

Bringing engineering to K-12 classrooms – Initiatives and Results

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Abstract

Since 1989, the Women in Engineering Committee at Ryerson University has been developing strategies to increase the participation rate of young women in engineering at Ryerson. The Discover Engineering Summer Camp was launched in 1991, as a day camp targeting female students in grades 10 to 12. The aim of the camp was to introduce engineering concepts to young women through hands-on and creative activities. In 1999, the committee launched the Discover Engineering High School Workshop program with a goal to raise awareness about careers in engineering among all high school students. The High School Workshop program brings Discover Engineering directly to the classroom, and is offered in a co-ed classroom environment - not just to female students. This new initiative has allowed us to disseminate our information to a wider audience and to survey the high school students about their knowledge of and interest in engineering before and after participating in our programs. We also were able to study how role models within the family influenced their choices.

Our study found that the existing level of knowledge about engineering was low; over half of the students were 'not sure' what an engineer does and less than one-third could correctly describe engineering prior to the Discover Engineering Workshop program. Furthermore, less than one-third of the students were interested in becoming engineers, and although almost half of the male students were interested, less than one-quarter of the female students would consider pursuing engineering as a career. An equal percent of males and females cited family/parents as influencing their decision about career choice, yet the female students were more likely to be interested in engineering when there was an engineer already in their family - especially if the engineer was female.

This paper describes the initiatives undertaken by Ryerson's Women in Engineering Committee and reports on the effect of the outreach program on students' knowledge about engineering and interest in pursuing engineering as a career.

Introduction

While women account for over 50% of the population and 55% of students enrolled in Canadian universities, only 20% of students enrolled in Canadian engineering programs are women^{1,2}.

Enrollment statistics from the Canadian Council of Professional Engineers (CCPE) show that the enrollment of women in Canadian engineering programs has quadrupled since 1975 (the first

year that the statistics were recorded) when less than 5% of students in engineering programs were women. However, engineering has not made the same advances as other traditionally male dominated fields such as medicine and law, which have both achieved equal representation^{3,4}.

Many studies have been undertaken to try to determine why so few women wish to 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 profession⁵⁻⁷. Our study reviews a number of these factors and through the use of questionnaires, investigates the effects 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 capture their interest⁸. 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 has recently been expanded to include a one-day career conference on campus and workshops presented directly in high school classrooms^{6,7,9-17}.

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 consider engineering as a career.

Discover Engineering High School Workshop Program

Ryerson initiated the high school workshop program in 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 is achieved by offering the program 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 in the class and helps change the stereotypical perceptions of engineers, held by both the 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, and about opportunities in engineering. After the discussion, a hands-on activity takes place followed by a question-and-answer period and workshop evaluation.

Duration of the workshops are tailored to the school's schedule, and typically run for 70 minutes. The workshops are currently funded through a government grant¹⁸ and 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, construction and project testing.

By bringing Discover Engineering directly to high school classrooms we have been able to reach many more students than previously with the summer camp alone.

Well over 1000 students benefit from Discover Engineering each year, with over 1000 participating in high school workshops, 120 students attending the summer camp and 100 attending the career conference annually. Since launching the Discover Engineering High School Workshop program in 1999, over 4000 high school students have participated in this program alone.

Survey of Students' Knowledge and Interest in Engineering

Through the use of pre-workshop questionnaires and post-workshop 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. We were also able to survey the students on whether they had an engineer in their immediate family and new for the 2001/2002 study we surveyed the students about influences on their future career choice.

Because the workshop 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 responses from the male and female students.

The 2001/2002 study involved over 1000 students from 20 high schools in the Greater Toronto Area (GTA). The gender ration was 46% male to 54% female students, and over half of the students were in Grade 10.

Table 1
Students participating in the 2001/2002 study (by gender)

Grade	Grade 9	Grade 10	Grade 11	Grade 12	Grade 13
Total Males & Females, n=1074	8%	56%	27%	6%	3%
Males, n=498	11%	45%	35%	6%	3%
Females, n=576	5%	65%	20%	6%	4%

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 counseling^{6,7}.

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 answer ‘not sure’. The descriptions were reviewed and scored as ‘not sure’, ‘incorrect description’, or ‘correct description’.

Over half of the students were ‘not sure’ what an engineer does, and less than one-third could correctly describe engineering. Examples of correct descriptions are ‘engineers use math and science to make calculations needed to design, build, repair...’ and ‘an engineer is the ‘brain’ behind most of the technology out there today, they design, manufacture and test’. Examples of incorrect descriptions are that an engineer ‘works with computers and stuff’ and ‘fixes things’.

Overall, there was no significant difference in knowledge about engineering between the male students (33%) and their female classmates (29%). 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 almost 60% 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^{19,20}.

Table 2

Knowledge of engineering, prior to Discover Engineering High School Workshops (by gender)*

Description of engineering	Not Sure	Incorrect	Correct
Total Males & Females, n=1068	52%	17%	31%
Males, n=495	46%	21%	33%
Females, n=573	58%	13%	29%

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

Students who had one or more engineer (1+ Eng) in their family were more knowledgeable about engineering than the students without an engineer (No Eng) in the family. This was not a surprise since exposure to role models is a key element in gaining knowledge about any career choice.

Table 3

Knowledge of engineering, prior to Discover Engineering High School Workshops (engineer in family)

Description of engineering	Not Sure	Incorrect	Correct
Total students, n=1062	52%	17%	31%
No Eng in family, n=688	55%	17%	28%
1+ Eng in family, n=374	46%	17%	37%

Interest in pursuing engineering careers, prior to Discover Engineering High School Workshops

Prior to the workshop presentation the students were asked if they were interested in becoming an engineer. There was a significant difference between the responses from the male students versus the female students in the class. Overall, almost half the male students were interested, yet only 15% of the female students were interested in becoming engineers. This indicates that there is still an initial gender bias by female students against engineering careers.

Table 4

Interest in pursuing engineering as a career, prior to Discover Engineering High School Workshops (by gender)*

Interested in pursuing engineering	Yes	Probably	So-so	Not Likely	No
Total Males & Females, n=1073	15%	14%	28%	22%	21%
Males, n=497	23%	22%	28%	16%	11%
Females, n=576	8%	8%	28%	27%	29%

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

To investigate whether lack of knowledge about engineering was contributing to the low level of interest among women, the students with knowledge about engineering (those who correctly described engineering) were reviewed separately. We found that the interest level was much higher among students with knowledge about engineering (39%) than among the general population (29%). For male students the interest level increased to over half, but still less than one-quarter of the female students were interested in pursuing it as a career. This indicates that it is not just 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 5

Interest in pursuing engineering as a career, prior to Discover Engineering High School Workshops (students who knew what engineering was)*

Interested in pursuing engineering	Yes	Probably	So-so	Not Likely	No
Total Males & Females, n=330	24%	15%	23%	24%	14%
Males, n=163	34%	22%	22%	17%	5%
Females, n=167	14%	9%	25%	30%	22%

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

When students with one or more engineers (1+ Eng) in their immediate family were compared to students with no engineer (No Eng), the level of interest in pursuing engineering was much higher with an engineer (37%) than without (25%).

Table 6

Interest in pursuing engineering as a career, prior to Discover Engineering High School Workshops (engineer in family)

Interested in pursuing engineering	Yes	Probably	So-so	Not Likely	No
Total students, n=1073	24%	15%	23%	24%	14%
No Eng in family, n=690	12%	13%	28%	23%	24%
1+ Eng in family, n=376	21%	16%	27%	21%	15%

To see if this was also the case for the female students, the data was further reviewed. When female students with one or more engineers in their immediate family (1+ Eng) were compared to students with no engineer, the level of interest in pursuing engineering was more than double with an engineer (24%) than without (10%). In fact, female students with female engineers in their family (1+ F-Eng) were twice as interested in pursuing engineering (38%) than female students with male engineers (1+ M-Eng) in the family (19%). This reinforces the importance of female role models in career choice by female students^{6,7}.

Table 7

Interest in pursuing engineering as a career, prior to Discover Engineering High School Workshops (female students, engineer in family)

Interested in pursuing engineering	Yes	Probably	So-so	Not Likely	No
Total Female students, n=576	8%	8%	28%	27%	29%
Female students, no Eng, n=362	4%	6%	29%	28%	33%
Females, 1+ Eng, n=210	13%	11%	26%	27%	23%
Females, 1+ M-Eng, n=25	10%	9%	25%	30%	26%
Females, 1+ F-Eng, n=32	19%	19%	34%	13%	15%

Influences on the Career Choices of High School Students

Since having engineers in the family appeared to influence students' interest in engineering, they were also asked to indicate who is the major influence on their career decisions. Almost half of the students indicated that 'family/parents' had the most influence on their future career. When reviewed by gender, significantly more female students (54%) than male students (43%) chose family/parents.

Table 8

'Most influence' on students' future career choice (by gender)

Most influence	Guidance	Teachers	Friends	Family/parents	Media	Other
Total Males & Females, n=1071	4%	5%	7%	49%	12%	23%
Males, n=498	4%	4%	8%	43%	13%	28%
Females, n=573	4%	6%	6%	54%	10%	20%

Since family/parents were shown to have the most influence on the majority of the students, we wondered if the students who had engineers in their families had been more influenced to pursue engineering careers than those who did not. Of the students selecting family/parents as the major influence on their career decisions, 40% have an engineer in their immediate family. However, equally for both the male and female students in the class, who chose family/parents as a strong influence on career choices, almost all of the engineering role models were male engineers (M-Eng).

Table 9

Students who indicated family/parents as 'most influence' on their career choice (by gender)

Engineers in their family	None	1 F-Eng	1 M-Eng	2 F-Eng	2 M-Eng	Other
Total Males & Females, n=520	60%	5%	28%	1%	4%	2%
Males, n=212	60%	6%	28%	1%	4%	1%
Females, n=308	60%	5%	28%	0%	4%	3%

Students who selected family/parents as the major influence on their career decisions, and had one or more engineers in their immediate family (1+ Eng) were twice as likely (38%) to be interested in engineering as students without an engineer in their family (19%).

Table 10

Interest in pursuing engineering as a career, prior to Discover Engineering High School Workshops (students indicating family/parents as ‘most influence’ on their career choice, engineer in family)

Interested in pursuing engineering	Yes	Probably	So-so	Not Likely	No
Total students, n=522	13%	14%	31%	23%	19%
No Eng in family, n=311	8%	11%	33%	26%	22%
1+ Eng in family, n=211	19%	19%	28%	20%	14%

When female students who selected family/parents as the major influence on their career decisions, and had one or more engineers in their immediate family (1+ Eng) were compared to female students with no engineer, the level of interest in pursuing engineering was more than double with an engineer (25%) than without (9%). Moreover, female students who selected family/parents as the major influence on their career decisions, and had female engineers in their family (1+ F-Eng) were twice as interested in pursuing engineering (50%) than female students with male engineers (1+ M-Eng) in the family (21%). This suggests that role models are a strong influence on career decision-making and female role models within the family are even more influential.

Table 11

Interest in pursuing engineering as a career, prior to Discover Engineering High School Workshops (female students indicating family/parents as ‘most influence’ on their career choice, engineer in family)

Interested in pursuing engineering	Yes	Probably	So-so	Not Likely	No
Total Female students, n=308	8%	7%	30%	30%	25%
Female students, no Eng, n=184	4%	5%	32%	31%	38%
Females, 1+ Eng, n=124	15%	10%	27%	28%	20%
Females, 1+ M-Eng, n=99	12%	9%	29%	28%	22%
Females, 1+ F-Eng, n=16	25%	25%	26%	12%	12%

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.

Almost 70 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 60% of the students indicated that the program increased their knowledge about engineering and almost 50% indicated that the program increased their interest in pursuing engineering as a career.

For female students, over 75% of the students indicated that the program increased their knowledge about engineering and over 30% indicated that the program increased their interest in pursuing engineering as a career.

Table 12

Impact of Discover Engineering High School Workshops on knowledge and interest in pursuing engineering (by gender)*

Impact of workshops	Increased knowledge	Increased interest
Total Males & Females, n=1057	69%	41%
Males, n=487	62%	49%
Females, n=570	75%	34%

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

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 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^{6,17}. Once students become aware of the broad range of engineering fields and participate in hands-on activities related to engineering, they become more interested.

Table 13

Comparison of interest in pursuing engineering as a career, before and after Discover Engineering High School Workshops (by gender)*

Interest in pursuing engineering	Pre-workshop	Post-workshop	Increase
Total Males & Females, n=1057	29%	41%	+12%
Males, n=487	45%	49%	+4%
Females, n=570	16%	34%	+18%

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

Summary

Our study has shown that the existing level of knowledge about engineering among high school students is low, with less than one-third of students able to describe what an engineer does. And 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.

Our study found that having an engineer in their immediate family had a significant influence on the student's knowledge about engineering and interest in pursuing engineering as a career and female role models provided the greatest influence on female students.

The majority of high school students consider family/parents to be the greatest influence on their future career choice, but role models proved to be an equally strong influence especially on female students. Female students with an engineer in their immediate family were more than

twice as interested in engineering as female students without an engineer, regardless of choosing family/parents as the ‘most influence’.

Participation in outreach programs, such as Discover Engineering, was found to increase students’ interest in pursuing engineering as a career, and this increase was significant for female students.

The potential effect of the workshop program on future engineering enrollments is also significant. With over 1000 students participating in the 2001/2002 program, more than 400 students indicated that they would consider pursuing engineering, with almost 120 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 2001/2002 program, there were an additional 12 male students and 105 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.

Since launching the Discover Engineering High School Workshop program in 1999, over 4000 high school students have participated in the program, and our annual studies show that interest in pursuing engineering as a career increases by up to 15% overall, and up 20% for female students, after participating.

While it is still too early to see the actual increases in engineering enrollment due to Discover Engineering High School Workshop program, 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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