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Image of Engineering among Canadian high school students

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ABSTRACT:
Enrollment statistics from the Canadian Council of Professional Engineers show a recent decline in percentage of women enrolled in engineering programmes in Canada. Enrollment peaked at 21% in 2001, and has since dropped to 19% [1]. Many studies have been undertaken to try to determine why so few women choose to become engineers [2]-[4]. 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. Our *Image of Engineering study* reviews a number of these factors, specifically students' knowledge about engineering, general views about the profession and their interest in pursuing engineering as a career. If Canadian universities hope to increase the number of women studying to become engineers, it is critical that they become aware of how the profession is perceived by students at the high school (secondary) level. Our study hopes to assist by studying the knowledge, interest and perception of engineering among almost 2500 Canadian high school students.

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 programmes in general, and at Ryerson in particular. The Committee's first initiative, the Discover Engineering Summer Camp, was launched in 1991 and several other programmes followed [3]-[16].

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 Programme

The high school workshop programme 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 programme 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, 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 5.1 million), for Grade 9-12 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 programme is offered to both male and female students, it has not only allowed us to survey the students about their knowledge of engineering and their view of the profession before they participate in the workshop, it has also allowed us to compare the responses of 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, this particular study surveyed the students about their knowledge of engineering, general views about the profession and their interest in pursuing engineering as a career.

The *Image of Engineering study* included Discover Engineering High School Workshop 2002/2003 and 2003/2004 participants - almost 2500 students from high schools across the Greater Toronto Area (GTA). Although racial information

was not collected, the student population reflects the overall population of the GTA, which includes more than 20 different ethnic origins and over one-third visible minorities [17]. The gender ratio was 45% male to 55% female students. Of the total students in this study, almost three quarters were at the Grade 10 level. Comparisons were done using Chi-square tests, and levels of significance were set for $p<0.001$.

Knowledge of engineering

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-programme questionnaire, which included asking them to describe what an engineer does. Students were allowed to indicate 'not sure'. The descriptions were reviewed and scored as 'not sure', 'incorrect description', or 'correct description' depending on the response.

Over half of the students were 'not sure' what an engineer does, and almost one-quarter of the students wrote an incorrect description.

The following were viewed as incorrect descriptions since they indicated that the student viewed engineering as a purely technical job. Examples are; *"I think they work with machinery and fix cars", "They fix machines and computers", "Work with their hands"*.

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

Examples of correct descriptions were: *"An engineer is a problem solver mostly. They design systems, fix things and work largely with automation, construction, machinery and computers", "An engineer researches and develops different tools, devices to find better ways of using them", "I believe engineers use technology to develop machinery to help improve people's lives"*.

More male students attempted to describe what an engineer does and the percent of males that gave a correct definition was significantly higher than the percent of women who gave correct responses (Table 1). However the males also were more likely to give incorrect definitions than the females. Furthermore, compared to women, fewer male students indicated 'not sure'. These results suggest that males were more likely to know or think that they knew what engineers do. Female students were less likely to put 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 [18][19]. Furthermore the general public has an incomplete understanding of what engineering is and what engineers do [20]. These factors may contribute to the limited exposure to the engineering profession and to the lack of knowledge that young women have about what an engineer does.

Table 1
Knowledge of engineering, prior to Discover Engineering High School Workshops (compared by gender)*

Description of engineering	Not Sure	Incorrect	Correct
Total Males & Females, n=2482	55%	21%	24%
Males, n=1112	48%*	23%	29%*
Females, n=1370	60%*	20%	20%*

* Chi-square results are statistically significant ($p<0.001$) when comparing male verse female responses.

Interest in pursuing engineering as a career

On the questionnaire the students were also asked if they were interested in becoming an engineer (Table 2). Overall, over one-third of the male students were interested, yet just over 10% of the female students were interested in becoming engineers. This implies that there still exists a gender bias by female students against engineering careers.

Table 2
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=2482	12%	11%	27%	23%	27%
Males, n=1112	21%*	18%*	27%	14%*	20%*
Females, n=1370	5%*	6%*	26%	31%*	32%*

* Chi-square results are statistically significant ($p<0.001$) when comparing female verse male responses.

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 (Table 3). 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 3
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=529	18%	12%	25%	22%	23%
Males, n=261	29%*	18%*	26%	14%*	13%*
Females, n=268	7%*	5%*	25%	30%*	33%*

* Chi-square results are statistically significant ($p<0.001$) when comparing female verse male responses.

Image of engineering as a career

Often the perceived image of a career dictates whether someone is interested in pursuing that type of career [20]. On the questionnaire we asked the students to choose up to three statements that best described their views about engineering as a career. We hoped that their responses would shed some light as to why women did not often choose engineering as a career option. The statements are outline below.

- I see engineering as an exciting, creative career.
- I see engineering as a dull, boring career.
- I see engineering as a career that is interesting to men.
- I see engineering as a career that is interesting to women.

- I see engineering as a career that uses a lot of math.
- I see engineering as a career that uses lots of machinery.
- I see engineering as a career where you work in a factory.
- I see engineering as a career where you work in an office.
- I see engineering as a high paying career (high salary).
- I see engineering as a low paying career (low salary).

The top four statements about the engineering profession selected by the students were that engineering: "uses a lot of math", "uses lots of machinery", is "a high paying career (high salary)" and is "an exciting, creative career" (Table 4).

Table 4
Views about engineering, prior to Discover Engineering High School Workshops (compared by gender)*

Statement	Overall n=2482	Males n=1112	Females n=1370
Exciting, creative career	32%	44%*	27%*
Dull, boring career	18%	15%*	20%*
Career that is interesting to men	16%	15%	18%
Career that is interesting to women	5%	3%	6%
Uses a lot of math	62%	56%*	66%*
Uses a lot of machinery	40%	38%	42%
Work in a factory	11%	9%	12%
Work in an office	8%	9%	7%
High salary	40%	42%	39%
Low Salary	3%	4%	3%

* Chi-square results are statistically significant ($p<0.001$) when comparing female verse male responses.

Interestingly, the ranking of the selected statements were different when comparing female to male responses. For male students the top four views about the engineering profession were:

1. uses a lot of math (56%)
2. exciting, creative career (44%)
3. high salary (42%)
4. uses a lot of machinery (38%)

For female students the top four views about the engineering profession were:

1. uses a lot of math (62%)
2. uses a lot of machinery (42%)
3. high salary (39%)
4. exciting, creative career (23%)

Both groups of students acknowledged that engineering; uses a lot of math, can use a lot of machinery and can be a high paying job. The most striking result was the difference in the percent of students in each group that ranked engineering as an exciting, creative career. Almost half of the males (44%) viewed engineering as an exciting, creative career while only 23% of females viewed engineering the same way. This significant difference was accompanied by having females rank "uses lots of machinery" as their second overall statement compared to males who ranked that statement fourth. Previous studies [21][22] have also indicated that engineering is perceived as a technical pursuit in which one works with machines, or drives trains, rather than interact with people. Furthermore, since women traditionally have been discouraged from participating in jobs with heavy manual labour their perception that engineering contains a lot of machinery may influence their decision to consider engineering as a career.

Interestingly, neither group thought that engineering was a career that would be interesting for women. What factors of society or the environment convey this notion to young people is not known but the notion that engineering is not for women appears still be embedded in the views of high school students.

The students' knowledge about engineering did not seem to change their views about the profession. Comparison of students that gave correct definitions for engineering with those that did not, did not change the order that statements were selected for either the male or females (data not shown). This implies that whether or not the students were aware of what engineering is all about, their perceptions of the profession were the same.

The most discouraging outcome of the survey was that gender bias towards engineering still exists. Both males and females do not consider engineering to be an appealing career for women. Secondly, women viewed engineering different from men and most notably still consider it a machinery intensive career, a notion that may discourage many from participating.

After the survey was conducted, all the students participated in our Discover Engineering workshop. This activity did increase their awareness about engineering [5][7][8] and hopefully dispersed some of the myths surrounding the engineering profession. However, many high school students do not participate in programmes such as ours and therefore will continue to hold gender bias notions about engineering. We hypothesize that these views impede the engineering profession from attracting more women into engineering careers.

CONCLUSION

Our survey found that female students have different views than their male counterparts about engineering. These differences may foster misconceptions about engineering that result in less women pursuing engineering careers. Although programmes like ours help to dispel the myths about engineering there appears that initial gender bias against pursuing engineering as a career still exists.

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