PARTICIPATION TRENDS IN AND LESSONS LEARNED FROM OUTREACH

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Abstract — The National Capital Region of Ottawa, Canada, has a population approaching 1,000,000. Ottawa is the centre of Canadian government, the National Research Council and the Canadian high-tech sector. It has three universities and a number of colleges. For over 20 years, the local and regional school boards, some private schools, and several colleges and universities have participated in the Enrichment MiniCourse (EMC) Program. This program is aimed at bright, gifted and highly motivated students in grades 8 through 12. The author will share some of the lessons she has learned over the years with respect to outreach in this age group; e.g. girls favour cool course names. The EMC data are combined with national enrolment data to qualitatively relate trends in EMC participation to those at the undergraduate level. It is shown that it took a decade to raise participation of teenage girls in EMC science from 39% to 48%. In that same decade the participation in engineering improved from about 20% to 28%. It is the author's opinion that the trends observed in the teen population will be reflected in undergraduate enrolment within a decade. The results show that unless substantive changes in outreach occur, 50/50 by 2020 is not an achievable target.

Index Terms — engineering, outreach, science, youth, 50/50 by 2020

INTRODUCTION

As part of its mission the EMC program is committed to introducing students to new areas of study or to the pursuit of familiar subjects. In addition, the program is intended to stimulate the intellectual, social and personal growth of participants by encouraging them to explore possible career options, study subjects of personal interest and acquire knowledge and skills beneficial to them in the classroom. It is expected the participants will achieve a greater understanding of themselves and others and develop an interest in pursuing their post-secondary studies while increasing their knowledge of the resources available at the local post-secondary institutions. A final goal is to heighten the awareness of educators, parents and the public to the needs and profiles of bright, gifted and highly motivated students.

The long history, over 20 years, of the EMC program provides a remarkable and continuously increasing data set for studying the interest of teenagers in many topics. As the students are recommended by their teachers and schools, and are usually placed in one of their top three choices, it is assumed that participation is a reflection of the interest and skill levels of youth in these topics. As an example, in 2002, over half of the 2241 students were placed in their first choice [1]. Furthermore, students in this wealthy high-tech and government city are those with the academic, financial and social means favouring their eventual arrival at college and university education. Trends observed in this young population will likely become post-secondary trends.

Roughly 25,000 students have participated in the EMC program which runs for one week each May. They have been instructed by a variety of graduate students, technicians and professors who receive a small honorarium for their involvement. The continued presence of the EMC program indicates it works well for the students, school boards and post-secondary institutions. EMC funding is provided principally by the families of the participating students with administrative support provided by the local school boards

The author originally participated in EMC program in the late 1980's offering over several years, a course entitled, 'Computer Aided Engineering'. Very few girls attended, perhaps 10%. It was this low participation, when the author was herself the only female doctoral student in mechanical engineering, which was the start of the author's active participation in issues related to women in engineering.

DATA AND METHODOLOGY

The EMC program offers topics in arts, social sciences, science and engineering (including architecture and industrial design). The participation in science and engineering minicourses has been of particular interest to the author who has incorporated EMC data in several papers [2][3][4]. The initial study [2] included data from 1982 to 1990 in which 160 minicourses involving 6250 students were offered at Carleton University. In the second study [3], EMC data from 1991 to 1999 were captured from four postsecondary sites in the Ottawa area: Carleton University (including also 2000 and 2001), University of Ottawa, La Cité Collégiale and Algonquin College. Several hundred minicourses involving 14,681 students were included. Although the majority of courses were offered in English, a number were offered in French. The National Capital Region is effectively a bilingual area of the country where local, provincial and national government services are available in both official languages. Most retail services also have fully bilingual staff.

In [2], [3] and [4] the data were first inspected using line and bar graphs with SPSS [5]. This was followed by crosstabulation using topics such as grade, year, and language to

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examine statistical variations in participation. This was tested using a Chi-square test for equality of proportions. Only results significant with at least a 95% confidence level are reported. When appropriate, they are reported with their p value, which corresponds to the error rate associated with claiming the proportions differ when they, in fact, do not.

One of the principal conclusions from [3] was that in 2000, 13- to 17-year old girls were still more interested in science than in engineering and that participation in science minicourses had climbed from 39% to nearly 48% over the two decades. While the gender split had approached an overall level of 50/50 [4], the girls favoured biology/botany courses and were least interested in math and computer science.

AGE 13 IS IMPORTANT

During the late 1980's and throughout the 1990's, many creative and proactive programs were put in place with the specific goal of addressing the under-representation of women in science and engineering. Although many of these programs were focused on women in high school; e.g., [6] the initiatives varied across the country. Many were small, unadvertised local efforts. The author, for example, attempted to focus her own outreach in the early primary years as [1] had shown the gender barrier to be in place by age 9. At the national level, the National Research Council created, in 1990, the Women in Engineering and Science award to develop role models. Since then, about 300 awards of summer employment-scholarship-mentorship have been made to female students across the country. The NSERC/Nortel National Chair for Women in Engineering was established in 1989 and, in 1997, the five regional Chairs for Women in Science and Engineering were established. All the chair holders have been active in recruiting and retention of women in science and engineering. The Canadian Engineering Memorial Foundation, created in 1989, devoted resources for high profile scholarships, one of which was originally aimed at high school girls, but is now awarded to women who have completed first-year engineering.

Anecdotal evidence and a rise in the percentage of women in engineering schools, suggest that these measures have been successful to some extent. Nevertheless, women are still under-represented in engineering. Furthermore, there is concern that a 20% plateau in undergraduate enrolment in engineering has been reached.

It is important to re-examine the opinions and interests of teenage, and indeed younger, girls. The focus on intervention in the high school years has been an ongoing concern to the author who feels that most young teens have already formed strong career-related opinions despite a general lack of knowledge about engineering; e.g., Anderson [6] showed that only 40% of camp participants for her Discover Engineering Summer Camp, aimed at grade 10 students (age 15), have some prior knowledge of engineering.

Figures 1 and 2 show the changes in EMC participation that were observed over the two decades considered. In the 1982 to 1990 period, 6250 students were part of the study group. Of these, 2087 (roughly one-third) were age 13. Analysis showed there was no statistically significant variation of female participation with age; i.e., 20.2% in engineering for ages 13 to 17 years and 24.3% at age 13.



FIG. 1 MINICOURSE PARTICIPATION, 1982-1990, AGE 13, 2087 STUDENTS (CHI-SQUARE=641.8 WITH 3 DF, P=0.000)

In the second study from 1991 to 1999 including 2000 and 2001 from Carleton University, 14,681 students participated and, of these, 7488 were age 13 (over one-half). Again, the overall enrolment of girls in engineering minicourses was statistically consistent through ages 13 to 17 (28%). The participation of girls at age 13 was 28.5%.

While the overall value was nearly 29%, it should be noted that throughout the 1990's there were year-to-year variations in the participation of girls varying from a low of 23% in 1992 to a high of 34% in 1998 as will be seen in Figure 3. Of side interest was a peak in the mid 1990's of grade 12 women. This was a time when pro-active outreach programs were in place in many high schools in the Ottawa area.

The author believes that age 13, typically grade 8, represents a critical assessment point and that participation at this age is a key to possible future university enrolments. The EMC engineering participation at age 13 in the 1980's was 24.3%. This climbed to 28.5% in the EMC program during the second decade [3]. The author feels that until female participation in EMC engineering courses approaches 50% overall, we cannot expect university undergraduate enrolment to even approach 50% as there is no significant change in participation in these courses over the teen years.



FIG. 2 MINICOURSE PARTICIPATION, 1991-1999, AGE 13, 7488 STUDENTS (INCLUDES CARLETON U. 2000 & 2001) (CHI-SQUARE=475.3 WITH 3 DF, P=0.000)

OLDER TEENS

While the results above suggest the very early teens are a key point of reference, it is necessary to see if other interventions could have a statistically proven effect in the later years. To explore the possibility of directly regaining the interest of girls in their midteens, the statistical study was expanded to include data from Carleton University's Grade 10 Experience Weekend [3]. The intention of the weekend program, which in the last two years has been replaced by a University Day, is to allow local and regional high school students to experience a university-like lecture and social environment. It is a combined outreach and marketing tool that is funded by the students' families with administrative support from the university. Instructors are chosen from faculty with an established rapport with this age group. Courses offered by instructors who do not demonstrate this rapport are not repeated in subsequent years. There is no honorarium. In addition to attending lectures, the students have access to the recreational facilities such as the pool and the fitness centre as well as social events

Students choose to attend several of 23 lectures across the undergraduate curriculum as part of the university experience. All courses have descriptions and titles meant to appeal to university-bound students; e.g., one course in sociology is entitled, 'Sex, Drugs and Rock n Roll'. In the author's case rather than 'Materials Science', the author used the title, 'Everything is Made of Something'. The description follows:

"Have you ever wondered why commercial aircraft have aluminum skins? Have you ever wondered why stainless steel doesn't rust? Have you ever wondered why some plastics break in cold weather while others don't? Have you ever wondered why most tennis rackets and fishing poles and skis are now made of composite materials? If so, this lecture is for you. Using a show-and-tell approach, you will be introduced to different types of materials, their characteristics and uses. Come and explore the world of engineering materials"

In 1997, 1998 and 1999, 2864 students attended the weekend. At age 15, without the grade 10 experience data, the participation of 15-year old girls in EMC engineering courses was 28%. When the university weekend was included, female participation of 37% for 15-year olds was noted (sample size 1713, Chi-square = 20.459 with 8 df, p = .009) [4]. This statistically significant change suggests that using interesting descriptions and titles has the potential attract the attention of girls in their midteens. There is no guarantee of course that the interest will be maintained.

As a direct outcome of this research, the author and colleagues created a new minicourse entitled 'You Go Eng-Girl'. In its first year (2001) it was fully subscribed (20) and attracted a 75% female audience, about half of which were in grade 8. In its second year it has attracted all girls (20) and of those 75% are in grade 8. The course description for 'You Go Eng-Girl' follows:

"Have you ever wondered about a career in engineering? Well. Eng-girls love engineering and engineering makes the world a better place to live. In this course vou'll be introduced to eng-girl and mathgirl professors. You'll study things like history of the cardiac pacemaker with a biomedical engineer and examine the issues of air and water pollution with an environmental engineer. A civil engineer might help you design and test a popsicle stick structure. A mechanical engineer will talk to you about engineering materials and you'll make silly putty to see how materials can change their behaviour. Did you know that IT (information technology) can be used to help people? A computer systems engineer will show you that IT is cool. You'll also work with a math professor who will show you how statistics and engineering fit together. Through it all, you'll see the importance of teamwork in engineering."

By way of comparison, consider a traditional course which has been offered for a number years. It is entitled, 'Strength and Stability'. Not surprisingly, it is positioned in the low end of EMC Engineering courses in terms of female participation. In 2002 it attracted 20 students, 17 boys and 3 girls (15%) despite having a female instructor.

While it is difficult to make absolute judgments without an accompanying statistical model, it is clear that the use of cool course descriptions and names does have the potential to attract girls to EMC courses and the University Experience lectures. In fact, in 2002, a group of teens appeared in both the 'You Go Eng-Girl ' minicourse in early May and then a few weeks later in the 'Everything is Made of Something' lecture.

Other EMC Trends seen in the Teen Years

Within the undergraduate community, it is common knowledge that disciplines such as chemical and environmental engineering lead the way in participation of female students and that disciplines such as electrical and mining engineering tend to lag. It is of considerable note that these trends exist in the teenaged EMC participants as well [4]. Attitudes and preferences are formed early!

Within engineering, the EMC topics considered are: design-based architecture/industrial design/interior design. chemical engineering, civil engineering, electrical engineering, mechanical and aerospace engineering, and computer systems engineering. The participation within the various disciplines is hardly uniform with the design-based topics proving to be the most popular (high 67% female participation). Civil engineering (high 53%) and chemical engineering (high 40%) attract considerable interest. In recent years, the civil engineering courses have included an environmental component and this appears to account for higher female participation. Mechanical and aerospace engineering (high 35%) are less interesting to teenage girls. Computer systems engineering has scores similar to that of computer science results mentioned earlier (high 25%). Electrical engineering minicourses have had consistently poor female participation (high 10%).

As part of the examination of EMC data, a regression model was used [4] to examine the likelihood of certain trends being maintained. Several results are worth repeating:

- The model showed that the odds of taking a science or engineering minicourse drop 70% (i.e. exp(B)=.30) if the student is a woman.
- The model showed that overall odds of taking a science or engineering minicourse drop by 88% (i.e. exp (B)=.12) if the student is Francophone. This result may be of interest to other areas where the regional population includes two principal languages with a substantial proportion of the population speaking a second language.
- The regression analysis showed that grade 12 students are 23% (i.e. exp (B)=.77) less likely to take an EMC science or engineering minicourse than are Grade 8 students. As one would expect at the point of university entry, their career decisions are well in hand.
- Finally, there is now evidence that students are becoming less likely to study science or engineering minicourses when compared to courses in arts and social sciences. When compared to 1991, the odds of a student participating in a science or engineering minicourse declined 4% in

1994, 8.5% in 1995, by 2% in 1996, 22% in 1998 and 38% (exp (B)=.62) in 1999. This trend for both boys and girls, in an evermore complex and technological society should be of considerable concern.

50/50 by 20/20 -- Relating EMC data to University Enrolments

The EMC program represents a best-case scenario group with the academic, financial and social means favouring their eventual arrival at college and university education. Trends observed in this young population are likely to become post-secondary trends. Thirteen-year olds who took the EMC courses in the mid 1980's would have completed a 4-year university degree in the early 1990's. A 13-year old who took an EMC in 1990 likely completed university in about 1999. The author proposes to link EMC data with national enrolment trends to predict possible trends with respect undergraduate engineering.

According to the Canadian Council of Professional Engineers (CCPE) [7], the participation rate of women in all undergraduate programs in engineering across Canada was 3.6% in 1975, the year the author began her undergraduate degree, 12.3% in 1988, the year the author completed her PhD, and had reached 19.5% in 1998, the year the author attained the rank of full professor.

Obviously within these national statistics there are variations by geographical area and within the various disciplines of engineering. CCPE data are presented in detail in [7]. The Association of Universities and Colleges Canada (AUCC) compiled similar data for 1975 to 1985 [8]. The federal department, Statistics Canada has data for 1990 to 1999 [9]. These sources provide national undergraduate university enrolment data in engineering and science over 25 years; i.e., 1975 to 1999.

Figure 3 shows the national data as follows: CCPE data for engineering (CCPE Engng); AUCC plus Statistics Canada data for engineering (AUCC Engng): and AUCC plus Statistics Canada data for science (AUCC Science). It should be noted that participation, as defined by CCPE, is slightly lower than that of AUCC and Statistics Canada; e.g., 20.3% in 2000 [7] rather than 22.6% in 2000-2001 [9]. A simple linear trend is drawn through the combined engineering data.

The EMC data, for ages 13 to 17, are also included in Figure 3. Science data for the 1982 to 1990 study [2] are placed at a single representative point in 1986. Science data for the second study [3] are similarly placed in 1995. These are referred to as EMC Science in Figure 3. Data on participation in EMC engineering minicourses (EMC Engng) are placed in 1986 for the 1982 to 1990 study [2] and then shown on a year-by-year basis [3]. They are plotted along with a simple linear trend.

It is clear that science in general has broken the gender barrier. The EMC female participation for ages 13 to 17 went from 39% in the 1980's to 48% sometime during the 1990's. Examination of results in [4] suggests that the nearly 50/50 participation was achieved early in the decade. Undergraduate enrolment of 48.2% was achieved in the 1999-2000 academic year [9].

The engineering data are of more significance here. First, concern about a 20% plateau should be addressed. The plateau shows in the year-by-year CCPE data but not the AUCC and Statistics Canada data plotted here. Although in immediate terms there appears to be a local plateau, there is still strong upward trend when data over 25 years are considered



FIG. 3 NATIONAL ENROLMENT DATA AND EMC DATA WITH PROJECTIONS

The simple linear trend can also been used to extrapolate the EMC data for engineering. It also shows a strong upward trend suggesting the 50/50 gender split in engineering will be reached a sometime after 2020 for the teenage population. Undergraduate enrolment will lag behind. It might be safer to say 50/50 in 2050 unless intervention strategies are significantly more effective than those used in the 1990's. For example, courses such as 'You Go Eng-Girl' with extremely high female participation might be able to affect dramatic change. A proper statistical analysis based on a substantial population base will be carried out in a few years.

CONCLUSIONS

Age 13 appears to be a critical year with respect to choices made for the future. There is no significant change in interest in EMC engineering participation after age 13. Teenage girls appear to have formed strong opinions by this point not only with respect to general subject areas but also for specific topics within these areas.

Although the EMC program did not show a change in participation with age, it was noted that other courses with interesting description and titles, have the potential to significantly affect participation rates in the midteens. An important note is that the instructors must live up to the title of the course by incorporating strong rapport with the students.

A new course with the title, 'You Go Eng-Girl' has since been added to the EMC courses and appears to have the potential to dramatically affect change.

While 50/50 by 2020 is a target that may be within reach for the teenage population it is unlikely to be achieved as an overall statistic in undergraduate engineering.

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