		
	(a) None	60	02	56	2		
	(b) One	89	22	66	1		
	(c) Two	45	21	23	1		
	(d) Three or more	23	13	10			
72	How many boys, including you, are there in your family?						
		<u>N</u>	<u>F</u>	<u>M</u>			
	(a) None	32	19	13			
	(b) One	68	24	44			
	(c) Two	72	12	58	2		
	(d) Three or more	45	03	40	2		

PLEASE CHOOSE THE OPTION THAT BEST DESCRIBES YOUR SITUATION

	TOTAL	FEMALE		MALE		MISSING
		N	%	N	%	
73 In what size community did you spend MOST of your high school years?						
(a) Large city, (e.g. Saskatoon, Regina).	91	26	45	64	41	1
(b) Smaller city, (e.g. Prince Albert, Moose Jaw).	24	02	3	22	14	
(c) Town, (e.g. Humboldt, Kindersley).	15	02	3	12	8	1
(d) Smaller town or village.	41	13	22	28	18	
(e) Reserve.	1	1	2			

(f) Acreage outside city or town.	08	1	2	06	4	1
(g) On a farm.	35	13	22	22	14	
(h) Other.	02			2	1	1

FOR THE NEXT FEW QUESTIONS, (a)=YES, (b)=NO, (c)= N/A

	TOTAL N	YES		MISSING		
		FEMALE N	%	MALE N	%	N
74 Are there any engineers in your family or circle of friends?	116	30	52	85	54	1
75 Are any of these engineers women?	19	07	12	12	8	
76 Did this/these engineer(s) encourage you to study engineering?	64	13	22	50	32	1
77 Did this/these engineer(s) discourage your study of engineering?	7	03	5	04	3	

PLEASE CHOOSE THE OPTION THAT BEST DESCRIBES YOUR SITUATION

	TOTAL N	FEMALE		MALE		MISSING N
		N	%	N	%	
78 What was your FAVOURITE pastime/activity during your grade school years?						
(a) Reading books.	21	14	25	07	5	
(b) Building blocks (Lego, Meccano).	56	15	26	41	27	1
(c) Cars/trucks/tractors/racing sets.	24	02	3	21	14	1
(d) Dolls/doll-houses, Playing "house".	06	04	7	02	1	
(e) Action type figures, e.g. GI Joe.	15			15	10	
(f) Guns.	15			15	10	
(g) Jigsaw puzzles.	05	01	2	04	3	
(h) Watching TV.	12	04	7	08	5	
(i) Video/computer games.	26	02	3	23	15	1
(j) Other toys/games/play things/activities.	34	15	26	19	12	
79 What was your FAVOURITE pastime/activity during your high school years?						
(a) Reading books.	17	09	15	08	5	
(b) Building blocks (Lego, Meccano).	05	01	2	04	3	
(c) Cars/trucks/tractors/racing sets.	04			04	3	
(d) Board games.						
(e) Guns.	06			06	4	
(f) Jigsaw puzzles.						
(g) Video/computer games.	23	02	3	20	13	1
(h) Watching TV.	10	01	2	09	9	

	(i) "Hanging out" with friends.	71	16	28	54	35	1
	(j) Other activities(Possibly sports).	80	28	49	51	32	1
80	What kind of books do you prefer						
	(a) Mysteries.	32	18	31	14	9	
	(b) Classical Authors (e.g. Tolstoy, Shakespeare).	13	07	12	06	4	
	(c) Modern novels.	25	10	17	15	10	
	(d) Romance novels.	05	04	7	01	1	
	(e) Non-fiction (e.g. biographies).	10	01	2	09	6	
	(f) War stories.	12			12	8	
	(g) Humorous novels/short stories.	11	02	3	08	5	1
	(h) Other.	54	08	14	45	29	1
	(i) Sci-Fi.	48	08	14	39	25	1
81	What kind of TV shows do you prefer to watch?						
	(a) News/Current events/Documentary programs.	08	01	2	07	5	
	(b) "Soap Operas" (evening or daytime).	02	02	3			
	(c) Sit-Coms.	55	10	17	45	30	
	(d) Crime/suspense shows.	08	02	3	06	4	
	(e) Science programs.	10	03	5	07	5	
	(f) Adventure shows.	09			09	6	
	(g) Variety Shows.	03	01	2	02	1	
	(h) Westerns.	01			01	1	
	(i) A variety of shows. (Or Sports)	66	23	40	42	28	1
	(j) I watch very little TV.	50	16	28	32	20	2

82 Who was MOST/LEAST supportive of your choice of career?)

83 Did anybody discourage your choice of career?
)

THE CHOICES ARE

	MOST				LEAST			
	N	F (%)	M (%)	Missing	N	F (%)	M (%)	Missing
(a) Mother.	27	-07(12)	--20(13)		03	--01(2)	--02(1)	
(b) Father.	23	--06(10)	--17(11)		02		--02(1)	
(c) Both parents equally.	94	--20(51)	--61(40)	3	05	--01(2)	--04(3)	
(d) Sister.	04	--02(3)	--02(1)		03		--03(2)	
(e) Brother.	05		--05(3)		03	--02(4)	--01(1)	
(f) Members of extended family.	03	--01(2)	--02(1)		05	--02(4)	--03(2)	
(g) Teacher, school counsellor.	05	--02(3)	--03(2)		04	--02(4)	--02(1)	
(h) Religious leader.	-----				01		--01(1)	

	(i) Other.		11--02(3)--09(6)		17--02(4)--15(10)		
	(j) Nobody.		41--08(14)--33(22)		169-47(83)--119(78)		3
84	What is your marital status?			Missing			
	(a) Single.	199	53(93) 143(94)	3			
	(b) Married.	4	1(2) 3(2)				
	(c) Cohabiting.	5	2(3) 3(2)				
	(d) Separated/divorced.	2	2(..1)				
	(e) Widowed.						
	(f) Other.	3	1(2) 2(1)				
85	Do you have children?						
	(a) Yes	6	2 4	(b) No	208	55	150 (Missing: 3)
86	If so, how many?						
	(a) One	3	2 1				
	(b) Two	1	1				
	(c) Three	3	1 2				
	(d) Four or more	3	3				
	(e) Not applicable	199	53 143 (Missing: 3)				
87	Do your children live with you?						
	(a) Yes	2	2 0	(b) No	6	2	4
	(c) Not Applicable	204	54 147 (Missng: 3)				
88	What are the ages of your children?						
	(a) Mostly pre-schoolers.	4	2 2				
	(b) Mostly elementary school age.						
	(c) Mostly teenagers.	3	1 2				
	(d) A combination of (a) and (b).						
	(e) A combination of (b) and (c).	2	2				
	(f) Not Applicable.	206	58 148				

THE END - THANK YOU FOR COMPLETING THIS SURVEY!

APPENDIX "C"

THE SOCIAL CONSTRUCTION OF FEMALE ENGINEERS INTERVIEW SCHEDULE

First year, fourth year and transfer students

Preamble

First, thank you for agreeing to this tape recorded interview. I realize that all students are busy, and that you maybe could use your free time doing something else.

The University requires that all individuals who take part in research must give informed consent to such participation. As you know, I have publicly stated that I am studying Engineering education, and that I am especially interested in what makes young women and men choose Engineering as a career. Your answers, in addition to the other components of my research, will contribute to a better understanding of this issue.

Your participation in my study is voluntary, anonymous, and confidential. Only I know who you are, and only my supervisor, my transcriber, and I will hear this interview. I will ask you to give me an alias - a cover name - which I will use when I refer to your experiences or quote you directly. I personally like that better than to refer to you as a participant number. You are free to terminate the interview or ask that the recorder be turned off at any time. During the interview, I ask you to be as honest and specific as possible. You are also welcome to ask questions of me, and I will answer honestly and to the best of my ability. I may have to contact you again if something in the transcript is unclear to me. I want to be sure that what I heard is what you meant. When the interview is over, we will talk briefly about it, and about my research in general.

I have prepared an **INFORMED CONSENT** form that I ask you to please sign before we continue. Thank you very much.

- 1 When did you decide to become an engineer?
- 2 Why did you make that decision? What events led to it?
- 3 What did you think you could contribute to the Engineering profession?
- 4 What kind of Engineering specialization had you planned to choose? Why?
- 5 How old are you?
- 6 What is your parents' level of education? What do they do for a living?
- 7 In what type of community (size only) did you go to school? How large was your grade 12 class?
- 8 Do you believe your school prepared you well for studying Engineering (e.g. in calculus or sciences)?
- 9 Do you consider yourself an introvert or an extrovert?
- 10 How did you get along with your lab partners?
- 11 How did you feel about the alphabetically assigned partners (in EP124)? Was it the same in other labs?
- 12 Would you have preferred another lab partner?
- 13 How did you and your partner share the work? Who made the decisions?
- 14 Which of the lab jobs did you consider the most important?
- 15 Did you feel competent, or well prepared for the labs? In the classrooms (lectures)?

- 16 Where did you prefer to sit in the classroom? (With whom? Old friends? New friends? A group of female students? A group of male students?)
- 17 How many hours per week did you spend on homework/studying?
- 18 How was the work load? Did you have a strategy for managing the work load?
- 19 What did you do for relaxation? Was that different from your high school days?
- 20 If you lived independently, how did you divide your time between school and house work?
- 21 If you lived with somebody (family, spouse, friend, etc.), how did you share the chores?
- 22 How are you doing grade-wise? (How were your grades in Engineering courses? What was your Average? Your highest/lowest mark?)
- 23 What is/was your favorite course? What is/was your least favorite course?
- 24 What did you think of your instructors? Without giving names, what did you like about your favorite instructor? Dislike about your least favorite?
- 25 What did you think about the GE 131.1 concept? The large and small sections?
- 26 Do you think that women in Engineering are discriminated against because of their gender?
- 27 Have you ever been harassed, sexually or otherwise, either on the job or in this College?
- 28 What do you think about women as engineers? Would you like to work with them?

For students who had left Engineering:

- 29 Was it a difficult decision to quit Engineering?
- 30 If you were doing quite well in Engineering, why did you leave?
- 31 If you felt you were doing poorly, did you take the Christmas bailout?
- 32 What do you do now? If you transferred to another College or discipline, do you feel better there?
- 33 What are your present plans? How do they compare with, or differ from your plans in Engineering?
- 34 Did you ask for any counselling before you quit? Did you get it? Was it helpful at all?
- 35 What about the people in Engineering - the faculty? the staff? the students? Did they treat you well?

For all students:

- 36 Would a support or discussion group be/have been beneficial to you?
- 37 Is there anything else that you want to tell me about your experiences as an Engineering student? Academic? Personal?

Thank you for your participation.

APPENDIX "C"-1

+File 04 Hugh First Year	1
I: Thank you...why engineering?	3
R: I was working as a piano technician but that didn't really have anything to do with going into engineering.	5 6 7
I: Starting this late as a second or third career what do you think you can contribute to engineering?	9 10 11
R: I'm hoping that there is something that I can contribute besides personal satisfaction. I don't feel a great chance at getting a job but I want to get my degree. There is a possibility for work but I don't want to face mandatory retirement at 65.	13 14 15 16 17 18 19
I: Speciality?	21
R: Physics combined with computer science. It is advisable to have very good math skills. I take it one step at a time. I may have to change my direction.	23 24 25 26 27
I: Parents?	29
R: Mother died when I was 5, my father was an accountant for one of the hospitals in Victoria. I was born in Flin Flon because my father worked in the mine and then we moved to Victoria and I grew up there. I joined the service when I was eighteen that's where I got my electronics training.	31 32 33 34 35 36 37 38 39
I: Large school in Victoria?	41
R: Outside Victoria it was a fairly large school because it covered quite a few different communities.	43 44 45
I: Prepared?	47
R: Probably not that school but I quit at grade 10 and then in 94 I got basic education grade 11 and 12, I think that prepared me very well. I	49 50 51 52

shewshy

contribute

eng pcc

parents

schooling

preparing

APPENDIX "C"-2

to male interaction where one will 1197
 ask another for help with homework 1198
 and the male student will say no then 1199
 I'll see a female student go and ask 1200
 that same male student for help and 1201
 he'll say yes. But at the same time 1202
 I think that women are discriminated 1203
 against for their knowledge. The 1204
 male students in the college, from 1205
 the ones that I know, feel the 1206
 women's knowledge base is lower that 1207
 women don't know as much as the males 1208
 and therefore the males try to be 1209
 more accomodating. The eighteen and 1210
 nineteen year old male students the 1211
 ones that are still in peak horomonal 1212
 stage because of the work load they 1213
 don't get much of an opportunity to 1214
 see the rest of the University. It's 1215
 hard for them to get social 1216
 interaction with females and to find 1217
 a girlfriend and things like that. 1218
 So a number of the single males run 1219
 around here extremely excited. But 1220
 nothing to do and no one to talk to 1221
 so if they see a female they're 1222
 pretty happy. 1223

discrim

I: Have you ever been harassed 1225
 sexually, verbally or otherwise 1226
 either in a job or in this college? 1227

R: Actually in this college by a 1229
 professor and I won't say his name. 1230
 Oh heck it doesn't matter my names 1231
 confidential his isn't Professor 1232
 [redacted] in the math department. We 1233
 were in class and the first day I was 1234
 sitting in his math class I sat up 1235
 front, he asked me for an answer on a 1236
 question, I worked through it and 1237
 gave an answer he laughed at us 1238
 because he said our answer was 1239
 incorrect. He said if you were in my 1240
 section last term you would have got 1241
 the right answer. First that's one 1242
 notch because being an ex-teacher 1243
 myself, don't criticize a students 1244
 answer right or wrong. Specifically 1245
 don't make fun of other professionals 1246
 by saying if you were in my section 1247
 you would have known that answer. 1248

*harass
 had prof*

perhays

going to prove it and because they 261
 are a female and because they are an 262
 engineer they are going to be paid 263
 twice as much so they are in it for 264
 the money they aren't really enjoying 265
 themselves which I suppose might lead 266
 to depression. If you aren't 267
 enjoying something then obviously 268
 it's wrong. 269

I: Harassed? 271

R: I can't point out an instance no. 273
 I don't think so I'm not 274
 particularly perceptive to those 275
 things because I don't expect them. 276
 I'm sure, I have friends that feel 277
 they have been discriminated against 278
 because there is a push for the women 279
 but the men are just perceived as the 280
 dogs, pigs, they are perceived as 281
 people who are just out for 282
 themselves and really do believe that 283
 women can't do it when they don't 284
 think that at all it's just the whole 285
 push for women and all the 286
 scholarships and that for 287
 specifically women they find they are 288
 discriminating against them and they 289
 are quite hurt by that and I see why. 290
 I believe personally any 291
 discrimination that's based on your 292
 sex is sexist I just think that such 293
 a push from women to get themselves 294
 into things and to prove that they 295
 can do anything like the men can do 296
 it just making the situation worse 297
 sometimes because it makes the men 298
 feel as if they are the bad guys. No 299
 one I have run into really thinks, 300
 with the exception of one person that 301
 women are less intelligent and can do 302
 things as well as they can. In fact 303
 I know some that really believe that 304
 women are very much intelligent and 305
 very much capable and even more so 306
 than they are at some things. 307

Not in

Harass

Not men

I: Decision to quit difficult? 309

R: Yes it was. It was based solely on 311
 the fact that I had made friends here 312

APPENDIX "C"-3b

0001 7 File 05 Oct First Year

SEARCH CODE: HARASS

#-HARASS

X-BADPROF

1: Have you ever been harassed 1225 # -X
 2: sexually, verbally or otherwise 1226 #
 3: either in a job or in this college? 1227 #
 4: 1228 #
 5: 2: Actually in this college by a 1229 #
 6: professor and I won't say his name. 1230 #
 7: Oh heck it doesn't matter my name's 1231 #
 8: confidential his isn't Professor 1232 #
 9: ██████████ in the math department. We 1233 #
 10: were in class and the first day I was 1234 #
 11: sitting in his math class I sat up 1235 #

#-PEDAGOGY

12: front, he asked me for an answer on a 1236 # -X
 13: question, I worked through it and 1237 #
 14: gave an answer he laughed at me 1238 #
 15: because he said our answer was 1239 #
 16: incorrect. He said if you were in my 1240 #
 17: section last term you would have got 1241 #
 18: the right answer. First that's one 1242 #
 19: notch because being an ex-teacher 1243 #
 20: myself, don't criticize a students 1244 #
 21: answer right or wrong. Specifically 1245 #
 22: don't make fun of other professionals 1246 #
 23: by saying if you were in my section 1247 #
 24: you would have known that answer. 1248 # -X

SEARCH CODE: RELAX

APPENDIC "C"-4

APRILA I

+File R April Fourth Year

SEARCH CODE: RELAX

#-RELAX

Q: Is Relaxation?	258	-#
A: I love music, I listen to alot of	260	#
music. I play trombone, I tried	261	#
doing it first year but I didn't have	262	#
the time, engineering the first year	263	#
I was donating alot of time to it.	264	#
I'm going to start after I graduate.	265	#
I would go to a concert band. I	266	#
think music is essential as anything	267	#
else. I was much more active	268	#
musically in high school, relaxation	269	#
in high school I don't think I needed	270	#
it high school was relaxing.	271	-#

BETTY4 I

+File A Betty Fourth Year

SEARCH CODE: RELAX

#-RELAX

Q: Is Relaxation	194	-#
A: Play pool, going skiing, don't watch	196	#
too much TV, it takes up too much	197	#
time. Reading, novels, fiction	198	-#

BILL4 I

+File B Bill Fourth year

SEARCH CODE: RELAX

#-RELAX

Q: Is Relaxation?	234	-#
A: Talk with friends and watch t.v. I	236	#
love playing sports I play on a city	237	#
league basketball team and a city	238	#
league indoor soccer team.	239	-#

APPENDIX "D"

INFORMED CONSENT

THE SOCIAL CONSTRUCTION OF FEMALE ENGINEERS

Preamble

Any research project at the University of Saskatchewan that involves human participants must have the approval from the **Advisory Committee on Ethics in Behavioral Science Research**. The Committee requires that interview informants give written consent to their participation. The purpose and intent of such consent is to assure that the researcher respects the privacy and confidentiality of the individual. It does not imply that the participation in the project involves personal risks.

This research project is part of a Doctoral Dissertation under the supervision of Dr. Lesley Biggs, Department of Sociology, University of Saskatchewan. One part of the study examines what makes young men and women choose Engineering as a profession and how they perceive their Engineering Education. Another part investigates why Engineering students decide to discontinue their studies when their grades indicate that they are doing well in their courses.

In order for me to complete the project, which has the approval of the Dean of Engineering, I ask you to agree to an interview about your decision to pursue Engineering as a profession and about your perception of Engineering education at the University of Saskatchewan.

If you wish to contact Dr. Biggs or myself with questions or comments about the study, you may call Dr. C.L. Biggs, Department of Sociology, University of Saskatchewan: 966-6931.
Inger Anderson (at home): 343-5844, e-mail: Inger.Anderson@usask.ca.

I agree to participate in this study, with the understanding that I may withdraw from it at any time. I understand that my answers will be kept strictly confidential and that I will not be identifiable in the presentation of the study. I may select a code name that will be used when my words are cited directly.

Signature: _____

Date: _____

If you would like a copy of the summary results of the study, please fill out this section. Because it may be year 2000 before it is completed, please provide a permanent address.

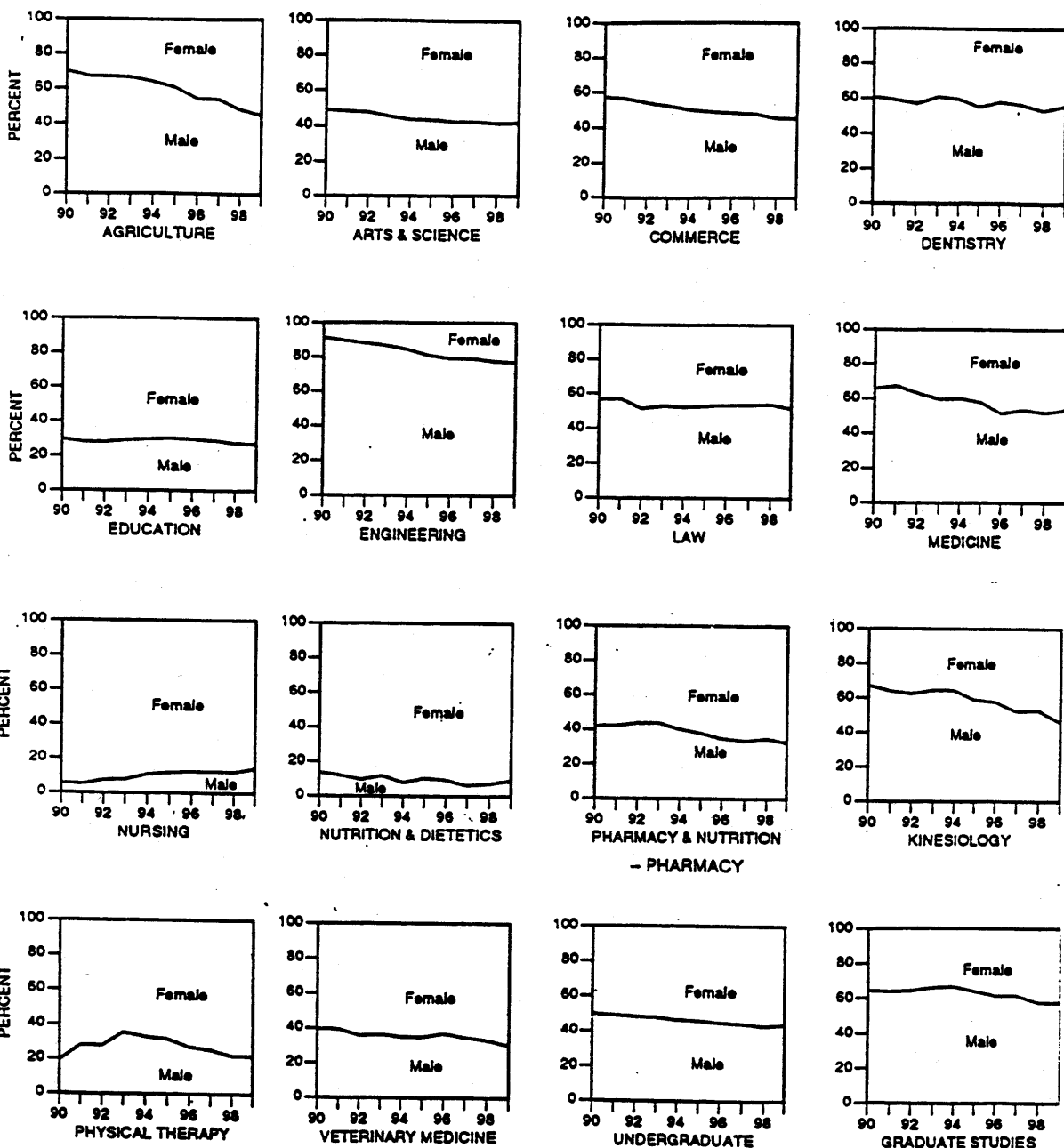
NAME _____

ADDRESS _____

PHONE _____

APPENDIX "E"

FULL-TIME STUDENTS BY COLLEGE & GENDER



Academic Year Ending