Draft/Preprint: New Frontiers, New Traditions – St. John's July 6-8, 2000

TRACKING THE GENDER BARRIER: A 1990'S FOLLOW-UP STUDY

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ABSTRACT

A 1991 study, based on data from the 1980's, of over 13,000 Canadian children showed that the participation of girls in technological subjects such as engineering was limited by a gender barrier that appeared as early as age 9. The principal sources of data for the study were university minicourses and summer camps attended in several locations across Canada.

During the late 1980's and throughout the 1990's, many proactive measures were made to encourage the retention of girls in mathematics and science as well as their participation in technological studies. Anecdotal evidence and a slow 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 science, math and engineering and in the information technology area.

A follow-up study of over 52,000 Canadian children, using data from the 1990's is presented. Data sources consistent with the previous study are used; i.e., special university minicourses for ages 13 to 17, and summer camps for ages 6 through 14. The results show that while there is still a gender barrier for engineering it is easing. The original study showed female participation of 24% in engineering at age 13 while the current study shows 30% female participation. It is shown that girls are still more interested in science than in engineering. Within engineering, interest is highest in disciplines such as interior design, environmental and chemical engineering. Use of interesting names for courses is seen to increase female participation while subjects identified as computer-linked show a gender barrier with female participation in the 20 to 30% range. The participation of teenage girls in these areas is noted to be below 20%. Finally, and surprisingly, a language effect is identified that shows female participation in engineering is higher, at 48%, for predominantly francophone minicourses (ages 13 to 17) but much lower in camps aimed at children under 14.

INTRODUCTION

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

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these programs were focused on women in high school [1], the initiatives varied across the country and from the local to the national levels. Many were small, unadvertised local efforts. It is not possible to present a detailed summary, nevertheless it's useful to look at typical initiatives.

At the national level, the National Research Council created, in 1990, the Women in Engineering and Science award to develop role models. About 250 awards have been made to female students across the country. The NSERC/Nortel 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 chairholders are active in recruiting and retention. The Canadian Engineering Memorial Foundation, created in 1989, devoted resources for scholarships, one of which was aimed at high school graduates entering engineering.

The Ontario Government developed and distributed in the early 1990's, to all elementary and secondary schools in the province, 'An Inventory of Ontario Women in Scientific and Technical Fields'. This assisted teachers in their individual efforts of inviting role models into the classroom. Pathmakers, a 1986 initiative of the Ontario Women's Directorate, was created to provide female university-level role models to high school students.

School boards also addressed the under-representation of women in technical areas often by giving conferences and workshops led by women in the trades, engineering and science, to girls; e.g., Opening Doors (Toronto 1992) and Showcase for Women in Science (Ottawa 1996). Schools and industry had co-operative ventures such as a 1998 special event at Nortel for grade 10 students [2].

Summer camps and special programs appeared across the country. For example, 'WISH, Women into Science, Hopefully' was run in 1984 by the Department of Physics at York University in Toronto. 'Worlds Abound', a gender-balanced summer camp for grades 5 to 8 was run at the University of New Brunswick in the mid 1990's.

An increase in the general awareness of technology, combined with the types of initiatives discussed above are now thought to be associated with a measurable change in the enrollment statistics. For example, in 1983/84 undergraduate enrollment of women in all engineering disciplines was 8.4% [3]. Between 1991 and 1995, the enrollment of women in engineering across Canada, rose from 16% to 19% [4]. In 1996, 18.2% of the undergraduate engineering degree were awarded to women [5]. According to Frize [6], statistics are slightly higher than this in computer science and physics. On closer examination though other trends appear. The 1991-1995 study [4] showed that the percentage of women was highest in environmental engineering (47%), followed by chemical engineering (38%). National statistics, by province, are fairly consistent except in Nova Scotia. In 1998, by province, the enrollment of women in engineering was [7]: Alberta - 21.9%, British Columbia - 17.3%, Manitoba - 21.6%, Ontario - 21.4%, Quebec - 17.0%, New Brunswick - 20.6%, Newfoundland - 19.5%, Nova Scotia - 4.9%, Prince Edward Island - 16.7% and Saskatchewan - 22.8%. The 1998 numbers divided by disciplines show women were still clustered in certain disciplines with Environmental Engineering the highest at 42.9% and Computer Engineering the lowest at 11.9%.

There have been few studies to quantitatively examine the effect of the many and varied initiatives across the country. Vickers et al. [8] showed that many programs which raise the general interest and knowledge in science, mathematics, engineering and technology have a more positive impact on boys while improved success was achieved in a single gender program, 'Girl's into Science'. Frize reported success as well in a 1997 study on the previously mentioned 'Worlds Abound Camp' [9]. These studies, by necessity, have used relatively small statistical samples. Clearly, there is a need for a more comprehensive, broader-based study to examine the trends associated with the gender barrier over the last two decades.

OBJECTIVE AND STATISTICAL BASIS

The intent of the current project was to follow-up the study done with data from the 1980's [10] using corresponding data from the 1990's for children aged 6 to 17. The application of proper statistical techniques is essential in a study of this type. The goal was to determine if the gender barrier is still a measurable phenomenon in science and engineering and to examine its effect in the early primary years and through the high school years.

Review of Original Study

The original research showed that the gender barrier becomes a significant factor in the lives of girls as early as age 9 and is firmly in place by age 13. The principal source of data for the original project was the Enrichment Minicourses Programme for bright and highly-motivated students from ages 13 to 17 [11]. Between 1982 and

1990, 163 minicourses involving 6250 students were offered at Carleton University. The gender and age of the students in each course were obtained and the courses were categorized into 4 content areas: arts, social sciences, science and engineering. The engineering category included technologically-based disciplines such as architecture, industrial design and computer programming. In all cases the participants had a free choice of subject area.

Additional data for 6967 children between 9 and 15 years of age were obtained from 4 university sites, each in a different province. Carleton University, University of Calgary, University of Manitoba and Simon Fraser University ran children's summer camps which combined athletic and academic modules. Data were obtained for the period covering 1987 to 1990. Gender and age, where available, were obtained.

Data for Follow-Up Study

The principal source of data for ages 13 to 17 was the university enrichment minicourse program, this time captured from four sites in the Ottawa area: Carleton University, University of Ottawa, La Cité Collégiale and Algonquin College. 14,681 students attended their choice of several hundred courses between 1991 and 1999. Although the majority of courses were offered in English, a number were offered in French. To broaden the scope of the study for this age group, data from Carleton University's Grade 10 Experience Weekend were included. Local grade 10 students were invited to attend their choice of 23 lectures as part of a university experience. 2864 students attended during 1997, 1998 and 1999. All courses were given titles meant to inspire the students; e.g., rather than 'Materials Science', the authors used the title, 'Everything is Made of Something'. One course in sociology was entitled, 'Sex, Drugs and Rock n Roll'.

Data for the 6 to 14 year old group were provided by Youth Engineering and Science-Virtual Adventures Camps Canada (YES-VACC) [12] who offered a variety of summer camps in science and engineering between 1993 and 1999. These camps are truly national with 26 member programs from Victoria to Iqaluit to St. John's. The summer day camps are largely cross-curricular and include subjects in the natural sciences, computer technology and mathematics. They are aimed principally at children between about 9 and 14. YES-VACC national statistics on average participation for boys and girls were available for 1993-1999. Numbers detailing participation were available for 1997, 1998 and 1999 for 32,817 children. Within this group were several more specific sources of data. Although not delineated by age, data on the total percentage of girls involved at each YES-VACC site were available for 1997 for the 8811 campers that year. Data for the 1997 University of Ottawa camps which included 838 children were available by topic and age as were data for 808 children from the Virtual Adventures (VV) camps [13] offered at Carleton University in 1998 and 1999. Also, in 1999 of the 26 member sites, 8 offered specific computer camps for which the participation rate of girls was known.

Methodology

In all cases the data were first inspected using line and bar graphs with SPSS [14]. This was followed by cross-tabulation of the relevant data in order to examine mathematically whether female participation varied across several dimensions such as faculty of study and type of course (whether minicourses, the experience weekend courses or camps). This was tested using a Chi-square test for equality of proportions. Only results significant with at least a 95% confidence level are reported. 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.

RESULTS AND DISCUSSION

It should be remembered that children attending university minicourses, the grade 10 experience weekend and most summer camps are those whose financial and academic means will favour their eventual arrival at post-secondary education. Bluntly put, the 52,000 children studied here represent a privileged group and the results will reflect a best-case scenario for enrollment of women in science and engineering. In summary, this follow-up study had a statistical base covering the years 1991 through 1999, for ages 6 to 17 as follows: university minicourses 14,681; grade 10 experience weekend 2,864; YES-VACC camps 32,817 plus other data from 1993 to 1996.

Minicourses

Figure 1 shows the overall distribution of girls and boys in the minicourses by discipline for all years studied. The trend in the arts and social sciences parallels the original study with female participation between 60 and 70%. Interest in the study of science has improved from about 40 to 50% showing that science has nearly eliminated the gender barrier in the high school years. Engineering, unfortunately, still lags science appreciably with a female participation of about 28.5%. However, this is a substantial improvement over the original study in which female participation was closer to 20%.

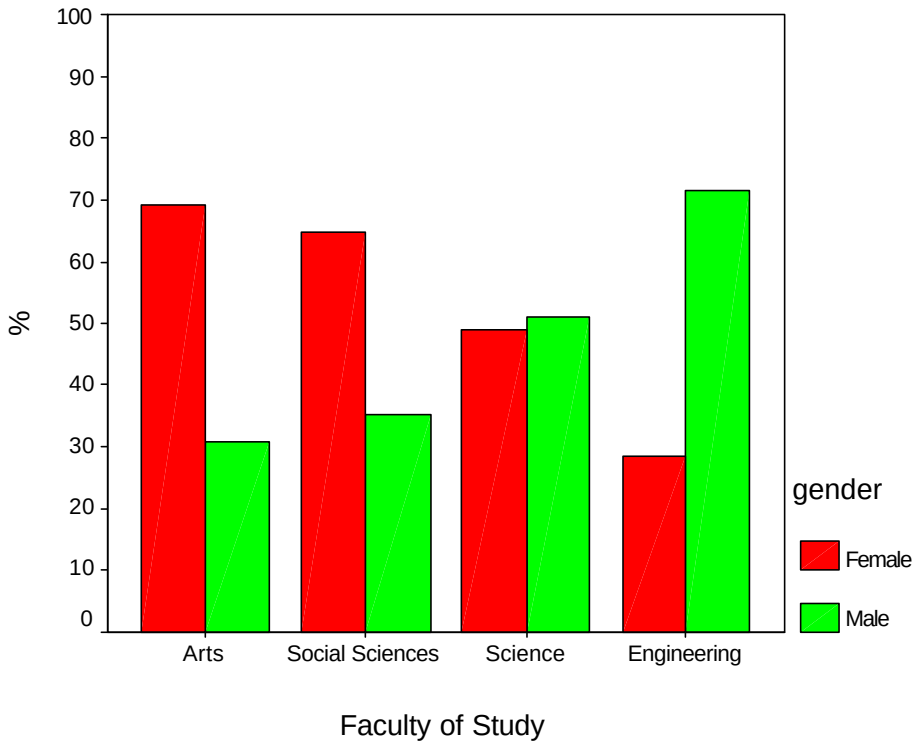

FIG. 1 MINICOURSE PARTICIPATION, 1991-1999, AGES 13-17. SAMPLE SIZE: 14,681
(CHI-SQUARE = 929.754 WITH 3 DF, P = 0.000)

Within the engineering minicourses, statistical analysis showed that female participation was statistically consistent through ages 13 to 17 ranging from a low of 23% in 1992 to a high of 34% in 1998 as shown in figure 2. This allows the 13-year old participation group to quantify the level of gender barrier at the beginning of the high school years.

Figure 3 shows overall involvement of girls in engineering at age 13. The original study showed 24% female participation in engineering at age 13. The current study shows that over the 1990's this improved to 30% for engineering. The corresponding results for science show a female participation of 46%.

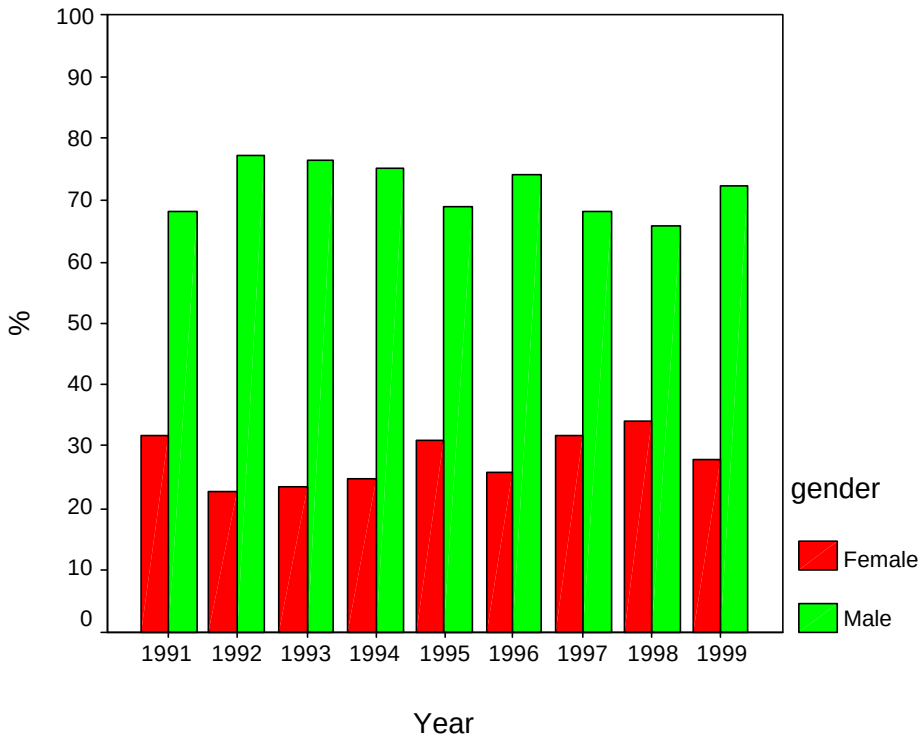

FIG. 2 ENGINEERING MINICOURSE PARTICIPATION, 1991-1999, AGES 13-17. SAMPLE SIZE: 1303 (CHI-SQUARE = 8.992 WITH 8 DF, P = 0.343)

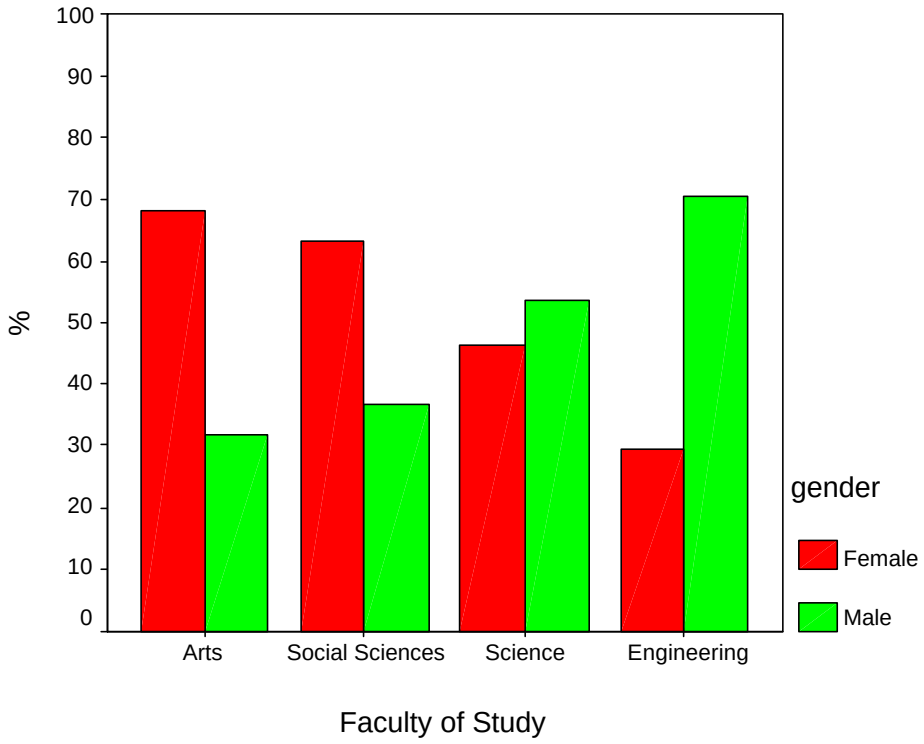

FIG. 3 MINICOURSE PARTICIPATION, 1991-1999, AGES 13. SAMPLE SIZE: 7488 (CHI-SQUARE = 475.321 WITH 3 DF, P = .000)

In the various statistical analyses run, the phenomenon of a bump at age 15 was noticed when the minicourse data were combined with the grade 10 experience data. A separate analysis was carried out to determine the significance of the bump which was attributed to the 15-year olds in the experience weekend. At age 15, without the grade 10 experience data, the participation of 15-year old girls in engineering courses is 28%. For the grade 10 experience weekend, all courses were titled to appeal to the interest of university-bound teenagers. The improved response of girls to these titles was an observable effect giving a female participation of 37% for 15-year olds (sample size 1713, Chi-square = 20.459 with 8 df, p = .009). Simply changing a title might attract the attention of girls and expose them to an interesting subject area, however there is no guarantee however that the interest will be maintained after the course.

Perception appears to have an effect throughout the engineering topics. Courses in interior design had female participation approaching 80%, environmental courses attracted 49% female participation, courses in mechanical and aerospace engineering attracted 21%, while female participation in systems engineering was 15% and electrical engineering only 6.5%.

A number of minicourses were taught in French only. The authors were surprised to isolate a combined gender and language effect for science and engineering courses. For this group which had a sample size of 3955 (Chi-square = 824.575 with df 3, p = .000), the participation of females in the engineering courses was nearly 48% compared to the overall English participation at 28%. A similar effect was noted in science with female participation in the courses offered in French at 57% as compared to participation in English science minicourses at 44%. Participation of males in the arts and social sciences did not increase in this sample group suggesting that the overall male participation may be decreasing. This is a trend that requires more study.

Camps

Having completed the study of the older group, emphasis switched to the group attending the largely cross-curricular summer camps aimed principally at ages 9 to 14. The YES-VACC [13] camps, being cross-curricular in nature, make it difficult to assess the gender barrier with respect to only engineering. Figure 4 shows the national statistics for 1993 to 1999. The female participation varies between about 32% and 38% over these years. The sample size for 1997, 1998 and 1999 was 32,817. This participation rate is largely consistent with the results from the older group. Figure 5 shows the percentage of girls participating across the country in 1997.

It is interesting to note that the camps offered in the province of Quebec show a lower interest rate of girls, about 20%, than did the minicourses offered in French shown above. It is possible the French camps emphasize the computer and technology areas, which, as will be seen below, indicate a stronger gender barrier. Further study of francophone camps offered perhaps in News Brunswick, the Ottawa area, and Manitoba might shed some light on this issue.

An attempt was made to separate the cross-curricular camps offered under the umbrella of YES-VACC from the computer and technology camps. For example, in 1999, 8 YES-VACC members offered computer camps. The participation rate of girls in these camps was 22.5% (sample size, 1758) whereas the cross-curricular camps had a female participation rate of 35% (sample size, 4684). It was clear that the computer-related camps were showing a gender effect. To try to isolate this effect, the 1997 University of Ottawa Adventures in Science and Engineering (sample size, 838) and the 1998 and 1999 Carleton University VV camps (sample size, 808) were examined. The analysis showed that between ages 6 to 13, the participation of girls in the computer and technology camps varied between 25% to 28%. This is consistent with a recent report by the American Association of University Women [15] which reports that women account for only 28% of the degrees in computer science in the United States. Their conclusion was that girls are not anxious or phobic about technology, just disinterested in the perceived culture.

The VV camps showed a discouraging trend for teenage girls with female participation at less than 20%. This was also seen in the results for the minicourses in systems and electrical engineering showing female participation for ages 14 to 17 below 15%. The authors feel that there is still a serious gender barrier for computer technology and information technology particularly in the teenage years.

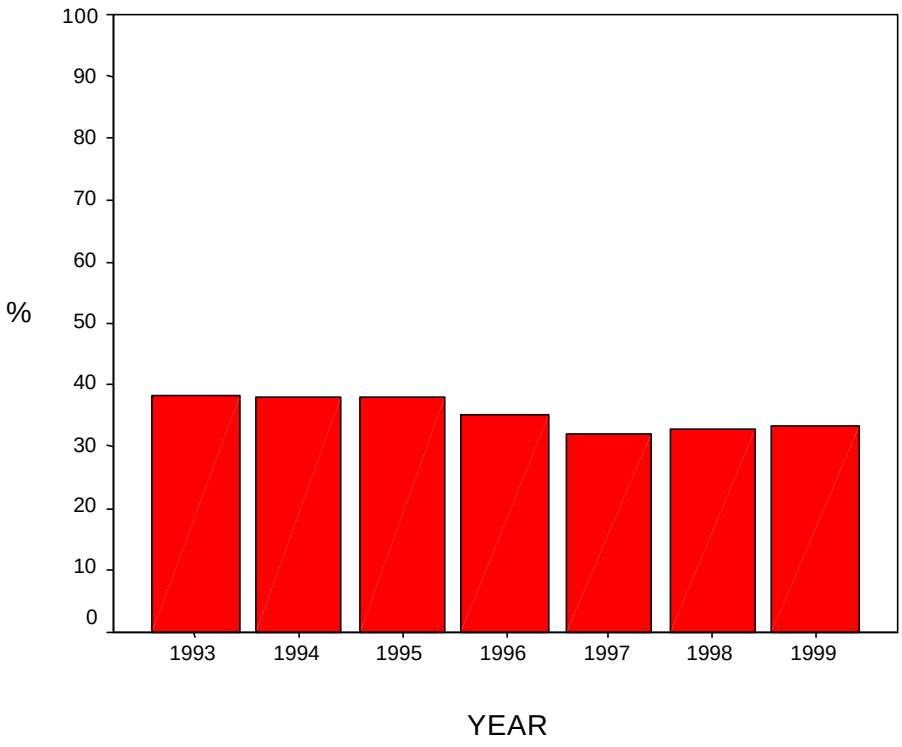

FIG. 4 FEMALE PARTICIPATION YES-VACC CAMPS, 1993-1999

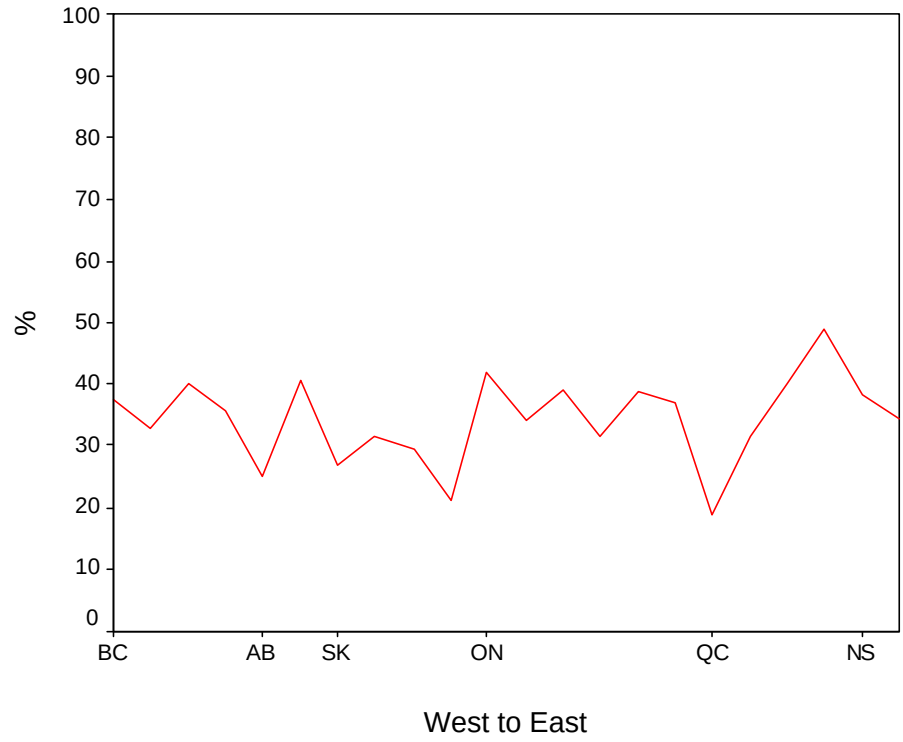

FIG. 5 FEMALE PARTICIPATION BY PROVINCE IN YES-VACC CAMPS 1997

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CONCLUSIONS AND CONTRIBUTIONS

[1] Girls are still substantially more interested in science than in engineering. Science appears to have eliminated the gender barrier seen in the original study. Participation of women and men in the minicourses shows a nearly 50/50 split.

[2] The gender barrier for engineering, while still in place, appears to have eased since the 1980's. Overall participation of girls in engineering minicourses, at age 13 is now to 30% while the original study showed 24% female participation at age 13.

[3] Simply renaming engineering courses to a less traditional form can be associated with improved participation. Here participation improved from 28% to 37% for 15-year girls.

[4] Within the engineering minicourses, female participation was higher in subjects such as interior design, architecture, environmental engineering and chemical engineering and lower for computer-related subjects and electrical engineering.

[5] Two interesting language effects were noted. For engineering minicourses offered in the Ottawa area, female participation for ages 13 to 17 approached 50% while in summer camps for ages 9 to 14 in Quebec, this dropped to less than 25%.

[6] For the younger children, principally in the 9 to 14 age group, computer and technology camps in general attract fewer girls than in other cross-curricular camps. The participation rate of girls in these camps ranges from 20% to 30% suggesting a serious gender barrier is still in place in these areas. Of particular concern is the less than 20% participation of teenage girls in this area.

ACKNOWLEDGEMENTS

The financial support of Carleton University (GR-5) and the assistance of the Carleton University, the University of Ottawa, la Cité Collégiale and Algonquin College as well as the YES-VACC camps are gratefully acknowledged.

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