Engineering and Technology Labour Market Study

Right for Me?

A Study of Factors that Shape the Attitudes of Young Women towards Mathematics and Science and towards Careers in Engineering and Technology

Engineers Canada
and
Canadian Council of Technicians and Technologists

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Canada

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About Engineers Canada

Established in 1936, Engineers Canada is the national organization of the 12 provincial and territorial associations and ordre that regulate the practice of engineering in Canada and license the country's more than 160,000 professional engineers. Engineers Canada serves the associations and ordre, which are its constituent and sole members, by delivering national programs that ensure the highest standards of engineering education, professional qualifications and professional practice.

About the Canadian Council of Technicians and Technologists

The Canadian Council of Technicians and Technologists (CCTT) establishes and maintains national competency standards for certifying members with a 'quality seal of approval' in 14 applied science and engineering technology disciplines: bioscience, industrial, building, instrumentation, chemical, mechanical, civil, mining, electrical, petroleum, electronics, geomatics, forestry, and information technology. CCTT's provincial associations are responsible for issuing these highly regarded credentials, which are recognized by provincial statute in many Canadian provinces.

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Executive Summary

- This study examines the factors that motivate the educational and career choices of young women in high school. The findings are based on: a survey of young women in secondary school (426 responses), focus groups with young women in secondary school (98 participants), and interviews with secondary school teachers in mathematics and science (20 interviews). Five schools participated in the study. These were located in Calgary, Halifax, Montreal, Toronto, and Winnipeg.

- Enrolment data in engineering and technology programs show a pronounced bias toward men. In recent years, among first year students at the college level, engineering and applied science programs accounted for approximately 46% of enrolments by men but fewer than 10% of enrolments by women.[1] At the university level, after rising moderately for several years, the women's share of undergraduate enrolments in university engineering programs has fallen back to 17.5%, which is down from 21% in 1999.[2]

- The social science literature suggests various explanations for the gender bias in enrolments in mathematics and science subjects and for the even more pronounced gender bias in enrolments in engineering and technology programs. This study lends strong support to some of those explanations and weak or no support to others.

- Key findings were:
  1. A large majority of young women do not have a good understanding of what engineering and technology careers entail and therefore cannot aspire to those careers. Only 12.5% had heard of National Engineering Month, while only 9% reported having heard of National Technology Week.

  2. Among the minority of young women who had a better understanding of engineering and technology careers – often through a parent or close relative – this greater knowledge did not translate into an interest in postsecondary studies in engineering or technology.

  3. A large majority of young women have negative perceptions of engineering and technology occupations. Although a small minority of young women perceive engineering and technology as providing opportunities to be creative and to work in teams, most equate engineering and technology (but especially engineering) with construction work, outdoor work, working in a cubicle, and relating primarily to computers and machines, rather than people. Lower status is attributed to engineering and technology occupations in comparison with the health and social sciences.

  4. Compared to young men, young women do not have role models who encourage them to consider engineering and technology careers. Role models, including high school teachers and industry professionals, were viewed as extremely important by both teachers and young women.

[1] Statistics Canada, CANSIM, Table 477-0006

[2] Based on data supplied by Engineers Canada

Recommendations:

1. Together with industry, the engineering and technology professions should carefully review career information and career promotion strategies. It may be appropriate to develop separate career information materials for young women. At the very least, career information materials need to deal more deliberately with the attributes that young women appear to seek more strongly in a career (social engagement, 'making a difference', creativity, working in teams). Career information material and career programs also needs to tackle negative perceptions.

2. The engineering and technology professions need to address the female role model deficit by considering a program that will bring young women in high school in contact with women in engineering and technology.

3. The provincial and territorial engineering and technology professional associations should initiate, where they have not already done so, career promotion strategies that are consistent with the findings of this study. Engineers Canada and the Canadian Council of Technicians and Technologists should operate as clearing houses for disseminating the results of these initiatives. Engineers Canada and the Canadian Council of Technicians and Technologists should consider annually or biennially publishing a survey of trends in enrolments that will identify progress, where it has been made, in addressing the gender imbalance in enrolments.

Part 1: Introduction and Methodology

Introduction

Enrolment data in engineering and technology programs show a pronounced bias toward males. In recent years, among first year students at the college level, engineering and applied science programs accounted for approximately 46% of enrolments by men but fewer than 10% of enrolments by women.[3] At the university level, after rising moderately for several years, the women's share of undergraduate enrolments in university engineering programs has fallen back to 17.5%, which is down from 21% in 1999.[4]

The skewed demographic profile of the engineering and technology professions has motivated numerous studies of the factors behind continuing male dominance of university and college admissions into engineering and technology programs. Explanations for the low number of women applicants for these programs variously assign primary importance to economic, socio-cultural, or psychological factors. Some have suggested that the number of women entering engineering and technology has "hit a glass ceiling", implying that there are barriers that impede any significant improvement in the women's share of university and college admissions into engineering and technology programs.

The failure to sustain even moderate increases in the women's share of enrolment in technology and engineering programs is unsettling. Numerous initiatives, supported by governments, by the engineering and technology professions, and by universities and colleges have striven to correct the gender imbalance. Some of these programs are discussed in an accompanying report, *Achieving Diversity: Strategies that Work*. This report is also available on the Engineering and Technology Labour Market Study website: http://etlms.engineerscanada.ca. The paradox is that, at the 'micro level', there is compelling evidence that support programs work. And yet, at the 'macro level' it has proven difficult to significantly change the gender trends in enrolments.

This study is part of the *Engineering and Technology Labour Market Study* that is being undertaken by Engineers Canada and the Canadian Council of Technicians and Technologists, with support from Human Resources and Skills Development Canada.

This study looks behind enrolment trends to ask what factors motivate the educational choices of young women in high school. Specifically, this study asks two questions:

> First, what factors encourage or discourage women in high school to take the mathematics and science courses that are required for admission into engineering and technology programs?
>
> Second, what factors encourage or discourage women in high school who have taken the requisite mathematics and science courses to subsequently pursue or not pursue engineering or technology studies at the university or college level?

[3] Statistics Canada, CANSIM, Table 477-0006

[4] Data supplied by Engineers Canada

Several explanations have been advanced to account for the low proportion of young women in high school who complete mathematics and science subjects and for the even lower proportion who subsequently choose to pursue technology or engineering at the postsecondary level. Below we summarize a number of these proposed explanations, without commenting on their persuasiveness or completeness:

1. Young women are streamed out of mathematics and the sciences.

It is suggested that high schools may be more amenable to allowing young women to drop mathematics and science courses because their intended postsecondary studies do not have mathematics and science pre-requisites. Parents may also be more complaisant in allowing their daughters to drop mathematics and science courses. This is not to say that young women in high school are pushed out of mathematics and science courses. Rather, the hypothesis is that high schools (and perhaps also parents) are more amenable to permitting young women to drop mathematics and science courses, compared to young men who might similarly be inclined to drop mathematics and science courses.

2. Broad cultural factors account for gender preferences in academic interests and careers.

There is a large body of social theory that holds that young women are socialized at an early age to be care-givers, nurturers and people-oriented. This socialization then shapes subsequent academic interests and career aspirations. This theory is often cited to explain why a greater proportion of young women (compared to young men) pursue the health sciences and social sciences as both academic and career interests. These fields of study, it is said, prepare individuals for more socially engaged careers, compared to technical studies.

A second stream of social theory attaches importance to the additional responsibilities that women have in the home. This is sometimes referred to as working a 'second shift'.[5] These additional responsibilities can pose serious challenges for women wanting to succeed in careers while maintaining work-family balance. There is evidence that suggests that young women in high school alter their career preferences over time as they take more account of the need to combine a career with work-family balance.[6] The implication of this theory is that engineering and technology careers are perceived as being more inimical to maintaining a work-family balance than careers in other fields. It should be stressed, that the focus in this theory is on perceptions of careers. These perceptions may or may not be consistent with reality and they may or may not lag changes in actual career circumstances.

[5] Hochschild, A. R. (1989). *The second shift.* New York: Viking.

[6] Meinster, M. O. & Rose, K. C. (2001). Longitudinal influences of educational aspirations and romantic relationships on adolescent women's vocational interests, *Journal of Vocational Behavior*, 58, 313–327.

3. Too few parents encourage their daughters to study mathematics and science and to consider engineering and technology career options.

Parents project expectations onto their children. By doing so, parents foster career expectations that their children often internalize and later aim to achieve.[7] Some parents may project expectations that reflect broad cultural norms on gender roles. Other parents may consciously project expectations that go against the grain of broad cultural norms. The impact of parents on the academic and career choices of their children is an exceedingly complex issue. This study was able to look at only one aspect of parental influence. Specifically, the study explores the significance for academic and career choice of having a parent or relative in engineering and technology. The hypothesis we examine is that young women with a parent or close relative in engineering or technology will show a greater inclination towards those occupations and will also be more inclined to take the mathematics and science courses that are pre-requisites to studying these fields at the postsecondary level.

4. Peers are important influencers. For young women, peer influence encourages a negative attitude towards studying mathematics and science and towards entering engineering or technology programs at the postsecondary level.

During adolescence, friendship circles become increasingly important. It has been suggested that peers influence the likelihood of a student pursuing mathematics and science courses. This peer influence may either move in the same direction or in the opposite direction of parental and family influence. It has been found that when a young person's friends excel in mathematics and science, this has a positive influence on the likelihood of others in their friendship circle continuing in these subjects.[8] The influence of peers on career aspirations is complex. It is difficult to determine whether peers influence career and academic aspirations or whether, in their selection of peers, individuals gravitate to persons who already have similar aspirations.

5. Male dominance of science and mathematics classes discourages young women from continuing in these subjects through to graduation.

It has been suggested that male dominance of classes in science and mathematics subjects creates a negative atmosphere for young women and is, in and of itself, a deterrent to more young women continuing with science and mathematics courses through to graduation.

6. There is a subtle, but significant, gender bias in science and mathematics curriculum materials that discourages young women from continuing in these subjects through to graduation.

It has been suggested that curriculum materials communicate subtle gender biases. These biases discourage young women from pursuing mathematics and science subjects.

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[7] In a longitudinal study, gender-typed occupational expectations held by parents for their children were found to influence their child's occupational choices when measured in adulthood at age 28. For a full description of the study, see Chhin, C.S., Bleeker, M.M., and Jacobs, J.E. (2008). Gender-typed occupational choices: The long-term impact of parents' beliefs and expectations. In H.M.G. Watt and J.S. Eccles (Eds.), *Gender and occupational outcomes* (pp. 215-235). Washington: American Psychological Association.

[8] Riegle-Crumb, C., Farkas, G., and Muller C. (2006). The role of gender and friendship in advanced course taking. *Sociology of Education*, 79(3), 206-228.

7. Young women do not have a good understanding of what engineering and technology careers entail and therefore cannot aspire to those careers.

It is suggested that a general lack of knowledge about engineering and technology professions discourages young women from aspiring to those professions and, by inference, reduces the likelihood of young women taking mathematics and science subjects.[9] It should be noted that this is a somewhat different explanation than the 'negative perceptions' explanation that will be discussed next. This explanation focuses on the lack of knowledge, since knowledge about a career is a prerequisite to aspiring to that career.

8. Young women have negative perceptions of engineering and technology occupations.

Even more strongly than a general lack of knowledge about engineering professions, negative perceptions of these professions will discourage young women from pursuing these professions as careers. It is to be stressed that the emphasis here is on perceptions, not on the actual circumstances of engineering professions. There is some evidence, for example, that many in high school equate engineering with construction and reject engineering because they have no interest in construction work.[10]

9. Compared to young men, young women have fewer role models who encourage them to take mathematics and science courses and to consider engineering and technology careers.

The importance of role models is widely recognized. Female role models can correct misperceptions, serve as mentors, and provide avenues for networking.[11] Some have suggested that role models are especially important when seeking to alter gender patterns in careers and academic studies and that the relative dearth of female role models is an important factor explaining the low proportion of young women who pursue engineering and technology careers.

This study cannot, by itself validate or invalidate any of the suggested explanations for the observed gender patterns in engineering studies and in engineering occupations. However, this study does lend modest, but important, empirical support to some theories, and at the same time suggests that other theories may have less explanatory power than is sometimes believed. Figure No. 1 summarizes the factors investigated in this study.

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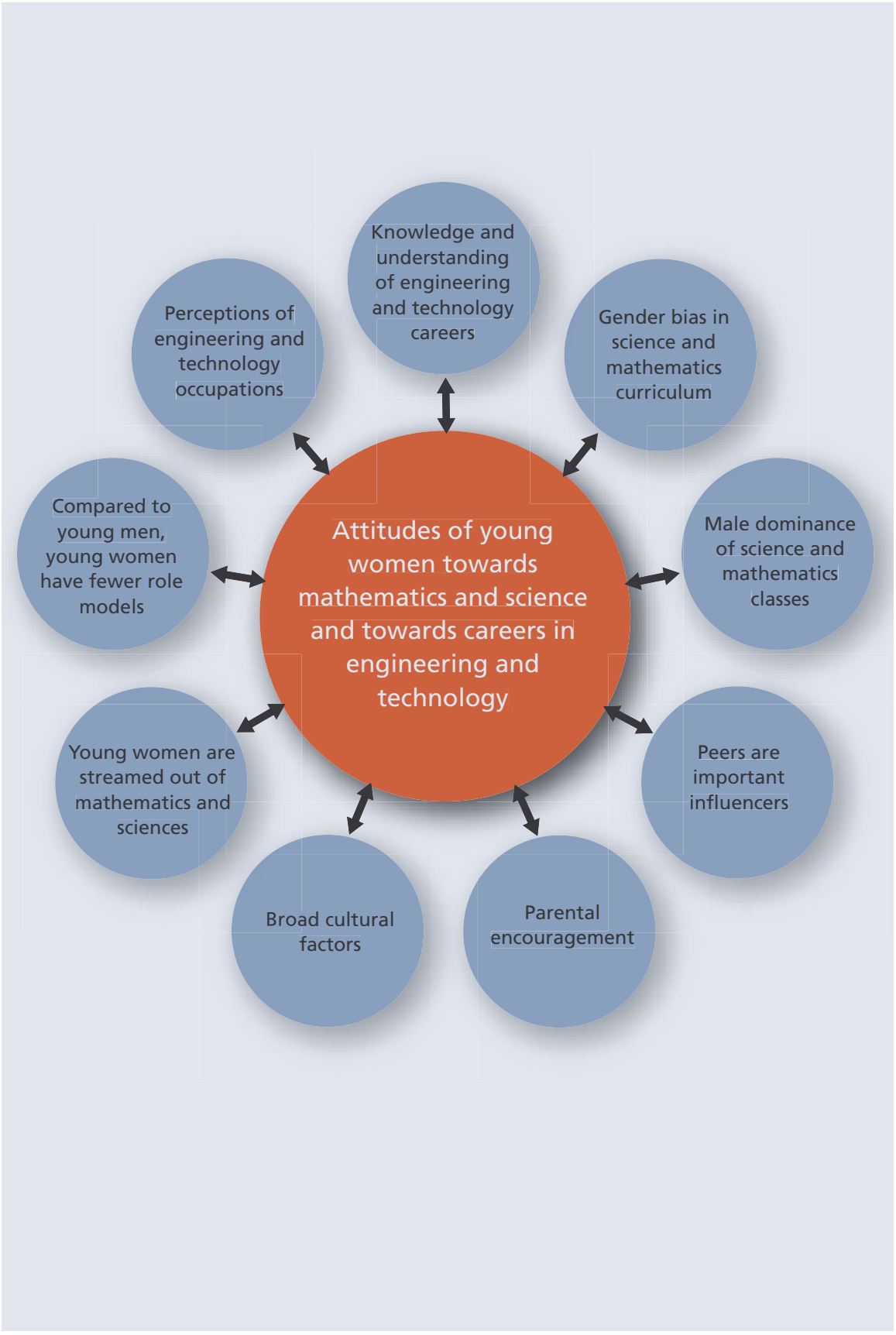
[9] Anderson, L. S. & Gilbride K. A. (2005), discovered that high school females relative to males reported greater uncertainty (60% versus 48%) regarding their knowledge of engineering occupations. Further, knowledge about engineering was found to slightly increase reported interest in engineering, indicating that knowledge along with other factors are at play when contemplating career goals. For a full description of the study *see* Anderson, L. S. & Gilbride, K. A. (2005). Image of engineering among Canadian high school students. *8th UICEE Annual Conference on Engineering Education*. Kingston, Jamaica.

[10] A "Draw an Engineer Test", revealed that students in Grades 3 to 12, portrayed engineering with the use of tools and with images of building/fixing. Students were likely to describe engineering in repair-type activities such as repairing car engines, and plumbing. High school students were more likely to associate engineering with creative design work versus students in earlier grades. For a full description see Knight, M. & Cunningham, C. (2004). Draw an engineer test (DAET): Development of a tool to investigate students' ideas about engineers and engineering. In *Proceedings of the* 2004 *American Society for Engineering Education Annual Conference and Exposition*. American Society for Engineering Education.

[11] Packard, B. W., & Wong, D. (1997). Clash of Future Selves in College: Women Considering Science Careers. Paper presented at the *American Educational Research Association Annual Meeting*, Chicago.

Figure No. 1
Potential Factors Affecting Educational and Career Choice among Young Women in Secondary School



Methodology

This report used three research methods:

1. Survey of young women in secondary school
2. Focus groups with young women in secondary school
3. Interviews with secondary school teachers in mathematics and science

Students and teachers in five secondary schools were invited to participate in this study. The schools were located in: Calgary, Halifax, Montreal, Toronto, and Winnipeg. The authors of the report wish to express their appreciation to the students, teachers and board of education for their support and assistance in conducting the study.
A profile of the participants is outlined below.

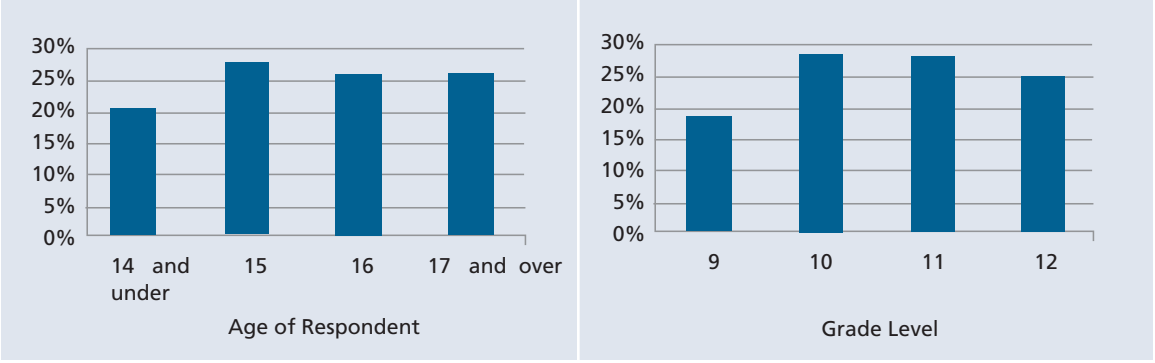
The Survey

- The sample consists of 426 responses from young women in secondary school.
- The data is skewed to respondents from Ontario and Manitoba because facilitators in these regions heavily promoted the survey.
- The sample is representative across age groups and grade levels. The tables and graphs below provide a description of the regional profile, along with the age and grade distribution of the sample.

Figure No. 2
Regional Distribution of Survey Participants

Province	% of Respondents
Ontario	68.2%
Manitoba	23.5%
Alberta	5.2%
Nova Scotia	1.2%
Quebec	1.2%
British Columbia	0.5%
Prince Edward Island	0.2%
Total	**100%**

Figure No. 3
Distribution of Survey Participants by Age and Grade level



Focus Group Participants

There were 12 focus groups conducted with young women in secondary school from Grade 9 through Grade 12. A total of 98 persons participated in the focus groups. The focus groups were conducted from December 2008 to February 2009. The regional distribution of these participants is set out in Figure No. 4.

Figure No. 4
Distribution of Focus Group Participants

Location	No. of Focus Groups	No. of Participants
Calgary	2	12
Winnipeg	3	30
Toronto	3	25
Montreal	3	23
Halifax	1	8
Total	**12**	**98**

Teacher Interviews

There were 20 teacher interviews conducted as part of this study. Those interviewed, taught Biology, Chemistry, Physics, Mathematics, and Technology courses across Grades 9 to 12.

Figure No. 5 summarizes the regional distribution of the teacher interviews.

Figure No. 5
Distribution of Teacher Interviews by Region

Location	No. of Teacher Interviews
Calgary	4
Winnipeg	5
Toronto	5
Montreal	3
Halifax	3
Total	**20**

Source materials are appended as follows:

Appendix A: Focus Group Questions
Appendix B: Teacher Interviews
Appendix C: Student Survey

Report Structure

This introduction is followed by Part 2, which describes in more detail the current trends in engineering enrolments and in engineering occupations. In Part 3, academic and career preferences among young women in secondary school is provided. In Part Four, the factors influencing attitudes towards mathematics and science and towards careers in engineering and technology is explored, followed lastly by Part 5, which includes a series of concluding remarks.

The Current Workforce

Women comprised 47 % of the workforce in the 2006 Census. In Technician and Technologist occupations, the participation rate of women ranged from 5% to 47%, depending on the technical field, with the average being 19% in 2006. For engineers the range of participation was 7% to 22 % with the average being 13%.

Figure No. 6
Women's Share of the ETT Workforce
Statistics Canada, Census 1996, 2001, 2006[12]

Engineering, Technicians and Technologists	% Women		
	1996	2001	2006
Aircraft instrument, electrical and avionics mechanics, technicians and inspectors	7%	8%	7%
Applied chemical technologists and technicians	38%	44%	47%
Civil engineering technologists and technicians and construction estimators	8%	10%	11%
Construction inspectors	6%	7%	12%
Drafting technologists and technicians	18%	23%	26%
Electrical and electronics engineering technologists and technicians	12%	12%	10%
Electronic service technicians (household and business equipment)	8%	8%	8%
Engineering inspectors and regulatory officers	15%	16%	20%
Geological and mineral technologists and technicians	21%	28%	25%
Industrial designers	19%	22%	26%
Industrial engineering and manufacturing technologists and technicians	19%	20%	19%
Industrial instrument technicians and mechanics	3%	4%	5%
Inspectors in public and environmental health and occupational health and safety	25%	30%	35%
Mapping and related technologists and technicians	29%	35%	34%
Mechanical engineering technologists and technicians	6%	8%	7%
Meteorological technicians	18%	29%	24%
Non-destructive testers and inspectors	9%	11%	8%
Survey technologists and technicians	11%	13%	16%
All Technician and Technologists	15%	18%	19%
All Engineering Technician and Technology Occupations	13%	16%	17%

Figure No. 6 continues on the next page

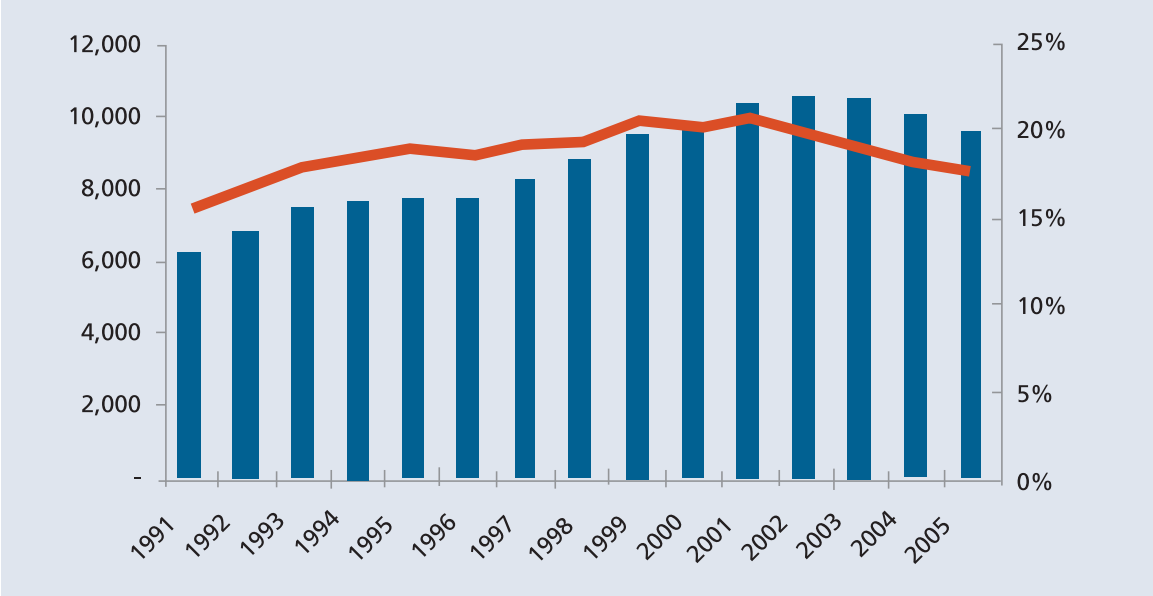
[12] Data for Computer Engineers is available for 2006. Females comprised 13% of this occupational group, which matches the average for all engineers in 2006.

Engineers	% Women		
	1996	2001	2006
Mining engineers	6%	10%	7%
Mechanical engineers	6%	7%	9%
Electrical and electronics engineers	8%	9%	10%
Aerospace engineers	8%	10%	11%
Civil engineers	8%	10%	12%
Metallurgical and materials engineers	6%	13%	12%
Geological engineers	11%	14%	13%
Petroleum engineers	7%	11%	15%
Industrial and manufacturing engineers	10%	14%	15%
Other professional engineers, n.e.c.	9%	12%	18%
Chemical engineers	14%	18%	22%
All Engineers	8%	12%	13%
All Engineering Technician and Technology Occupations	13%	16%	17%

The Future Workforce: Trends in Enrolment Rates

The likelihood of increasing the participation rate of women in engineering occupations in the near future is questionable given recent enrolment trends in undergraduate programs. After a successive increase in the number of women enrolling in undergraduate programs, throughout the 1990s, university administrators are witnessing a drop in female undergraduate enrolments. For instance, from 2000 to 2007, female enrolment rate decreased by 1%.[13] In absolute numbers, female enrolments peaked in 2002, and have dropped each subsequent year. At this point in time, the women's share of undergraduate enrolments is roughly at the same level relative to a decade or more ago (see Figure 7).

Figure No. 7
Number and Share of Women in Undergraduate Enrolments in Accredited Engineering Programs, Engineers Canada



[13] Anderson, L. & Colsante, S. (2008, November). Presentation at *Engineers Canada's National Conference on Women in Engineering*. London, Ontario.

In terms of graduate enrolments, there is a similar proportion of women enrolling in masters and doctorate programs relative to undergraduate programs. For instance between 2001 to 2005 average enrolments in graduate programs was 21% (including foreign female students), whereas average undergraduate female enrolments for this time period was 22%. Similar to trends in undergraduate enrolments, the proportion of Canadian female graduate students also shows signs of decline, specifically from 2001 to 2005 enrolments declined by 1.5%.[14]

Engineers, Technicians and Technologists versus Other Occupations

A male majority in a workplace setting is not an isolated phenomenon. For instance, historically physicians and lawyers were male dominated occupations, however the latter groups have made greater strides in increasing their share of female representation. A comparison of the 1986 and 2006 Census reveals that the proportion of women who are lawyers and physicians has increased by 16.8% and 13.6% respectively, whereas for engineers the increase is 6.1% and for technicians and technologists the increase is 7.2%.

Figure No. 8
Share of Women in Undergraduate Enrolments in Accredited Engineering Programs, Engineers Canada

Occupation	1986	2006
All Occupations	42.7%	47.4%
Engineers	6.1%	12.2%
Technicians and Technologists	14.3%	21.5%
Auditors, accountants and investment professionals	40.4%	49.4%
Occupations in Physical Sciences	22.8%	30.7%
Occupations in Life Sciences	29.8%	36.7%
Lawyers and Quebec Notaries	21.8%	38.6%
Physicians	22.8%	36.4%

A cost-benefit analysis implies that the four year degree required to practise engineering would be more appealing than the additional years of graduate school needed for a law or medical degree. However the evidence indicates that women are choosing otherwise, indicating that other factors are being weighed when making career decisions.

Implications

The determinants of the gender gap in engineering are important to understand. In the first place, current demographic trends indicate that the age cohort 15-19 will peak in 2009 and then decline. This implies that, if female enrolment rates in engineering do not increase, then universities and,

[14] Canadian Council of Professional Engineers. (2006). *Canadian engineers for tomorrow: Trends in engineering enrolment and degrees awarded 2001 to 2005*. Retrieved from http://www.engineerscanada.ca/e/pu_enrolment.cfm

colleges may have to lower their admission standards to maintain class sizes. In the long run this will have adverse implications for employers. Further, women in engineering, science, and technology positions are a value to their employers. Survey evidence suggests a higher rate of employer satisfaction with the workplace performance of women in these occupations.[15] And lastly, as a society, our notion of fairness has embraced the view that a reasonable degree of gender balance should be expected in professional occupations and that there is an obligation on the part of professional associations, employers, and postsecondary institutions to address and rectify serious imbalances.

[15] Dube, R. (2008, June 2). Fighting the female brain drain. Globe and Mail. Accessible at: http://www.theglobeandmail.com/servlet/story/RTGAM.20080602.wlscience02/BNStory/Science/ The article reports that 75% of women between the ages of 25 to 29 are rated superb, excellent, or outstanding in performance reviews versus 61% of men in the same age category.

Part Three: Academic Interests and Career Preferences of Young Women

Part Three of this report begins with an overview of the findings on the educational and career goals of young women in high school. An analysis in Part Four then reviews the factors influencing their attitudes towards mathematics and science and towards careers in engineering and technology.

As young women progress throughout high school their reported interest in specific science and technology subjects, like Chemistry, Physics, and Information and Communications Technology, along with Technology Studies decreases. These findings are particularly interesting given that one group of respondents attended a school that specialized in science and technical studies. This suggests that, interest in science and technology studies wanes over the course of high school, *even among those women who showed an earlier aptitude and interest in these fields*. This has been referred to as the 'leaky pipeline' in which women who had aspired towards traditional male-dominated fields choose other careers. Figure No. 9, portrays the decline in subject interests between individuals in Grade 9 to Grade 12, as revealed in our survey of women in high school.

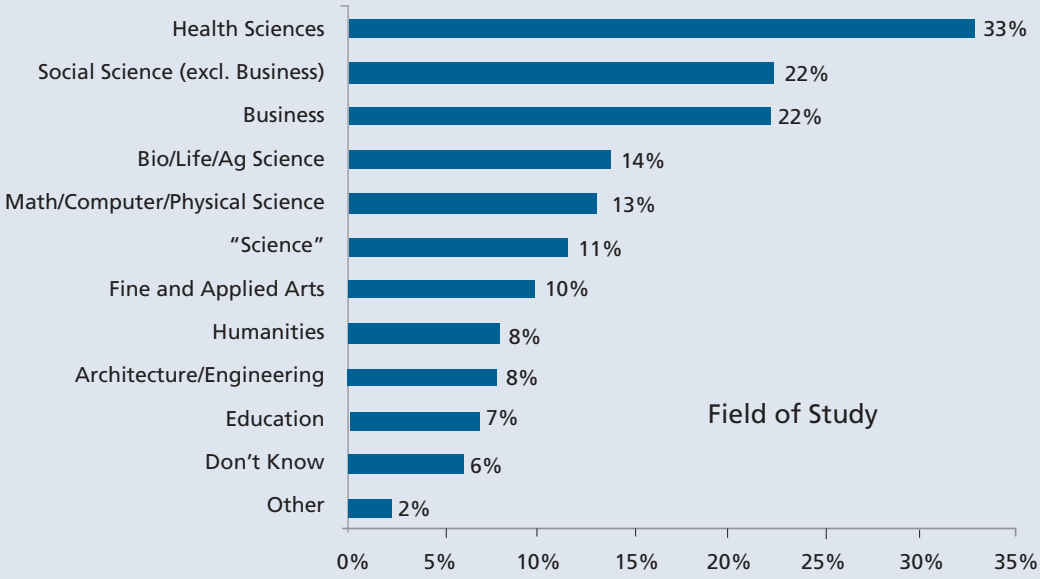
Figure No. 9
Average Reported Interest in High School Subjects for Grade 9 to Grade 12 Students: '1 = Very Low' and '5 = Very High'[16]

Subjects	Grade Level				All Grades
	Gr9	Gr10	Gr11	Gr12	
Fine Arts	4.1	4.1	3.8	3.6	3.9
English	3.5	3.6	3.6	3.4	3.5
Biology	3.3	3.6	3.4	3.4	3.4
Other Languages	3.4	3.5	3.2	3.5	3.4
Social Studies (e.g. sociology)	3.2	3.6	3.5	3.4	3.4
Mathematics	3.5	3.5	3.1	3.3	3.3
Chemistry	3.5	3.2	3.2	2.9	3.2
Business, economics	2.9	3.5	3	3.2	3.2
Physics	3.2	2.9	2.2	2.4	2.7
Information and Communications Technology	3.1	3	2.5	2.4	2.8
Other Science	3.1	2.7	2.6	2.6	2.7
History	2.6	2.8	2.8	2.6	2.7
Geography	2.8	2.7	2.6	2.4	2.6
Technical Studies	3	2.8	2.3	2.4	2.6

[16] Source: Student Survey, *The Role of Career Awareness in the Decision of Young Women to Take Math and Science Subjects*

As Figure No. 9 indicates, *interest in all science subjects declines, except for Biology*. Indeed Biology was considered the most interesting school subject by 54% of young women in our survey. In our focus groups, young women reported that they liked Biology because it deals with living things and provides the possibility to "make a difference". There was also a clear relationship between academic interest in Biology and intended postsecondary studies. The largest proportion of young women (33 %) intended to pursue a career in the health sciences, followed by social sciences (22%), and Business (22%). Figure No. 10 provides a complete list of intended fields of study.[17]

Figure No. 10
Intended Postsecondary Field of Study [18]



Corresponding to intended postsecondary field of study, the most popular career choices were:

Occupation	Percentage
Physician	16 %
Teacher	12 %
Lawyer	10 %
Nurse	10 %
Accountant	8%
Engineer	6%

Similar to previous research, young women reported choosing careers that were:

- in the health and social sciences
- humanitarian in nature
- perceived as socially engaging

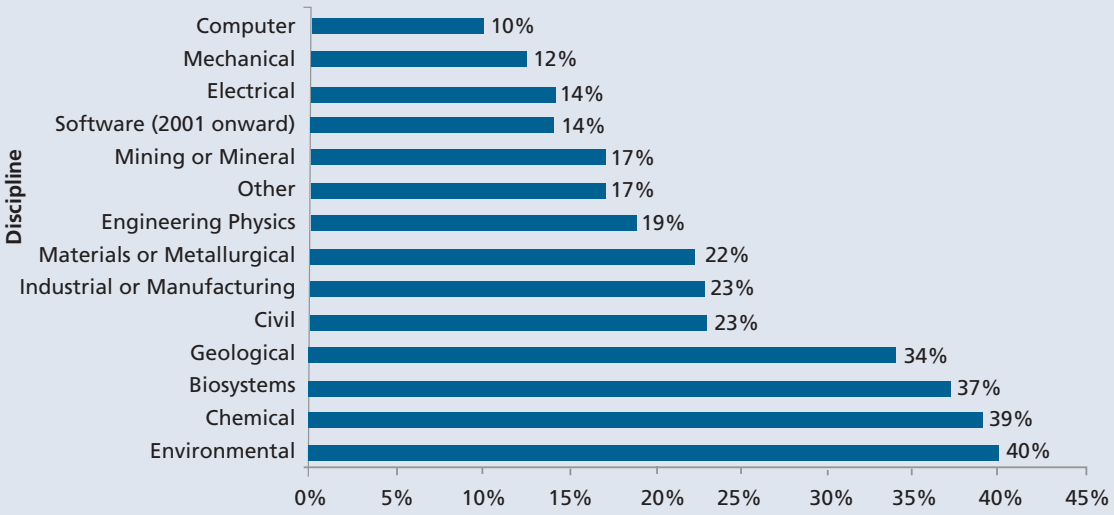
[17] Note: Survey results revealed that approximately, 91% of survey respondents indicated they intended to pursue postsecondary studies, 84% planned to attend university, 7% intended to attend community college/CEGEP, and nearly 10% were not certain of their postsecondary plans.

[18] Source: Student Survey, *The Role of Career Awareness in the Decision of Young Women to Take Math and Science Subjects*

The 6% of young women interested in pursuing a career in engineering should be interpreted with caution since one of the high schools that was included in the study is oriented to science and technical studies. Significantly, *young women in this study indicated that a biological or environmental dimension would make engineering studies and engineering careers more appealing*. Consistent with these comments from focus groups, data from Engineers Canada indicate that, on average, women make-up a greater percentage of Environmental, Chemical, and Biosystems Engineering classes, compared to other fields of engineering. See Figure No. 11 below.

> Engineering is appealing only if there is a little bit of Bio, like if it is Environmental because that seems like something I can connect with, because there seems to be so many environmental problems, with global warming and green house gases…"
>
> Focus Group Participant
> Calgary, Alberta

Figure No. 11
Average Share of Female Enrolment in Undergraduate Engineering by Discipline (1991 to 2007)[19]



Our study confirms that career interests of young women are strongly biased towards 'making a difference', 'working with people' and other forms of social engagement. Thus, those young women in our study who are interested in pursuing a career in engineering are attracted to these professions because they believe that these professions provide tangible benefits to society. They also viewed engineering professions as having high status, because the courses were perceived as difficult and challenging to complete. Conversely *those young women in our study who were not disposed to consider engineering careers perceived engineering professions as not being socially engaged and not having high status.*

> "Engineering is perceived as being isolated and male-dominated. People don't see it as a successful career option. They don't perceive it as something which directly helps people. They don't realize that engineers *do* help people by designing structures and machines, which help us function the way we do."
>
> Focus Group Participant
> Toronto, Ontario

[19] Data supplied by Engineers Canada

Part Four: Factors Affecting the Attitudes of Young Women towards Mathematics and Science and towards Careers in Engineering and Technology

Part Four investigates the factors that the study indicates contribute significantly to the career decisions of young women, and their perceptions of careers in engineering in particular. Below is a summary of the variables investigated.

1. Young women are streamed out of mathematics and the sciences.

Current Enrolments

Mathematics and science courses are the gateway to subsequent postsecondary studies in engineering. Enrolment in Grade 12-level Calculus can be a strong predictor of the likelihood that a young women going on to postsecondary studies will subsequently major in science and engineering rather than the liberal arts, social sciences, or business and commerce.[20]

This study found that enrolment rates in mathematics dropped moderately after Grade 10 and somewhat more so after Grade 12, but were still high (88.2%) at Grade 12. Enrolment in science subjects declined more significantly – to 68.6% in Grade 12. (It should be kept in mind that these results are biased by the inclusion of a high school that is focused on mathematics and science oriented students).

Figure No. 12
Current Enrolment in Secondary Mathematics and Science Courses, by Grade Level [21]

Currently Enrolled	Grade 9	Grade 10	Grade 11	Grade 12
% in Mathematics	84.4%	98.3%	96.6%	88.2%
% in Science	92.3%	99.1%	89.7%	68.6%

The principal reasons participants in our study offered for dropping mathematics and sciences courses were:

- lack of interest in the subject (or in the curriculum)
- marks in mathematics and science subjects were lower than desired; higher marks were achievable in other subjects
- intended college or university major does not require (or is not understood to require) upper level science or mathematics

[20] Ma, X., & Johnson, W. 2008. Mathematics as the critical filter: Curricular effects on gendered career choices. In H.M.G. Watt and J.S. Eccles (Eds.), *Gender and occupational outcomes* (pp. 55-83). Washington: American Psychological Association

[21] Source: Student Survey, *The Role of Career Awareness in the Decision of Young Women to Take Math and Science Subjects*

The downward enrolment trend in mathematics and science subjects reduces the potential pool of female candidates for admission to engineering programs and subsequently for entry into engineering occupations. Despite the decrease in enrolments, the survey results do indicate that a substantial proportion of young women – both the science and mathematics oriented school, and in the other schools - enrolled in upper level mathematics and science courses. The majority of teachers we interviewed validated the survey findings indicating that for mathematics and sciences (including pre-calculus, and calculus), physics, chemistry and biology, young women were approximately 50% of each class, and sometimes more. *The roughly equal distribution of young men to young women in general mathematics and science classes in upper high school implies that enrolment in mathematics and science courses alone is not the strongest predictor of whether young women will pursue engineering studies at a later date.*

In this study, *achievement in mathematics and science subjects also failed to play a significant role in predicting the likelihood of young women pursuing science and technology fields.* This is an important finding. Focus group participants in this study, self-reported being successful in their mathematics and science courses, a fact that was confirmed by their teachers. Achievement aside, participants in Grades 9 and 10 indicated that their intention to pursue mathematics and science is related to 'hearing from society' - and parents, in particular, that 'you need mathematics and science because you do not want to close any doors for yourself'. By Grades 11 and 12, the motivation for taking mathematics and science courses changes somewhat. In Grades 11 and 12, students reported continuing in mathematics and science streams because these courses are required for university or college admission and for their intended careers.

> "In engineering you only know it, if you look in a text book. In English and Social, you learn it, you read it, and you can apply it to your everyday. In physics, you look in a text book, you look at the answer, and you look at the calculator - and that's it."
>
> Focus Group Participant
> Calgary, Alberta

Many young women in this study reported that, despite their confidence in their mathematical skills, they neither enjoyed nor intended to pursue postsecondary studies with a heavy emphasis in mathematics. Mathematics was described as: 'boring', 'lacking in opportunities for creative and broad minded thinking' and 'not related or applicable to the everyday'.

Other studies validate these findings. For instance, the *attitude* of young women in Grades 11 and 12 towards mathematics was found to be a stronger predictor of the likelihood of women enrolling in advanced mathematics, compared to their *achievement* levels in mathematics.[22]

Overall, these findings imply that the majority of young women are not being streamed out of mathematics and science courses. Indeed, many young women are enrolling in mathematics and sciences courses because these are pre-requisites for postsecondary studies in the health sciences and, in the case of mathematics, for some of the social sciences.

[22] Ma, X. (1997). *A national assessment of mathematics participation in the United States: A survival analysis model for describing students' academic careers.* Lewiston, NY: Edwin Mellen.

2. Broad cultural factors account for gender preferences in academic interests and careers.

"In the Arts, it's your own interpretation of what you think, and you connect to it much easier. In engineering, its kind of hard for me to see how I can affect peoples lives, how can I make an impact, because life is only so short – and you want to do the best you can, for everybody, including yourself, so you are left thinking – how can I apply that to my job?"

Focus group participant
Calgary, Alberta

There is a large bloc of social theory that holds that women are socialized for nurturing or caring roles and that this subsequently affects their career choices. A large majority of young women in this study reported that they aspired to careers which they perceived as 'people oriented' and which would contribute to improving the welfare of others. Thus, *our focus group findings are broadly consistent with that large body of social theory that puts emphasis on the importance of 'working with people' and 'improving well-being' as determinants of career preferences on the part of young women. Women in our study who were attracted to engineering professions were drawn to these professions because they saw them in this light. Conversely, women who were not attracted to engineering professions were likely to characterize these professions as not involved in working with other people and not improving well-being. This has potentially important implications for how career information is communicated to young women.*

Female household responsibilities are perceived by young women in this study as outweighing those performed by men. Young women believe that this reduces the time they can dedicate to their careers. Teacher interviews from Quebec stood out from other provinces because of the consistent mention of cultural norms as a perceived paramount reason for fewer women in mathematics and science related occupations. Consistent with the views of teachers in Quebec, focus group participants in that province perceived that engineering and technology careers are likely to infringe on work-family balance and possibly limit the number of children a woman can raise. Curiously, the perception that engineering careers are inimical to work-family balance does not appear to carry over to health science careers. Again, it is important to stress, that this study is reporting perceptions. Reality may or may not be consistent with these perceptions.

"She doesn't have a big family – two kids max."

Focus Group Participant
Montreal, Quebec

3. Too few parents encourage their daughters to study mathematics and science and to consider engineering career options.

In this study, 55% of survey respondents had parents and relatives working in engineering occupations. However, only 6% of survey respondents indicated an interest in pursuing engineering studies. This is significantly lower than might be expected, given the high proportion of parents in engineering. Even more puzzling is that *there was no significant statistical relationship between having a parent or relative in engineering and*

"I was thinking about engineering…for me it was because of my dad - he's an engineer, I looked up to him, so I wanted to follow in his footsteps, but that dream kind-of died quickly…"

Focus Group Participant
Halifax, Nova Scotia

intention to pursue a career in engineering. Our focus groups revealed similar findings. Young women with parents or relatives in engineering or technology did not appear significantly more interested in pursuing engineering or technology studies than students without a parent or close relative in these fields. These are puzzling, but potentially important findings. On their face, *our results suggest that parental influence is an important factor in the decision to take mathematics and science subjects, but not nearly as important a factor in shaping career aspirations, at least in so far as engineering careers are concerned.* Our study offers no explanations for this paradox.

4. Peers are important influencers. For young women, peer influence encourages a negative attitude towards studying mathematics and science and towards entering engineering or technology programs at the postsecondary level.

Teachers and students alike generally reported that peers do not play a large part in career decision making, although, students are sometimes believed to select courses to be with friends, which is consistent with previous research.

"Girls are time-tabling together - I have one girl who is struggling in a class, but she wanted to be with her friends, so there she is."

Teacher Interview
Winnipeg, Manitoba

5. Male dominance of science and mathematics classes discourages young women from continuing in these subjects through to graduation.

"It's mostly guys; some girls can get intimidated by that. In my computer science class, it was only me and two other girls, so it was uncomfortable. I wasn't sure I wanted to continue after…"

Focus Group Participant
Winnipeg, Manitoba

In this study, mathematics and science classes were not significantly gender imbalanced. However, technology classes (e.g., IT) do reflect male dominance. Our study, therefore, does not support theories that male dominance in the classroom accounts for lower female participation in mathematics and science courses. *This may be a factor in technology courses, but does not appear to be a significant factor in mathematics and science subjects.*

6. There is a subtle, but significant, gender bias in science and mathematics curriculum materials that discourages young women from continuing in these subjects through to graduation.

In this study, a small minority of teachers believed that curriculum material in mathematics and science subjects conveyed a subtle gender bias. We did not, however, hear young women in our focus groups characterizing their course materials in this way. In any event, our study shows fairly high participation rates in mathe-

"The subjects are not taught in school enough with a female slant – in Grade 9 Science, the girls wanted to put stickers on the tool box, and have pink handles on the tools – and they won the competition – this should not be seen as a sacrilege to science…instead of talking about building a machine, build a telephone."

Teacher Interview
Calgary, Alberta

matics and science subjects, among the sample group. Clearly, whatever subtle biases there may be in the curriculum materials it was not having a significant effect on this group of women. Our study, therefore, provides no support for this theory.

7. Young women do not have a good understanding of what engineering and technology careers entail and therefore cannot aspire to those careers.

> "Everyone has been to the doctor at one time in their life, but how many of us have gone to an engineer's office, so they can build us a building?"
>
> Focus Group
> Montreal, Quebec

The majority of young women in this study reported very little or no knowledge concerning the roles and responsibilities of engineers, technicians and technologists. In contrast, young women, on average, reported being familiar with the roles and responsibilities of teachers, physicians, and nurses. This is not surprising, given the likelihood of direct contact with the latter occupations, as well as their portrayal in the media – a factor that also applies to lawyers. See Figure 13, below for a full listing of students' familiarity by occupation.[23]

Figure No. 13a
Familiarity with Selected Occupations among Young Women in Secondary School

Occupations	Knowledge Rating (%)				
	1 Very Little	2	3	4	5 A Great Deal
Accountant	12.5	16.1	24.7	28.5	18.2
Architect	15.2	23	28.7	20	13.1
Business Manager	13.1	17.6	28.7	24.7	15.9
Chemist	26.6	28.5	25.4	15.2	4.3
Computer Programmer	22	22.7	23.9	20.3	11.1
Doctor	6.2	8.1	21.1	26.4	38.2
Engineer	22.1	25.4	24.2	17.4	10.8
Engineering Technologist/Technician	30.3	28.9	22.5	12.3	5.9
Lawyer	9.4	12.5	24.8	32.8	20.5
Nurse	6.1	11.1	19.9	27.4	35.5
Physicist	31.5	30.6	24.6	10.2	3.1
Social Worker	12.2	19.6	28.9	21.8	17.5
Teacher	5.0	6.1	12.3	33.3	43.3

Figure No. 13b shows the weighted average level of awareness on this 1-5 scale for each of the occupations:

[23] Source: Student Survey, *The Role of Career Awareness in the Decision of Young Women to Take Math and Science Subjects*

Figure No. 13b
Familiarity with Selected Occupations among Young Women in Secondary School (Weighted Average)

1 = Very Little Awareness
5 = A Great Deal of Awareness

Selected Occupations	Weighted Average on 1-5 Scale
Teacher	4.0
Doctor	3.8
Nurse	3.7
Lawyer	3.4
Accountant	3.2
Business Manager	3.1
Social Worker	3.1
Architect	2.9
Computer Programmer	2.8
Engineer	2.7
Chemist	2.4
Engineering Technologist/Technician	2.3
Physicist	2.2

As can be seen from Figure Nos. 13a and 13b, engineering occupations rank significantly behind other selected occupations in terms of career awareness. *Almost 60% of young women report that they have very little or only a small amount of knowledge of engineering or technology occupations. This is a serious challenge for the professions*. An individual cannot aspire to a career that they know little about.

Sources of Information

Close Family and Friends

As noted earlier, 55% of young women in our survey reported having at least one parent or relative working in an engineering related occupation. In this study, *parents and relatives in the field were among the top sources of information for those articulating some knowledge regarding engineering occupations*. Young women in the focus groups who had knowledge of engineering occupations through parents and close relatives reported the following perceptions:

- good salaries
- strong employment demand in Western Canada
- male dominated
- opportunities to work in teams
- different fields of specialization
- risk of job instability relative to other occupations

While some of these parentally informed perceptions are clearly positive (e.g., good salaries and opportunities to work in teams), others are somewhat negative (e.g., demand in Western Canada which may require relocation or travel in order to be employed, male domination, and job instability).

Teachers

Teachers (and to some degree, guidance counsellors) also play important roles in providing career information either directly or by telling students where they can obtain this information. In this study, teachers were familiar with programs and initiatives aimed at facilitating interest and exposure to mathematics and science careers, although few of the programs targeted women. The following table summarizes the programs reported by teachers:

Figure No. 14
Programs and initiatives listed by teachers that facilitate interest and exposure to mathematics and science careers

Calgary	Winnipeg	Toronto	Montreal	Halifax
Alberta Heritage Foundation for Medical Research, CIRC, and Natural Sciences and Engineering Research Council of Canada fund first year university students to work in professors' labs for the summer	Canadian Armed Forces offers co-op placements	High school scholarships available for both men and women.	l'école polytechnique excursion reserved exclusively for girls	Dalhousie: Women in Science
The Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)	Spaghetti Bridge Competition at the Civil Engineering Department at Camosun College	National Engineering Week		
Heritage Youth Researcher Summer Program (HYRS)	High School Engineering Outreach Day is available twice a year and only for select students	Ontario Science Centre		
MINERVA Foundation mentors women with female scientists	First Robotics Competition	OSSPS scholarships (high school scholarship)		
Research Internships in Science and Engineering (RISE)	Job Fairs	Partnerships with the Information Communication and Technology Council, in which a guest speaker comes to high schools		
Sanofi-Aventis Biotech Challenge – matches students with university professors who mentor the student	Sanofi-Aventis BioTalent Challenge	Professional Engineers Ontario provides the 'Engineer in Residence' Program		
The Canadian Gene Cure Foundations provides the opportunity to become a gene researcher for a week	Shad Valley offers a four week summer enrichment program	University of Toronto offers promotional materials		
Women in Engineering through the University of Calgary hosts spring events	St. Bonifice Genera Hospital partners with the University of Manitoba	York university has different speakers available across disciplines for in-class presentations		
Women in scholarship, engineering, science and technology (WISEST) has 6 week summer projects for Grade 11 and 12 girls in science and engineering at University of Alberta	Women in Science and Engineering (WISE)			

All teachers in this study were motivated to encourage young women's interest in engineering. However, all teachers stressed that class hours are limited and that there are many demands on classroom time. Nevertheless, *the engineering professions should understand that they have important allies in mathematics and science teachers as channels for disseminating career information.*

> "I am supposed to expose kids to career opportunities, but the curriculum is so dense that career information is the first thing that is dropped."
>
> Teacher Interview
> < undisclosed location>

Professional and Industry Initiatives

National Engineering Month (formerly known as Engineering Week) and National Technology Week are among the most expansive professional and industry initiatives aimed at increasing awareness and understanding of engineering careers and the role of engineering and technology in Canadian society. These programs are nation-wide. They include local workshops, interactive events, media advertising, and competitions for different age groups. These events are excellent opportunities to expose more young women to engineering occupations and the impact engineers, technicians and technologists have on daily living. The activities are also a potential opportunity for young women to gain exposure to role models and to develop social networks. For example *Go Tech Girl* is an initiative between the National Council of Deans of Technology and the Canadian Council of Technicians and Technologists, for girls in Grade 7 to 11. This initiative conducts various activities during National Technology week.

> "Promote more, we just don't know enough about engineering to become interested in it."
>
> Focus Group Participant
> Toronto, Ontario

It is significant therefore that our survey results indicate that there is still a considerable distance to traverse in regard to fostering improved awareness of engineering careers. *Only 17% of young women at the mathematics and science-oriented high school reported knowledge of National Engineering Month, while only 11% reported knowledge of National Technology Week. In the other schools, only 8% of young women were aware of National Engineering Month and only 7% were aware of National Technology Week.*

Students reported that they were most likely to obtain information concerning engineering occupations from visiting websites (56%) and secondly from visiting colleges/CEGEPs or university campuses (55%). Having a parent or relative in an engineering occupation did not affect the likelihood of a young woman being aware of National Engineering Month or National Technology Week. Only 1 teacher out of 20 cited these events as important potential sources of career information.

> "I went to his work once, what he does is very complicated. Mostly he has to make sure no one fries any circuits because that is very expensive."
>
> Focus Group Participant
> Toronto, Ontario

In our survey, 40% *had* attended career awareness programs that provided information on science and technology careers. *Notwithstanding this comparatively high participation rate in science and technology career awareness, the survey evidence still suggests a significant lack of knowledge about engineering careers. Clearly there is a disconnect: much of the information is not reaching the intended recipients.*

These results should not be interpreted as diminishing the importance of career information. On the contrary, young women in our focus groups attached considerable importance to more informa-

tion on engineering careers. Compared to professions such as law and the health sciences, which are often portrayed in the media, the engineering professions are starting from behind and must struggle to catch up in the competition for career awareness.

8. Young women have negative perceptions of engineering and technology occupations.

This section describes the *perceptions* of engineering occupations that was communicated primarily through focus groups. By reporting these perceptions, we are not, in any way, suggesting that they are necessarily correct. However, it is important to understand how engineering and technology professions are perceived, if steps are to be taken to address current preference trends in academic studies and careers.

Creativity and Innovation

"There is a lot of creativity in engineering, and I guess you have to be a little bit artistic if you are going to design a building or a bridge."

Focus Group Participant
Halifax, Nova Scotia

Engineering and technology occupations are perceived as providing opportunities for innovation and creativity through design work. However, this is allied to *a perception that engineering and technology work is about buildings and machinery, not about people.*

Mathematics in Engineering Occupations

Young women in this study were more likely to report that mathematics was required for pursuing studies as an engineer or engineering technologist/technician (89% and 87% respectively) compared to studying medicine or nursing (71% and 60% respectively).The perception that engineering is more mathematically intensive was a significant disincentive to pursuing studies in these fields. Most survey respondents - even those intending to pursue engineering studies – regarded the mathematics intensity of these fields as a strong negative. A very small minority indicated their enjoyment of mathematics was a primary reason for their interest in engineering. Clearly engineering, technology and mathematics are intertwined. Students may or may not have an exaggerated view of the mathematics intensity of engineering and technology. Many tended to discount, or to be unaware of the need for team work skills, good communication skills, and creative thinking in engineering and technology careers. *The majority of young women in this study perceived mathematics as disconnected and asocial. In turn, they attributed these negative characteristics – being disconnected and asocial – to engineering and technology work.*

"I can do Calculus, but I don't want to be doing it all day for a career. I want to do something that leaves a mark on society, that makes a difference, that's why I like Genetics - you can help people."

Focus group participant
Winnipeg, Manitoba

"Some girls pursue biology because they don't think its going to involve a lot of math, but they don't know that in the later years it does."

Teacher Interview
Winnipeg, Manitoba

High Level of Responsibility

Engineering occupations were associated with high levels of responsibility, and perceived as potentially stressful as a result. Young women in this study strongly associated mathematics with engineering, and in-turn perceived that minor miscalculations could equate to disastrous design flaws leading to structural instability in buildings and bridges.

> Engineering is the type of work that carries too much responsibility. The smallest error could have large repercussions - this involves too much job-related stress."
>
> Focus Group Participant
> Montreal, Quebec

Machine Oriented

Students who did not have parents or close relatives working in engineering or technology understood careers in these fields almost entirely in terms of civil and mechanical engineering. The most frequent characterization of engineers was – "they build buildings, and bridges." This one branch of engineering was largely believed to encapsulate the entire field of engineering. Young women understood engineering as working with 'things' not people. Perceptions about technologists were much less defined.

When engineering was perceived as a corporate profession, the perception was of an individual working in a cubicle and relating chiefly to their computer. Similar perceptions apply to technology occupations. This perception goes against the desire to be socially engaged. Few individuals in the study were aware that the typical engineering career and many technology careers entail advancing into management functions. The majority of the study participants were not aware of how important project management is in many engineering jobs.

Those study participants who associated engineering work with the construction industry also associated this profession with outdoor work and physically vigorous work. This was perceived as a major negative by many women.

> "The last time, I went to a project, out in the oil fields, it made me more discouraged because I am not as strong and I am not as big as the guys, so if it is outdoor work for engineering, I am kind of iffy about that."
>
> Focus Group Participant
> Calgary, Alberta

Significantly, *participation in career awareness programs did not appear to alter the perception of engineering work as 'construction work' or 'cubicle work'*. This poses significant challenges to the design of future career awareness programs and materials.

Male Dominance in the Workplace

Discomfort with a male dominated environment and the consequent need to adapt were considered clear deterrents to pursuing engineering studies. Focus group participants' descriptions of female engineers, included attributes such as: serious, less emotional, excellent communicators, self-assured and strong-willed.

> "There is a perception that girls have to be strong, so they don't get pushed around by the guys."
>
> Focus Group Participant
> Calgary, Alberta

Status and Prestige

Young women in this study with little to no knowledge regarding engineering were more likely to associate engineering occupations with the construction industry and with the construction trades. As a result they did not, in general, attribute high status to engineering occupations.

> "Can be considered a blue-collar job not a white collar-job. I don't know the difference between engineers and construction workers."
>
> Focus Group Participant
> Calgary, Alberta

"If you are a doctor you have the title doctor, but not if you are an engineer."

Focus Group Participant
Calgary, Alberta

In this study, *participants seeking a career in the health sciences, specifically in medicine, reported that engineering occupations were below their career aspirations, in terms of societal status.*

9. Compared to young men, young women have fewer role models who encourage them to take mathematics and science courses and to consider engineering and technology careers.

"Because, we have such a strong, math, science department - seeing that we have a lot of female teachers here - that we see as successful happy people, that makes things sound exciting."

Focus Group Participant
Toronto, Ontario

Female role models can counter stereotypes, correct misperceptions and foster a sounder understanding of the many dimensions and facets of engineering and technology professions. *Both teachers and young women in this study stressed the rarity of female role models in career information programs.* This is clearly a challenge that the engineering professions can address. Equally important – although not a factor that the engineering professions can address – is the under-representation of women as science and mathematics teachers. It should be noted that *younger female professionals are seen as more persuasive role models and speakers than older female professionals.*

Part Five: Conclusion

This study investigated the contributing factors that motivate the educational and career choices of young women. The catalyst for this research is the continued gender imbalance in engineering programs, and in particular the recent declining female share of undergraduate enrolments in universities. It is important to understand the reasons women with the academic aptitude to excel in engineering choose otherwise, because severe gender imbalances in engineering occupations are symptomatic of barriers and perceptions, be they true or not, regarding the profession. In the aim of attracting and retaining top candidates it is in the self-interest of professional associations to be aware of the reasons behind career goals in order to make positive strides in recruiting and retaining more women into the engineering profession. Above and beyond employer benefits, society values fairness and equal opportunities for all individuals, and so when an imbalance occurs the need to investigate underlying reasons is prompted.

This study asked two questions regarding the factors contributing to educational and career choice:

First, what factors encourage or discourage women in high school to take the mathematics and science courses that are required for admission into engineering and technology programs?

The women in this study are not dropping-out of mathematics and science courses (88.2% and 68.6% are enrolled respectively, in Grade 12). Women continue to enrol in these courses in their senior year because of postsecondary requirements. Women are not being streamed out of mathematics and science.

Second, what factors encourage or discourage women in high school who have taken the mathematics and science courses that are required for admission into engineering and technology programs to subsequently pursue or not pursue engineering and technology studies at the university or college level?

Survey results, focus group discussions and teacher interviews provided useful insight into the factors that influence career choice, and specifically attitudes towards a career in engineering or technology. Our study found that women who did not want to pursue engineering, by and large were inclined to pursue careers in the health and social sciences. They believed these careers would be more people-oriented (less machinery and mathematics focused), more humanitarian, and would provide greater prestige relative to a career in engineering or technology. Women who were attracted to engineering and technology saw these professions as having a positive societal impact and significant status.

Overall, young women had little to no knowledge regarding careers in engineering and technology. Those with a parent or close relative in the field reported greater knowledge, but surprisingly, this greater knowledge did not translate into greater interest in pursuing engineering or technology careers. Our study also underscored a widespread perception that equates engineering with construction.

Figure No. 15 compares the findings of this study with the various explanations that have been offered to explain the low proportion of women who take mathematics and science through to graduation and who subsequently pursue engineering or technology at the postsecondary level.

Figure No. 15
Summary of findings regarding factors that shape the attitudes of young women towards mathematics and science and towards careers in engineering and technology

Potential Explanations Investigated	Do the Results of this Study provide Support for this Explanation?	Findings
1. Young women are streamed out of mathematics and science.	No support	Women are not being streamed out of mathematics and science courses in high school. By Grade 12, 88.2% in our sample were still enrolled in mathematics and 68.6% were still enrolled in sciences. However the majority report not enjoying mathematics, irrespective of academic achievement.
2. Broad cultural factors account for gender preferences in academic interests and careers.	Support	Consistent with this explanation, young women in this study were overwhelmingly drawn to health and social science fields of study. These fields were perceived as more people oriented and more socially engaged. Careers in these fields were also perceived as allowing a better work-life balance.
3. Too few parents encourage their daughters to study mathematics and science and to consider engineering and technology career options.	Partial support with a paradox	Parental influence is an important factor in the decision to take mathematics and science subjects. However, parental influence is not nearly as important a factor in shaping career aspirations, at least in so far as engineering and technology careers are concerned.
4. Peers are important influencers. For young women, peer influence encourages a negative attitude towards studying mathematics and science and towards entering engineering or technology programs at the postsecondary level.	No significant support	Peers were reported to slightly influence the likelihood of enrolling in mathematics and science courses however there was no evidence that peers influence career goals.
5. Male dominance of science and mathematics classes discourages young women from continuing these subjects through to graduation.	No support for science and mathematics courses. Some evidence for technology courses.	This may be a factor in technology courses, but was not a factor in mathematics and science courses, where young women tend to make-up 50% of class size in the schools where this study was conducted.
6. There is a subtle, but significant, gender bias in science and mathematics curriculum materials that discourages young women from continuing these subjects through to graduation.	No support	A small minority of teachers reported that material in mathematics and science courses conveyed a gender bias. However, this did not appear to influence enrolment in mathematics and science courses.
7. Young women do not have a good understanding of what engineering and technology careers entail and therefore cannot aspire to those careers.	Strong support with a paradox	A large majority of young women reported that they have very little or only a small amount of knowledge of engineering occupations. Only 12.5% and 9% had heard of Engineering Month and Technology Week respectively However, paradoxically more knowledge of engineering did not necessarily equate to greater intent in pursuing postsecondary studies in these fields.
8. Young women have negative perceptions of engineering and technology occupations.	Strong support	Although some young women perceive engineering and technology as providing opportunities to be creative and to work in teams, most equate engineering and technology (but especially engineering) with construction work, outdoor work, working in a cubicle, and relating primarily to computers and machines, rather than people. Lower status is attributed to engineering and technology occupations in comparison with the health and social sciences.
9. Compared to young men, young women have fewer role models who encourage them to take mathematics and science courses and to consider engineering and technology careers.	Strong support	Role models by way of high school teachers and industry professionals were viewed as extremely important by both teachers and young women.

The study suggests three areas in which the engineering and technology professions can contribute to changing the current gender pattern in postsecondary enrolments in engineering and technology.

First, it is clear from this study that a large majority of young women in high school – including those who pursue mathematics and science to graduation – have little or no knowledge about what engineering and technology careers entail. *National Engineering Month and National Technology* Week have not met the profession's goals in communicating knowledge about engineering and technology careers.

Second, it is also clear from this study that a large majority of young women in high school who have the mathematics and science prerequisites to enter university or college programs in engineering or technology have strongly negative perceptions about the engineering and technology occupations. These negative perceptions are more pronounced for engineering. *National Engineering Month and National Technology Week* have not countered these perceptions about engineering and technology careers.

Third, non-parental female role models play an important role in over-turning stereotypes. However, there is a dearth of such role models.

Based on these findings, it is recommended that:

1. Together with industry, the engineering and technology professions should carefully review career information and career promotion strategies. It may be appropriate to develop separate career information materials for young women. At the very least, career information materials need to deal more deliberately with the attributes that young women appear to seek in a career (social engagement, 'making a difference', creativity, working in teams). Career information material and career programs also needs to tackle negative perceptions.

2. The engineering and technology professions need to address the female role model deficit by considering a program that will bring young women in high school into contact with women in engineering and technology.

3. The provincial and territorial engineering and technology professional associations should initiate, where they have not already done so, career promotion strategies that are consistent with the findings of this study. Engineers Canada and the Canadian Council of Technicians and Technologists should operate as clearing houses for disseminating the results of these initiatives. Engineers Canada and the Canadian Council of Technicians and Technologists should consider annually or biennially publishing a survey of trends in enrolments that will identify progress, where it has been made, in addressing the gender imbalance in enrolments.

Appendix A: Focus Group Questions

- What math, science, and technology courses are you taking?
- If you are in Grade 9/10: are you planning to continue math, science, and technology courses through to Grade 12? If so, why? If not, why not?
- Are you planning to go to college or university? If so, what field do you currently think you would like to study?
- Have you thought about studying science, technology or engineering in college or university?
- What do you know about engineering and technology work? Can you give some examples of engineering team work? Where did you learn this?
- What is there about engineering and technology studies or work that interests you, if anything? What is there about engineering and technology studies or work that turns you off?
- What do other professions/careers offer that engineering appears not to offer?
- What do girls need to hear from the engineering profession if they are to take an interest in engineering?
- In your opinion why are women less likely to study engineering, science or technology?

Appendix B: Teacher Interview Questions

1. In your final year class, approximately what proportion of students are women? Has this changed over the past ten years?

2. In your view, why do a greater proportion of females than males drop math, science, and technology as they proceed through high school?

3. In accounting for gender differences in math and science enrolments in the final year of high school, how much weight would you attach to: (a) gender differences in career aspirations, (b) gender differences in subject matter abilities or affinities, (c) gender differences in parental influence, (d) cultural norms, (e) role models, other than family, (f) peer pressure (g) other factors?

4. Are you familiar with any career awareness programs that have influenced students (especially women) to continue studying math, science, and technology?

5. Are there particular challenges that women face in pursuing math, science, and technology studies that are not faced by men, or are not faced to the same degree?

6. What types of supports might encourage more women to continue math, science, and technology studies through to the completion of high school?

7. What types of supports might encourage more women in their final year of high school to pursue engineering or technology studies at the postsecondary level?

Appendix C: Student Survey

The Role of Career Awareness in the Decision of Young Women to Take Math and Science Subjects

Student Survey

The national associations representing professional engineers and certified technicians and technologists (Engineers Canada and Canadian Council of Technicians and Technologists) are conducting a study of the role of career awareness on the decision of young women to take math and science subjects.

Thank you for taking a few moments to complete this survey. All responses are anonymous and confidential.

If you have any questions about the survey, or about women in engineering and technology, please feel free to contact us and we would be happy to follow up.

1. About you:
   Age: _____
   Grade: _____
   Gender: ___ Male ___ Female
   Language(s) spoken at home: _____
   Province of residence: _____

2. Did you take any math courses *this year*?
   ___ Yes
   ___ No

If "yes", indicate which course(s): _____

3. Do you intend to take secondary level math courses *next year*?
   ___ Yes
   ___ No
   ___ Uncertain

If "yes", indicate which course(s): _____

4. Did you take any science courses *this year*?
   ___Yes
   ___ No

If "yes", indicate which course(s): _____

5. Do you intend to take secondary level science courses *next year*?

___ Yes
___ No
___ Uncertain

If "yes", indicate which course(s): _____

6. How would you rate your *interest* in these subjects on a scale from 1 to 5, where 1 is very low and 5 is very high?

	Interest 1=Very Low 5=Very High				
	1	**2**	**3**	**4**	**5**
Math	O	O	O	O	O
Physics	O	O	O	O	O
Biology	O	O	O	O	O
Chemistry	O	O	O	O	O
Other science (e.g., geology)	O	O	O	O	O
Information and communication technology (e.g., computer programming)	O	O	O	O	O
Business, economics	O	O	O	O	O
English	O	O	O	O	O
Other languages	O	O	O	O	O
History	O	O	O	O	O
Geography	O	O	O	O	O
Social studies (e.g., sociology, psychology)	O	O	O	O	O
Fine arts (e.g., art, music, theatre)	O	O	O	O	O
Technical studies (e.g. drafting, electronics)	O	O	O	O	O

7 (a). Do you have *older* brothers or sisters who are taking (or have completed) high school/secondary school math?

___ Yes
___ No
___ Don't know

7 (b). Do you have *older* brothers or sisters who are taking (or have completed) high school/secondary school science?

___ Yes
___ No
___ Don't know

8. Do you have a parent who completed high school/secondary school math or science?

___ Yes
___ No
___ Don't know

9 (a). Do you have a parent who attended college/CEGEP or university?

___Yes

___ No

___ Don't know

9 (b). Do you have a parent who studied math or science at college/CEGEP or university?

___ Yes

___ No

___ Don't know

10. Do you have a parent or relative who is in an engineering or technology occupation?

___ Yes

___ No

___ Don't know

11. On a scale from 1 to 5, how much would you say you know about each of the following occupations (where 1 is very little and 5 is a great deal)?

	Knowledge of Occupation 1=Little Knowledge 2=Great Deal of Knowledge				
	1	**2**	**3**	**4**	**5**
Chemist	O	O	O	O	O
Physicist	O	O	O	O	O
Engineer (any type)	O	O	O	O	O
Engineering Technologist/Technician (any type)	O	O	O	O	O
Computer Programmer	O	O	O	O	O
Lawyer	O	O	O	O	O
Business Manager	O	O	O	O	O
Teacher	O	O	O	O	O
Nurse	O	O	O	O	O
Doctor	O	O	O	O	O
Accountant	O	O	O	O	O
Architect	O	O	O	O	O
Social worker	O	O	O	O	O

12. As far as you know, which of the following occupations require completion of high school math and/or science?

	Math	Physics	Chemistry	Biology	Math/Science Not Required
Chemist	O	O	O	O	O
Physicist	O	O	O	O	O
Engineer	O	O	O	O	O
Engineering Technologist/Technician	O	O	O	O	O
Computer Programmer	O	O	O	O	O
Lawyer	O	O	O	O	O
Business Manager	O	O	O	O	O
Nurse	O	O	O	O	O
Doctor	O	O	O	O	O
Accountant	O	O	O	O	O
Architect	O	O	O	O	O
Social Worker	O	O	O	O	O

13. When you finish high school, are you planning to attend:

___ Community college/CEGEP
___ University
___ Neither community college nor university
___ Don`t know/not sure

14. If you are planning to attend college/CEGEP or university, what field are you thinking about studying?

15. What career are you currently thinking about pursuing? _____

16. Have you visited a college/CEGEP or university campus? ___ Yes ___ No

17. Have you visited a college/CEGEP or university science lab? ___ Yes ___ No

18. Have you participated in any career awareness programs that provided you with information on science and technology careers? ___ Yes ___ No

19. Have you visited any websites that provided you with information about science or technology careers? ___ Yes ___ No

20. Have you had a summer job or part-time job where you met engineers or other technology professionals at work? ___ Yes ___ No

21. Do you recall seeing information about *National Engineering Week*? ___ Yes ___ No

22. Do you recall seeing information about National Technology Week? ___ Yes ___ No

Thank You For Your Participation!

Appendix D
Steering Committee

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