# ACADEMIC CHOICES OF ENGINEERING UNDERGRADUATES

**M. Elizabeth Cannon**
Faculty of Engineering
University of Calgary
2500 University Drive NW
Calgary, Alberta T2N 1N4
cannon@geomatics.ucalgary.ca

**Jean E. Wallace**
**Valerie A. Haines**
Department of Sociology
University of Calgary

## ABSTRACT

In the past two decades concern for increasing the participation of women in engineering has grown, mainly driven by the demands of the industrial sector as we move into the knowledge-based economy. These demands are in part due to the need for a highly skilled technical workforce, but are also affected by an awareness of corporations that diversity amongst their employees will assist in their global competitiveness. A breadth of intervention programs has been developed to encourage more women to consider careers in engineering, and while there have been important gains made towards their increased participation, there is a growing need to evaluate the critical factors that influence the decision to major in engineering. This information can provide valuable input to the development of new, targeted programs, or in the enhancement of existing programs. A research project was therefore developed to better understand the factors that influence the decision to choose an undergraduate major in engineering, and to assess whether these factors are gender-specific. The research was conducted through a detailed survey administered to students in the Faculty of Engineering at the University of Calgary in the Fall of 1998. The Faculty has approximately 2,000 undergraduate students and six major degree programs. The data and methods used in this study are first presented and followed by the results. The findings present a descriptive profile of engineering majors, followed by a discussion on the factors influencing the decision to major in engineering. Following the results and their interpretation, conclusions are made and policy implications are discussed.

## INTRODUCTION

In the past two decades concern for increasing the participation of women in engineering has grown, mainly driven by the demands of the industrial sector as we move into the knowledge-based economy. These demands are in part due to the need for a highly skilled technical workforce, but are also affected by an awareness of corporations that diversity amongst their employees will assist in their global competitiveness. A breadth of intervention programs has been developed to encourage more women to consider careers in engineering, and while there have been important gains made towards their increased participation, there is a growing need to evaluate the critical factors that influence the decision to major in engineering. This information can provide valuable input to the development of new, targeted programs, or in the enhancement of existing programs. A research project with the following objectives was therefore developed to address these issues: (i) to better understand the factors that influence the decision to choose an undergraduate major in engineering, (ii) to better understand the factors that influence the decision to choose an area of specialization within engineering, (iii) to explore whether the factors that influence the decision to choose engineering, and an engineering specialization, are gender-specific, and (iv) to contribute to the development of strategies for eliminating barriers for participation of students in engineering and its various specialization areas.

The research was conducted through a survey administered to students in the Faculty of Engineering at the University of Calgary in the Fall of 1998. The Faculty has approximately 2,000 undergraduate students and six major degree programs, namely Chemical and Petroleum, Civil, Electrical and Computer, Geomatics, Manufacturing, and Mechanical Engineering. Students in the first 1 1/2 years of study year are in a common core program after which they move to a department for specialization.

The focus of this paper is to present a descriptive analysis of the student in the Faculty of Engineering and to present the factors that influenced their decision to major in engineering. The paper describes a subset of the research findings. A detailed analysis can be found in Wallace et al. (1999).

## DATA COLLECTION AND ANALYSIS

A survey was administered to engineering students at the University of Calgary in the Fall of 1998. The survey consisted of 207questions and was given during engineering classes. In order to ensure a representative sample of the 1,946 engineering students, a sampling strategy was implemented to select the survey participants based on the year of study, department and gender representation. Using this strategy, 1,122 surveys were handed out and 1,069 were returned with virtually all (98%) being fully completed and eligible for analysis. The sample provided a fairly accurate representation of the proportions found in the population of engineering students at the University. In particular, 22% of all of the engineering students are women and in the sample 23% of the respondents are female.

Findings are presented in two different forms, namely frequency distributions and mean scores. Frequency distributions represent the proportion of survey participants who selected a particular response. Mean scores are based on five-point scales and represent the average score. Gender comparisons involve either a comparison of the frequency distributions or mean scores for male and female students. For gender comparisons of frequency distribution, either a chi-square test of independence or a t-test of significance was used.

## DESCRIPTIVE PROFILE OF ENGINEERING STUDENTS

Studies of factors influencing the decision to choose or avoid an undergraduate major in science have identified five sets of factors that may influence the decision to select an undergraduate major in engineering: family background, pre-university experiences, university experiences in engineering, perceptions of engineers and work attitudes and plans. To determine if these factors are also important for engineering undergraduates we begin by constructing a descriptive profile of our sample of engineering majors. This profile then forms the backdrop for our analyses of the factors that influenced students' decision to major in engineering.

### Family Background

Studies of differences in family background focus on the educational backgrounds and occupations of students' parents. Not surprisingly, many have focused on fathers and, in particular, on fathers as role models for women in science. We followed recent extensions of research in this area and examined the educational backgrounds and occupations of our students' parents and employment status of their mothers.

On the whole, the results are consistent with research on science majors. Like those of their counterparts in science, the parents of engineering undergraduates are very well educated. Over half of the mothers (55%) and fathers (54%) have a university degree, and over three-quarters (77%) of the mothers worked while their children were growing up. There was no significant difference in these results between the genders. In contrast, the occupational dimension of the family background did differ by gender. Only 2% of mothers work in engineering compared to 27% of fathers, which is expected, given that the number of women engineers who would have children of university age is quite low. While the percentage who have a mother in engineering does not differ significantly for female and male students (i.e., 3% versus 1%, respectively), significantly more female students (34%) have a father in engineering compared to male students (25%). Thirty-nine percent of students reported that they have a relative other than their mother or father in engineering and slightly more female students (47%) report this compared to male students (37%). When the results are combined with those who have a parent or other relative in engineering (results not shown) we find that half of the engineering students (51%) have either a parent or other relative in engineering. This high percentage may be influenced by the fact that the survey was conducted in Calgary where there is a high concentration of engineers.

### Pre-University Experiences

Researchers studying the science and engineering pipeline have established the importance of students' pre-university mathematics and science experiences. It is well established that students who pursue science report high levels of preparation and performance in high school mathematics and science. Compared to their non-science counterparts, science majors report that they found these subjects easier and that they were more interested in them. They also report higher mathematics and self-efficacy ratings at this point on the science and engineering pipeline.

The respondents completed, on average, about four mathematics courses. In science, they completed between two and three chemistry courses, about two physics classes and on average, one biology course. The findings for preparation in mathematics, chemistry and physics do not differ for male and female engineering students -- both entered university well prepared to study engineering in these three subject areas. Female students, however, completed slightly more biology courses than male students in high school, whereas male students were more likely to have completed a course in computer programming than female students. It should be noted that biology is not required for entrance to the University of Calgary's Faculty of Engineering whereas the other science and mathematics courses are required.

Table 1 shows the average grades that engineering students received for each set of courses in high school. A score of 5 indicates they received mostly A's and a score of 4 indicates they received mostly B's. The findings suggest that most engineering students received mostly A's and B's in mathematics, chemistry and physics. As well, the students who completed any high school courses in biology also typically obtained mostly A's and B's. Female students report significantly higher grades in mathematics, chemistry and biology compared to male students. Both genders, however, obtained relatively high grades in these three sets of courses. There is no gender difference in the grades reported for high school physics. Taken together, these findings show that both male and female engineering students obtained high grades in their high school mathematics, chemistry, physics and biology courses.

**TABLE 1. PERFORMANCE IN HIGH SCHOOL MATHEMATICS, CHEMISTRY, PHYSICS AND BIOLOGY**

| High School Performance | Total Sample | Female Students | | Male Students | |
|---|---|---|---|---|---|
| Average Mathematics Grade (N=1037) | 4.75 | 4.81 | > | 4.72 | * |
| Average Chemistry Grade (N=1029) | 4.66 | 4.72 | > | 4.64 | * |
| Average Physics Grade (N=1022) | 4.62 | 4.61 | | 4.63 | |
| Average Biology Grade (N=654) | 4.58 | 4.70 | > | 4.54 | * |

* Values are significantly different for male and female students ($p<.05$)
Scores range from 1 (mostly Fs) to 5 (mostly As)

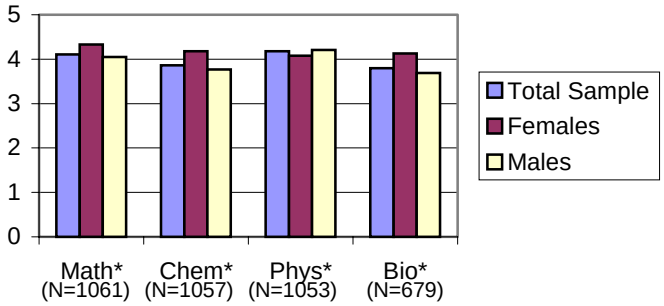
Table 2 shows how easy or difficult engineering students found each subject in high school. These scores are based on only those students who reported taking at least one course in the subject area. A mean value of 3 indicates that, on average, they found the subject area neither easy nor difficult and a mean value of 4 indicates that they found the subject to be somewhat easy. The findings show that, on average, engineering students found mathematics (Mean=4.16), chemistry (Mean=3.93), physics (Mean=3.79) and biology (Mean=3.79) to be relatively easy. The mean score for male students (Mean=3.87) suggests that they found physics to be somewhat easier than female students (Mean=3.53), although female students also found this subject area to be relatively easy to some degree.

**TABLE 2. PERCEPTIONS OF EASE/DIFFICULTY OF HIGH SCHOOL MATHEMATICS, CHEMISTRY, PHYSICS AND BIOLOGY**

| Ease/Difficulty of High School Courses | Total Sample | Female Students | | Male Students | |
|---|---|---|---|---|---|
| Ease/Difficulty of Mathematics (N=1060) | 4.16 | 4.17 | | 4.16 | |
| Ease/Difficulty of Chemistry (N=1057) | 3.93 | 3.97 | | 3.93 | |
| Ease/Difficulty of Physics (N=1054) | 3.79 | 3.53 | < | 3.87 | * |
| Ease/Difficulty of Biology (N=678) | 3.79 | 3.91 | | 3.75 | |

* Values are significantly different for male and female students ($p<.05$)
Scores range from 1 (very difficult) to 5 (very easy)

The engineering students were also asked to indicate their interest in mathematics, chemistry, physics and biology during high school and their responses are summarized in Figure 1. These results are reported only for those students who completed at least one course in the subject area in high school. As shown in this figure, respondents found mathematics (Mean=4.11) and physics (Mean=4.18) to be somewhat interesting. Chemistry (Mean=3.86) and biology (Mean=3.80) have slightly lower mean scores but they still suggest that these subjects were somewhat interesting. The results also show that female engineering students found mathematics, chemistry and biology to be significantly more interesting in high school than their male counterparts. In contrast, male engineering students found high school physics to be more interesting than female engineering students. It is important to note, that taken together, both male and female engineering students found these subjects to be somewhat interesting in high school.




* Values are significantly different for male and female students (p<.05)
Scores range from 1 (very boring) to 5 (very interesting)

**FIGURE 1. INTEREST IN HIGH SCHOOL MATHEMATICS, CHEMISTRY, PHYSICS AND BIOLOGY**

The results presented in Table 3 show how confident engineering majors felt they were in mathematics, chemistry, physics and biology during high school. The mean scores are all greater than 4 indicating that, on average, engineering majors felt somewhat confident in their ability to perform in all four subjects in high school. While female students (Mean=3.98) report a lower mean score for physics than male students (Mean=4.31), they were still somewhat confident in their ability to perform high school physics.

**TABLE 3. CONFIDENCE IN HIGH SCHOOL MATHEMATICS, CHEMISTRY, PHYSICS AND BIOLOGY**

| Confidence in High School Subjects | Total Sample | Female Students | | Male Students | |
|---|---|---|---|---|---|
| Confidence in Mathematics (N=1058) | 4.56 | 4.59 | | 4.55 | |
| Confidence in Chemistry (N=1052) | 4.26 | 4.29 | | 4.25 | |
| Confidence in Physics (N=1047) | 4.23 | 3.98 | < | 4.31 | * |
| Confidence in Biology (N=676) | 4.03 | 4.12 | | 3.99 | |

* Values are significantly different for male and female students (p<.05)
Scores range from 1 (very anxious) to 5 (very confident)

## Extra-curricular Science-Based Activities

Survey participants were asked to indicate which science-based extra-curricular activities they participated in prior to entering the Faculty of Engineering (e.g., computer club, robotics competition, Shad Valley). We found that slightly more than half (56%) participated in at least one activity that was open to both male and female students and participation rates varied significantly for male and female students -- 54% of the male students compared to 64% of the female students. The top three activities that were attended include the University of Calgary Engineering High School Open House (32%), Science Fairs (23%) and Mini-University (11%). The Open House is held specifically for students who have been accepted to the Faculty of Engineering, while Mini-University is a two-week summer day camp program for students aged 9 to 15 which includes a science or engineering component. There was no significant difference found between the participation of male (30%) and female (34%) students in the Open House. If we exclude this activity, we find that 38% of the male students compared to 42% of the female students participated in any of the remaining extra-curricular activities open to both genders prior to entering university.

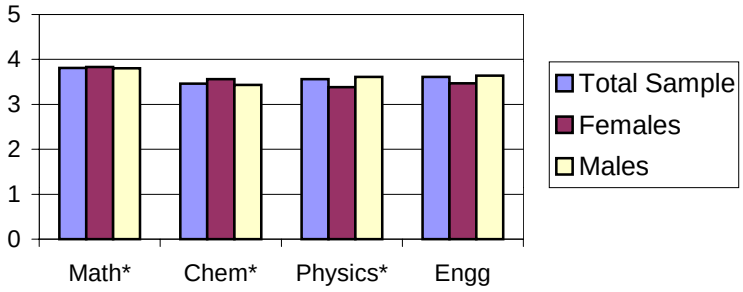
In addition, we also examined the extent to which the female students participated in any of the activities open exclusively to women and these include the following: all-girls physics classes, Operation Minerva and Women in Engineering Day for grade 10 and 11 girls. We found that only 14% of the female engineering students had participated in any of these activities and of those most (88%) had only participated in one. Operation Minerva is a job shadowing activity for Grade 8 girls in which they are paired with a practicing woman scientist or engineer for a half day. The Woman in Engineering Day is held each year by the Faculty of Engineering to introduce young women to engineering through hands-on activities and presentations by professional engineers.

## Experiences as an Undergraduate Engineering Student

To explore the role of university experiences on the academic choices of engineering undergraduates, respondents were asked how well they have performed in their engineering courses and to reassess their interests and perceived ability in mathematics and science. Because they now have direct experience with engineering, they were

also asked to assess their interest and ability in engineering. Drawing on the literature on science majors, we expect them to report relatively high levels of performance, interest and perceived ability in all subjects. On average, the students had obtained a 2.89 average (which approximates a B-average) and does not differ for males and females.

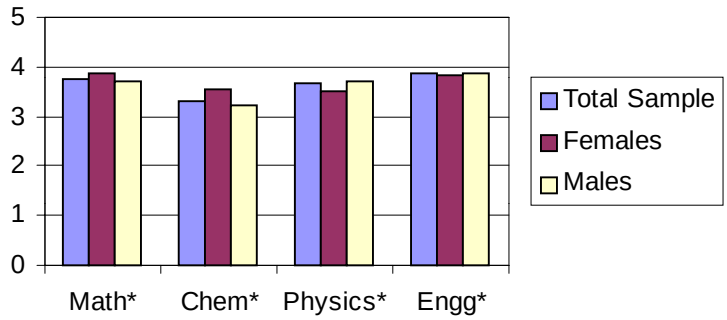
Figure 2 shows the results of the students' perceived ability. A score of 3 indicates respondents believe their ability is about average while 4 indicates above average. As can be seen, engineering students generally perceive their ability in all four subjects is above average. While male and female engineering students apparently feel equally able in mathematics, female students report higher perceptions of ability in chemistry compared to male students, whereas male students report higher perceptions of ability in physics and engineering. While three of these subjects show statistically significant gender differences, it is important to note the general pattern in which engineering students, regardless of gender, report that they believe they are above average in all four subjects.




* Values are significantly different for male and female students (p<.05)
Scores range from 1 (in the bottom 10%) to 5 (in the top 10%)

**FIGURE 2. PERCEIVED ABILITY IN UNIVERSITY MATHEMATICS, CHEMISTRY, PHYSICS AND ENGINEERING (N=935)**

Figure 3 shows engineering students' current interest levels in mathematics, chemistry, physics and engineering. A score of 3 indicates that they felt they have an average interest level and 4 indicates an above average interest level. The results suggest that engineering students have above average interest in all four subject areas, and that female engineering students report greater interest in chemistry than male engineering students, whereas male students report greater interest in physics and engineering than their female counterparts.




* Values are significantly different for male and female students (p<.05)
Scores range from 1 (in the bottom 10%) to 5 (in the top 10%)

**FIGURE 3. INTEREST IN UNIVERSITY MATHEMATICS, CHEMISTRY, PHYSICS AND ENGINEERING (N=1018)**

## Perceptions of Engineers

Research on undergraduates has shown that perceptions about different fields of study can influence choice of an undergraduate major. Survey participants were asked to indicate the extent to which they believed that the nine characteristics presented in Table 5 characterize a successful engineer. Means range from 1 to 5, where a value of 3 indicates that the characteristic is neither important nor unimportant, a value of 4 indicating that the characteristic is

somewhat important and a score of 5 indicating that the characteristic is very important. Table 4 presents the characteristics in descending order of importance.

Overall, engineering students believed that most of these characteristics are important with seven of the nine having mean score values of 4.00 or higher. Of these seven, possessing good problem-solving skills (Mean=4.56), an ability in math (Mean=4.48) and an ability in science (Mean=4.43) had the highest mean scores -- a pattern that suggests that these characteristics are widely regarded as important for successful engineering. In contrast, good writing and speaking skills and preference to work independently received scores lower than 4.00, suggesting that they are considered to be relatively less important than the other seven characteristics. The mean value for good writing and speaking skills (Mean=3.85) suggests that this characteristic is seen to be somewhat important, however, as the score is approaching 4.00. The mean value for preference to work independently (Mean=2.93) is closer to 3, which suggests that it is considered to be neither important nor unimportant for being a successful engineer.

**TABLE 4. PERCEPTIONS OF IMPORTANT CHARACTERISTICS OF SUCCESSFUL ENGINEERS (N=1040)**

| I think the following characteristics are important in order to be a successful engineer: | Total Sample | Female Students | | Male Students | |
|---|---|---|---|---|---|
| good problem-solving skills | 4.56 | 4.63 | > | 4.53 | * |
| ability in math | 4.48 | 4.58 | > | 4.46 | * |
| ability in science | 4.43 | 4.49 | | 4.41 | |
| good people skills | 4.08 | 4.20 | > | 4.05 | * |
| imagination and creativity | 4.04 | 4.00 | | 4.06 | |
| concrete/sequential thinking | 4.03 | 4.15 | > | 3.99 | * |
| mechanical inclination | 4.01 | 3.91 | < | 4.03 | * |
| good writing and speaking skills | 3.85 | 3.97 | > | 3.82 | * |
| preference to work independently | 2.93 | 2.93 | | 2.93 | |

* Values are significantly different for male and female students ($p<.05$)
Values range from 1 (strongly disagree) to 5 (strongly agree).

Turning next to the findings for male and female students we see that they differ significantly in their perceptions of six of the nine characteristics. Specifically, female students assign greater importance to possessing good problem-solving skills, ability in math, good people skills, concrete/sequential thinking and good writing and speaking skills than male students. In contrast, male students assign higher scores to mechanical inclination than female students in terms of what characteristics are important to be a successful engineer. It should be noted that despite the statistically significant gender differences, the absolute differences in mean scores are relatively small and both genders generally consider the same characteristics to be somewhat important.

## Work Attitudes

Researchers studying the factors influencing the choice of undergraduate majors in science have established the importance of students' work attitudes and plans. Some studies find that women and men differ in the importance that they attach to different characteristics of work whereas other studies report no gender differences. To explore the work attitudes and plans of engineering undergraduates, students were asked about which job characteristics they considered important and the results are shown in Table 5.

**TABLE 5. IMPORTANT CHARACTERISTICS OF FUTURE JOB (N=1036)**

| In my future job, it will be important to me: | Total Sample | Female Students | | Male Students | |
|---|---|---|---|---|---|
| to be paid well | 4.39 | 4.31 | < | 4.41 | * |
| to contribute to society | 4.08 | 4.27 | > | 4.02 | * |
| to use my engineering skills | 4.08 | 4.22 | > | 4.04 | * |
| to express myself creatively | 3.99 | 4.01 | | 3.99 | |
| to work as part of a team | 3.93 | 4.00 | | 3.91 | |
| to have a prestigious job | 3.66 | 3.68 | | 3.66 | |
| to work with people rather than things | 3.64 | 3.75 | > | 3.61 | * |

* Values are significantly different for male and female students ($p<.05$)
Values range from 1 (strongly disagree) to 5 (strongly agree).

As shown in the table, engineering students place importance on being paid well, contributing to society, using their engineering skills, expressing themselves creatively and working as part of a team, as shown by the mean scores of 3.90 or higher. They are less concerned with having a prestigious job (Mean=3.66) and working with people rather than things (Mean=3.64). The findings also show that there are four significant gender differences. Female 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. It should be noted that despite the significant gender differences, both male and female students indicate that they feel it is important that they will be paid well, contribute to society and use their engineering skills in their future job. Similarly, despite the significant gender difference, it is relatively less important for both male and female engineering students to work with people rather than things in their future job.

## FACTORS INFLUENCING THE DECISION TO MAJOR IN ENGINEERING

To understand if there are differences in the factors that influenced their decision to study engineering, students were given several factors and asked if they were positive or negative influences, or if they had no influence (i.e. neither positive or negative). The order in which these factors are discussed follows that for the descriptive profile with one exception, namely perceptions of engineers. Perceptions of engineers are not discussed because students did not identify them as a factor influencing their decision to major in engineering.

### Influence of Family Members on Decision to Major in Engineering

Students were asked whether they received encouragement to major in engineering from their mother, father and other relatives. About one-third of the respondents (34%) indicated that their mother encouraged them to pursue an engineering degree. In addition, we see that significantly more female students (40%) reported that their mother was a positive influence compared to male students (32%). Approximately half of the engineering students (51%) reported that their father was a positive influence and encouraged them to pursue an engineering degree and this does not differ significantly for female (54%) and male (50%) students. Almost one-third of the students (29%) reported that another relative was a positive influence and this finding does not differ significantly by gender of the student.

When the student has a parent or relative who is an engineer, the percentage of those students who were positively influenced increases. Most students with fathers in engineering (83%) reported that they encouraged them to major in engineering and this does not differ for female and male students. All of the females with engineering mothers reported that they received encouragement from their mothers to pursue an engineering degree, while 67% of the males felt the same. These findings should be interpreted with caution because of the extremely small number of cases involved. Lastly, about half (49%) of the students with a family member in engineering, other than a parent, reported that he or she was a positive influence on their decision to major in engineering and this finding does not differ by gender. It can be concluded that those students who had a mother, father or other relative in engineering were more likely to receive encouragement to pursue engineering compared to those students who did not.

### Pre-University Influences on Decision to Major in Engineering

Table 6 shows how three pre-university experiences that relate to students' performance and participation in engineering-related activities influenced their decision to major in engineering. The results show that for approximately three-quarters (76%) of the students, their performance in related high school subjects had a positive

influence on their decision to major in engineering in university. There is a significant gender difference where more female students (81%) indicated that this factor had a positive influence on their decision to major in engineering compared to male students (74%), but overall this factor was a positive influence for the majority of students regardless of gender.

Table 6 also shows the extent to which different high school contacts had a positive influence on students' decision to major in engineering. Approximately one-quarter (22%) of the students indicated that having had contact with an engineer in high school had a positive influence on their decision to major in engineering and this pattern holds for both male and female students. Close to one-half of both female (48%) and male (40%) survey participants indicated that their high school math or science teacher encouraged them to pursue an engineering degree. Fewer students (17%) identified high school guidance counselors as a positive influence to major in engineering.

**TABLE 6. INFLUENCE OF PRE-UNIVERSITY EXPERIENCES AND ENCOURAGEMENT ON DECISION TO MAJOR IN ENGINEERING (N=1062)**

| Influence on Decision to Major in Engineering | Total Sample % | Total Sample N | Female Students % | Female Students N | | Male Students % | Male Students N | |
|---|---|---|---|---|---|---|---|---|
| **Experiences** | | | | | | | | |
| Performance in Related High School Subjects | 76% | (808) | 81% | (194) | > | 74% | (590) | * |
| Participation in Extra-Curricular High School Science Activities | 17% | (180) | 17% | (41) | | 17% | (135) | |
| **Encouragement** | | | | | | | | |
| Contact with Engineers in High School | 22% | (236) | 24% | (57) | | 22% | (175) | |
| High School Math/Science Teacher | 41% | (437) | 48% | (115) | > | 40% | (319) | * |
| High School Guidance Counselor | 17% | (182) | 20% | (48) | | 16% | (128) | |

* Values are significantly different for male and female students ($p<.05$)

## Career-Related Influences on Decision to Major in Engineering

Table 7 shows the extent to which students' decision to major in engineering was influenced by three different career-related concerns. As shown in this table, 19% indicated that the extent to which they felt they could have an impact on the environment through an engineering career had a positive influence on their choice of major and significantly more female students (27%) identified this as an important factor than male students (17%). The majority of students also indicated that they decided to major in engineering because it is related to their career goals (57%) and their future job prospects (80%) and these findings do not differ by gender.

**TABLE 7. CAREER-RELATED INFLUENCES ON DECISION TO MAJOR IN ENGINEERING (N=1062)**

| Influence on Decision to Major in Engineering | Total Sample | | Female Students | | | Male Students | | |
|---|---|---|---|---|---|---|---|---|
| Impact on Environment through Engineering | 19% | (205) | 27% | (65) | > | 17% | (135) | * |
| Relation to Career Goals | 57% | (610) | 58% | (139) | | 57% | (453) | |
| Future Job Prospects | 80% | (848) | 81% | (194) | | 79% | (628) | |

* Values differ significantly for male and female students ($p<.05$)

## CONCLUSIONS AND POLICY IMPLICATIONS

The study of engineering students at the University of Calgary provides a set of data that has allowed the exploration of the characteristics of engineering students, and the factors that influence their decision to major in engineering. The sample consists of over 1,000 students and was stratified by year of study and department in order to ensure that it is representative and of sufficient size to make meaningful comparisons between genders and across departments. A number of conclusions can be drawn from the study that may be used to develop policies and programs for attracting students into engineering.

One area of concern is the role of high school physics for female students, who reported significantly less interest and perceived ability, but similar performance levels, compared to male students. This pattern appears to carry over to the university level where female students also report significantly less interest and perceived ability in physics than their male counterparts. These findings point to an examination of female students' high school experience in physics that may involve investigating, for example, curriculum content, teaching and learning styles,

as well as role models for female students. It is also important to examine whether physics acts as a barrier for female students who do not enter engineering at the university level because they have less interest or perceived ability in physics compared to male students. The finding that female university students in engineering show less interest in physics than male students suggests that there is also a need to evaluate the curriculum and teaching/learning environment at the university level. The findings reported in this study also support some of the new initiatives at the University of Calgary in this area, such as the physics exam-review sessions introduced in 1998 and operated through the Women in Science and Engineering (WISE) student club.

Turning next to the pattern of findings reported for mathematics, we found that female students were quite interested in this subject and also believe they have a high level of ability in this area. Female students' positive attitudes towards mathematics may function to counterbalance their slightly less positive attitudes towards physics in terms of attracting them to engineering. As a result, recruitment of female students into engineering may consider an emphasis on mathematics as a foundation to engineering studies.

Family members clearly play an important role in influencing both male and female students' decision to study engineering. This suggests that it is imperative to have outreach programs that are aimed at, or include, parents since they form an important positive component in students' overall decision-making process. It should be noted that the results obtained in this study show that half of the engineering students have a parent or other family member who is or was an engineer. This proportion is likely higher than average, however, since there are about 15,000 engineers in Calgary giving it one of the largest number of engineers per capita of any city in North America. Male and female students who had mothers or fathers who were in engineering were more likely to receive encouragement from their parents to major in engineering compared to those who did not have a parent in engineering. High school teachers are also a significant factor in influencing both men and women to enroll in engineering; thus they should be considered as part of the program development.

The results of participation rates of male and female students in extra-curricular science and/or engineering activities shows that the majority of engineering students did not take part in these initiatives. More importantly, since only a small percentage of students felt that these activities had a positive influence on their decision to select engineering, this may indicate that these programs are not important when compared to other factors (e.g., parents, high school performance), or that they are not properly targeted. These findings do not suggest that these programs are not worthwhile, since they may have had the result of students taking science and math courses to keep their career options open; however, they do support the need to evaluate the impact of intervention programs.

## ACKNOWLEDGEMENTS

This study would not have been possible without the support of a number of organizations and individuals. This project was funded by the Imperial Oil Charitable Foundation, which is gratefully acknowledged. Additional funding and support was received from the NSERC/Petro-Canada Chair for Women in Science and Engineering (Prairie Region) and the Departments of Sociology and Geomatics Engineering at the University of Calgary.

Special acknowledgment is also due to the individuals who contributed to the success of this study. Dr. Chan Wirasinghe, Dean of Engineering, supported this project and encouraged Engineering Faculty and students to participate. Ms. Marcia Inch and Ms. Corrine Ferguson provided invaluable assistance throughout this project in various stages and in numerous ways. Finally, this study would not have been possible without the support of the Faculty members who so graciously gave up class time to allow their students to participate in this study and the overwhelming number of students who completed the questionnaires. We thank you for your time and cooperation.

## REFERENCES

Wallace, J.E., V. Haines and M.E. Cannon (1999), Academic Choices of Engineering Undergraduates, Final Grant Report to Imperial Oil, University of Calgary, 29 pp.