GENDER BIAS TOWARDS ENGINEERING CAREERS: DOES IT STILL EXIST?

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Abstract *– Since the 1980's, the enrollment of women in engineering programs has more than doubled, from less than 8% to over 20%, yet the recent number show a leveling off, and in some universities, a decline. Why are there still so few women indicating a desire to investigate engineering as a career choice? Our study reviews whether female students are as aware of engineering as their male counterparts, investigates whether factors such as having an engineer in their immediate family or type of schooling (all-girl versus co-educational) influence the thinking of girls towards a male dominated field such as engineering, and shows the impact of our Discover Engineering High School Workshops on interest in pursuing engineering as a career.*

Index Terms – High School Outreach, K-12 Programs, Women in Engineering, Pre-college Programs.

INTRODUCTION

Enrollment statistics from the Canadian Council of Professional Engineers (CCPE) show a leveling off of the growth rate for women enrolled in engineering programs, near the 20% mark, during the late 1990's [1] [2].

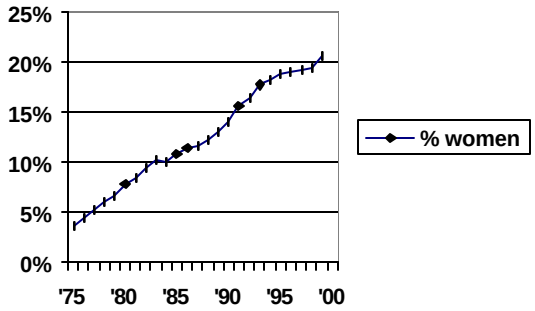

FIGURE 1
PERCENTAGE OF WOMEN ENROLLED IN UNDERGRADUATE ENGINEERING PROGRAMS IN CANADA (1975 – 1999)

Many studies have been undertaken to try to determine why so few women become engineers. Many factors have been cited including; streaming out of math and science courses, perception of difficulty, lack of exposure to role models, lack of knowledge about engineering and the social status of the profession [2] [3] [4]. Our study reviews a number of these factors and through the use of questionnaires, investigates the effect of these factors on the students participating.

Studies have also shown that simply knowing about engineering fields is not enough to attract young women into thinking about them as career choices, hands-on/brains-on activities are required to captures their interest [5]. Our study will show the effect of the Discover Engineering High School Workshop program on students' interest in pursuing engineering as a career.

BACKGROUND

In 1989, Ryerson University established the Women in Engineering Committee. The mandate of the committee was to develop strategies to increase the participation rate of young women in engineering programs in general, and at Ryerson in particular. The Committee's first initiative, the Discover Engineering Summer Camp, was launched in 1991 and several other programs followed [3] [4] [6]-[8].

The main objective of Discover Engineering is to provide education to students, especially young women, about engineering and to show them that it can be a viable career choice. This objective is achieved through involvement in hands-on activities, exposure to undergraduate engineering students, instruction by female science and engineering faculty and staff, and panel discussions with female professional engineers.

The main outcome is to increase awareness about the many facets of engineering and hopefully to convince some of the students to pursue engineering as a career.

Discover Engineering High School Workshop Program

The high school workshop program was initiated in September 1999 as an extension to the summer camp. The goal of this initiative is to raise awareness about careers in engineering among all high school students. This means that the program is offered in a co-ed classroom environment and not just to female students. However, the use of female presenters (faculty, staff and engineering students) provides strong positive role models for the young women. As well, this helps change stereotypical perceptions of engineers, held by both male and female students in the audience.

Each workshop begins with a 15-20 minute discussion about what engineering is, how it applies to our daily lives,

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and about opportunities in engineering. After the discussion, a hands-on activity takes place followed by a question and workshop evaluation period. Duration of workshops are tailored to the school's schedule, and typically run for 70-80 minutes.

The workshops are presented in schools across the Greater Toronto Area (population 4.68 million), for Grade 9-13 audiences. The workshops are provided at no cost to the schools.

Two activity modules are available for the teachers to choose from and each module addresses problem-solving, teamwork, communication skills, project development, budgeting, design and project testing.

Because the workshop program is offered to both male and female students, it has allowed us to survey the students about their knowledge of engineering before and after they participate in the workshop, and has also allowed us to compare the affect of the workshops on both the male and female students to see whether the traditional gender bias toward this male-dominated career choice still exists.

RESULTS OF PRE- AND POST-WORKSHOP SURVEYS

Through the use of questionnaires and evaluations, we were able to survey the students about their knowledge of engineering before and after participating, and assess the impact of our program on their interest in pursuing engineering as a career.

The Discover Engineering High School Workshop 2000/2001 participants included almost 1200 students from 20 different high schools in the Greater Toronto Area (GTA). Although racial information was not collected, the student population reflects the overall population of the GTA, which includes 20 different ethnic origins and one-third visible minorities [9]. The gender ratio was 48% male to 52% female students. Of the female students, two-thirds attended co-ed schools and one-third attended all-girl schools. Of the total students, almost half were at the Grade 10 level and one-third had one or more engineers in their immediate family. Comparisons were done using Chi-square tests, and levels of significance were set for $p<0.001$, $p<0.01$ and $p<0.05$.

Knowledge of engineering prior to Discover Engineering High School Workshops

Career options in engineering are not well known to most adults, let alone teenagers, and are not well represented in high school curricula or through career guidance counselling [3] [4].

Prior to the workshop presentation the students completed a pre-program questionnaire, which included asking them to describe what an engineer does. Students were allowed to indicate 'not sure'. The descriptions were reviewed by a Research Assistant with the Women in Engineering Office, and scored as 'not sure', 'incorrect description', or 'correct description'.

Less than one-third of the workshop participants were able to correctly describe engineering or what an engineer does.

Almost half of the students were 'not sure' what an engineer does, and almost 20% of the students wrote an incorrect description.

The most common incorrect description given was that an engineer *"fixes things"*. This description was deemed to be too vague. Other examples of incorrect descriptions: *"I think an engineer is a person who works with engines"*. *"I think they fix things like cars"*.

The most common correct description given was that *"engineers design and build things"*. Other examples of correct descriptions: *"An engineer designs things and puts them together to make them work"*. *"An engineer comes up with innovative ideas and solves problems"*.

Male students were more confident in venturing an answer, but not necessarily more knowledgeable. Although fewer male students indicated 'not sure', they also gave more incorrect answers. Female students were less confident in putting forth their ideas, with over half indicating 'not sure'. These responses were not surprising, as research has shown that female students indicate both lower interest and perceived ability than their male classmates in areas such as computer science, engineering and physics [10] [11].

TABLE I
KNOWLEDGE OF ENGINEERING, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (COMPARED BY GENDER)*

Description of engineering	Not Sure	Incorrect	Correct
Total Males & Females, n=1183	49%	19%	32%
Males, n=569	43%	22%	35%
Females, n=614	54%	17%	29%

* Chi-square results are statistically significant ($p<0.001$)

When the students attending all-girl schools were compared to the female students from co-ed schools, the level of knowledge and response patterns were almost exactly the same. This was surprising as education equity literature has often suggested that girls in all-girl schools do not have the same self esteem problems in their teen years as girls in co-ed situations. Although there is conflicting evidence about single-sex education, there is a general perception that girls fare better in math and science in all-girl environments [7] [8] [12]. Based on these theories we expected to see fewer 'not sure' answers from the all-girl students, as they should be more inclined to attempt to give a description.

TABLE II
KNOWLEDGE OF ENGINEERING, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (CO-ED VS. ALL-GIRL SCHOOLS)*

Description of engineering	Not Sure	Incorrect	Correct
Total Females, n=614	54%	17%	29%
Co-ed Females, n=405	54%	17%	29%
All-girl Females, n=209	55%	14%	31%

* Chi-square results are statistically significant ($p<0.01$)

When reviewed by grade, senior students were only slightly more knowledgeable than junior students, indicating that information about engineering is not improving in the curriculum at any level.

TABLE III
KNOWLEDGE OF ENGINEERING, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (FEMALE STUDENTS, BY GRADE)

Description of engineering	Not Sure	Incorrect	Correct
Total Females, n=614	54%	17%	29%
Gr.9 Females, n=84	52%	17%	31%
Gr.10 Females, n=308	59%	16%	25%
Gr.11 Females, n=136	51%	19%	30%
Gr.12 Females, n=68	43%	13%	44%
Gr.13 Females, n=18	55%	17%	28%

When the female students who had one or more engineers in their immediate family were compared to the female students with no engineer in their family, the level of knowledge was substantially higher with an engineer in the family (41%) than without (24%). This was not surprising since exposure to role models is a key element in gaining knowledge about any career choice. There was little difference in the level of knowledge when the engineer in the family was female (F Eng) versus male (M Eng). This would indicate that any engineering role model provides adequate information about the profession.

TABLE IV
KNOWLEDGE OF ENGINEERING, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (FEMALE STUDENTS, ENGINEER IN FAMILY)

Description of engineering	Not Sure	Incorrect	Correct
Total Females, n=614	54%	17%	29%
Females no Eng, n=413	59%	17%	24%
Females 1+ Eng, n=187	43%	16%	41%
Females 1-2 F Eng, n=30	47%	10%	43%
Females 1-2 M Eng, n=146	43%	17%	40%

Interest in pursuing engineering as a career prior to Discover Engineering High School Workshops

Prior to the workshop presentation the students were asked if they were interested in becoming an engineer. Overall, almost half of the male students were interested, yet less than 20% of the female students were interested in becoming engineers. This indicates that there still exists a gender bias by female students against engineering careers.

TABLE V
INTEREST IN PURSUING ENGINEERING AS A CAREER, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (ALL PARTICIPANTS)*

Interested in pursuing engineering	Yes	Probably	So-So	Not Likely	No
Total M & F, n=1197	16%	14%	30%	21%	19%
Males, n=574	27%	19%	30%	13%	11%
Females, n=623	5%	11%	30%	28%	26%

* Chi-square results are statistically significant ($p<0.001$)

To investigate whether a lack of knowledge about engineering was contributing to the low level of interest, the students with knowledge about engineering (those who correctly described engineering) were reviewed separately. We found that the interest level among students with knowledge about engineering was only slightly higher than the general population. Only half of the male students and less than one-quarter of the female students with knowledge of engineering were interested in pursuing it as a career. This indicates that it is not simply a lack of knowledge about engineering that is acting as a barrier, other factors must be contributing to the low interest among female students.

TABLE VI
INTEREST IN PURSUING ENGINEERING AS A CAREER, PRIOR TO WORKSHOPS (STUDENTS WHO KNEW WHAT ENGINEERING WAS)*

Interested in pursuing engineering	Yes	Probably	So-So	Not Likely	No
Total M & F, n=381	21%	15%	30%	18%	16%
Males, n=202	34%	15%	30%	12%	9%
Females, n=179	7%	16%	30%	23%	24%

* Chi-square results are statistically significant ($p<0.001$)

Again, when the students attending all-girl schools were compared to the female students from co-ed schools, the interest level was equal. As before, this was not expected based on traditional education equity theories.

TABLE VII
INTEREST IN PURSUING ENGINEERING AS A CAREER, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (CO-ED VS. ALL GIRL SCHOOLS)*

Interested in pursuing engineering	Yes	Probably	So-So	Not Likely	No
Total Females, n=623	5%	11%	30%	28%	26%
Co-ed Females, n=414	5%	11%	28%	27%	29%
All-girl Females, n=209	6%	10%	33%	31%	20%

* Chi-square results are statistically significant ($p<0.001$)

When reviewed by grade, senior students were only slightly more interested than junior students.

TABLE VIII
INTEREST IN PURSUING ENGINEERING AS A CAREER, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (FEMALE STUDENTS, BY GRADE)*

Interested in pursuing engineering	Yes	Probably	So-So	Not Likely	No
Total Females, n=623	5%	11%	30%	28%	26%
Gr.9 Females, n=87	3%	15%	31%	23%	28%
Gr.10 Females, n=309	5%	9%	28%	29%	29%
Gr.11 Females, n=138	7%	11%	33%	28%	21%
Gr.12 Females, n=70	6%	13%	35%	29%	17%
Gr.13 Females, n=19	11%	5%	21%	42%	21%

* Chi-square results are statistically significant ($p<0.05$)

When the female students who had one or more engineers in their immediate family were compared to the female students with no engineer, the level of interest in pursuing engineering was double with an engineer (24%) than without (12%). This is not surprising, as literature suggests that women who pursue engineering as a career have support for that choice in their immediate family [2] [13]. To see if the gender of the engineer in the family had any affect on the interest level of the female students, the data was further reviewed. Female students with female engineers (F Eng) in

their family were considerably more interested (40%) than female students with male engineers (M Eng) in their family (22%). This reinforces the importance of female role models in career choice by female students [3] [4].

TABLE IX
INTEREST IN PURSUING ENGINEERING AS A CAREER, PRIOR TO DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS (FEMALES, ENGINEER IN FAMILY)

Interested in pursuing engineering	Yes	Probably	So-So	Not Likely	No
Total Females, n=609	5%	11%	30%	28%	26%
Females no Eng, n=421	4%	8%	31%	31%	26%
Females 1+ Eng, n=187	8%	16%	27%	23%	26%
Females 1-2 F Eng, n=30	17%	23%	13%	30%	17%
Females 1-2 M Eng, n=147	7%	15%	29%	22%	27%

Impact of Discover Engineering High School Workshop program

After participating in the workshops, the students completed a post-program evaluation. This allowed us to assess the impact of the program on the students' knowledge of engineering and interest in pursuing engineering as a career.

Seventy-five percent of the students indicated that the program increased their knowledge about engineering and over 40% indicated that the program increased their interest in pursuing engineering as a career.

For male students, over 70% indicated that the program increased their knowledge about engineering and over 50% indicated that the program increased their interest in pursuing engineering as a career.

For female students, 80% indicated that the program increased their knowledge about engineering and almost 40% indicated that the program increased their interest in pursuing engineering as a career.

TABLE X
IMPACT OF DISCOVER ENGINEERING HIGH SCHOOL WORKSHOPS ON KNOWLEDGE AND INTERE ST IN PURSUING (COMPARED BY GENDER)

Impact of workshops	Increased knowledge	Increased interest
Total M & F, n=1152	75%	44%
Males, n=532	71%	51%
Females, n=620	80%	38%

* Chi-square results are statistically significant ($p<0.001$)

When the students attending all-girl schools were compared to the female students from co-ed schools, we found that the impact was even higher among students at all-girl schools. This was a bit of a surprise since prior to the workshops the female students from both school systems were responding in the same manner.

TABLE XI
IMPACT OF WORKSHOPS ON KNOWLEDGE OF ENGINEERING AND INTEREST IN PURSUING ENGINEERING AS A CAREER (CO-ED VS. ALL-GIRL SCHOOLS)

Impact of workshops	Increased knowledge	Increased interest
Total Females, n=620	80%	38%
Co-ed Females, n=407	76%	34%
All-girl Females, n=213	87%	47%

When reviewed by grade, there was no significant difference between the junior students and senior students. This shows that the workshops are equally effective in the senior classes as in the junior classes.

TABLE XII
IMPACT OF WORKSHOPS ON KNOWLEDGE OF ENGINEERING AND INTEREST IN PURSUING ENGINEERING AS A CAREER (FEMALE STDENTS, BY GRADE)

Impact of workshops	Increased knowledge	Increased interest
Total Females, n=620	80%	38%
Gr.9 Females, n=97	74%	38%
Gr.10 Females, n=318	82%	35%
Gr.11 Females, n=131	76%	47%
Gr.12 Females, n=72	80%	36%
Gr.13 Females, n=2*	100%*	100%*

* The number of female Gr.13 students who filled out post-workshop evaluations was significantly less (n=2) than the number who filled out pre-workshop questionnaires (n=19).

In order to assess the potential effect of the workshop program on future engineering enrollments, interest in pursuing engineering before and after the workshops was directly compared.

While there was a small increase in interest by male students, the interest level more than doubled from less than 20% to almost 40% for female students. This reinforces the theory that misconceptions about the true nature of engineering still act as barriers preventing women from considering such a career [3] [8]. Once students become aware of the broad range of engineering fields, they become more interested.

TABLE XIII
COMPARISON OF INTEREST IN PURSUING ENGINEERING AS A CAREER, BEFORE AND AFTER WORKSHOPS (COMPARED BY GENDER)

Interest in pursuing engineering	Pre-workshop	Post-workshop	Increase
Total Males & Females	31%	44%	+13%
Males	46%	51%	+5%
Females	16%	38%	+22%

When the students attending all-girl schools were compared to the female students from co-ed schools, the increase in interest was even higher among students from all-girl schools, with almost half of the students interested after participating in the workshop. This increase brought the level of interest in line with that of the male students.

TABLE XIV
COMPARISON OF INTEREST IN PURSUING ENGINEERING AS A CAREER, BEFORE AND AFTER WORKSHOPS (CO-ED VS. ALL-GIRL SCHOOLS)

Interest in pursuing engineering	Pre-workshop	Post-workshop	Increase
Total Females	16%	38%	+22%
Co-ed Females	16%	34%	+18%
All-girl Females	16%	47%	+31%

When reviewed by grade, there was no significant difference between the junior students and senior students.

TABLE XV
COMPARISON OF INTEREST IN PURSUING ENGINEERING AS A CAREER, BEFORE AND AFTER WORKSHOPS (FEMALE STUDENTS, BY GRADE)

Interest in pursuing engineering	Pre-workshop	Post-workshop	Increase
Total Females	16%	38%	+22%
Gr.9 Females	18%	38%	+20%
Gr.10 Females	14%	35%%	+21%
Gr.11 Females	18%	47%	+29%
Gr.12 Females	19%	36%	+17%
Gr.13 Females*	16%	100%*	N/A

* The number of female Gr.13 students who filled out post-workshop evaluations was significantly less (n=2) than the number who filled out pre-workshop questionnaires (n=19).

SUMMARY

Our study has shown that while female students have the same level of knowledge about engineering as their male counterparts, their interest in pursuing engineering as a career is initially much lower.

We also found that female students in a co-ed learning environment are initially no more biased against engineering careers than female students attending all-girl schools.

Our study found that having an engineer in their immediate family had a significant influence on the students' knowledge about engineering, even more so when the engineer was female. Having an engineer in the family also had a significant influence on interest in pursuing engineering as a career, and once again a female role model provided the greatest influence.

Grade level was found to have little to no effect on knowledge about engineering or interest in pursuing engineering as a career.

Participation in outreach programs, such as Discover Engineering, was found to significantly increase the female students' interest in pursuing engineering as a career, and in an all-girl enviroment can bring the level of interest in line with the values for the male students.

The potential effect of the workshop program on future engineering enrollments is also significant. With almost 1200 students participating in the 2000/2001 program, more than 500 students indicated that they would consider pursuing engineering, with 150 of them becoming interested due directly to participation in the workshop program.

When reviewed by gender, there was a small increase in interest by male students, while the interest level more than doubled for female students. Based on the number of students participating in the 2000/2001 program, there were an additional 15 male and 135 female students interested in pursuing engineering due directly to participation in the workshop program.

CONCLUSION

While there still exists an initial gender bias against pursuing engineering as a career, female engineering role models and outreach programs can significantly increase the interest in engineering among female students.

While it is still too early to tell the actual increases in engineering enrollment due to the Discover Engineering High School Workshops, the numbers indicate a positive contribution that the Women in Engineering Committee at Ryerson is making towards its stated goal of recruiting women into engineering programs.

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