Effect of Engineering Advocates on Young Women's Interest in Engineering

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Abstract

The Office of Special Programs of the College of Engineering at the University of Illinois at Urbana-Champaign (UIUC) sponsors Engineering Advocates (www.engr.uiuc.edu/sp/advocates), a voluntary student organization that presents information to high school students about engineering and UIUC. After each PowerPoint presentation and discussion, presenters collect evaluation forms completed by teachers, students, and the presenters themselves. In 2003-2004, 929 student evaluations were collected and analyzed. Results showed that, accounting for the covariate of presenter gender, a statistically significant number of young women changed their attitudes positively toward engineering as a career after viewing the presentation. Implications are discussed.

Engineering Advocates (EA) was begun in 1996 by women engineering students at the University of Illinois at Urbana Champaign (UIUC). Sponsored by the College of Engineering through its Women in Engineering program, the students helped design a Microsoft PowerPoint presentation about engineering and presented it to high school students across the state of Illinois. The presentation covered topics ranging from the diversity of opportunities in the engineering disciplines to what life is like for a freshman engineering student.

In the 1997-1998 academic year, eight presentations were made to 310 high school students. In the 2003-2004 academic year, 24 presentations were made to 929 students, a threefold increase! In addition to the growth of presentations, growth in the number of presenters had also occurred. In 1996, there were only five female student presenters, and in 2004, there were approximately 50 student presenters with a near equal number of males and females.

The purpose of the program was twofold: (a) to encourage more female high school students to consider studying engineering at the university, and (b) to improve the retention rate of women engineering students through participation in a service project. The first purpose was the focus of this study, and was grounded in recent research in engineering education and diversity. The existence of a gender gap in engineering career interest is well documented (AAUW, 1992, 1999; Giligan, 1982; Margolis & Fisher, 2002; Yauch, 1999).

Research has demonstrated that girls must be supported in their pursuit of science, technology, engineering, and mathematical (STEM) fields (AAUW 1992, 1999; Gilligan, 1982; Margolis & Fisher, 2002). The middle school level is a particularly vulnerable time in terms of girls losing interest in STEM fields. Although research has indicated that underrepresented students begin to opt out of STEM career choices in middle school or before, it has also suggested that some students are more likely to choose STEM careers if the choice is delayed until high school or college (Atwater, Colson, & Simpson, 1999). More specifically, some of the reasons for a lack of interest of female students have been found to be a lack of science and career knowledge, gender stereotyping of STEM fields as a male domain, and that females receive less encouragement to pursue STEM careers than males (Atwater et al., 1999; Takahira, Goodings, & Byrnes, 1998).

In the Women's Experiences in College Engineering (WECE) project, Goodman et al. (2002) found in a three-year study of 53 institutions that pre-college exposure encouraged students to pursue an engineering career. These methods included expanding enrichment activities in pre-college informal education settings, exposing girls to engineering at the elementary and middle school level, and greater implementation of universities' outreach initiatives that teach girls about engineering. The activities that were informal in nature and presented by university engineering students were advantageous in that the girls received knowledge on engineering, what engineers do, and what skills engineers do from someone close to their own age.

Thus, it would seem that engineering recruitment at the high school level would pay off strategically, and useful tactics should include providing high schoolers with information about engineering and its related careers, providing evidence that females can succeed in engineering (i.e.: having female engineering students present the information), and specifically encouraging females to do so. The purpose of this study was to determine whether the EA presentations, which utilized each of the aforementioned tactics, were effective in encouraging females to pursue engineering careers.

Methodology

Sample

A total of 929 students from 24 high schools in Illinois were given presentations and completed evaluation forms. Advocates made presentations at high schools that: (a) were selected by engineering students, (b) had requested a visit on the online request form on the EA web site (www.engr.uiuc.edu/sp/advocates), or (c) were selected by the Director of Special Programs. The Director targeted schools with large percentages of underserved populations (i.e.: minorities and women) and schools with outstanding academic reputations. The EA presenters were students in one of the 13 engineering disciplines at UIUC. Nine hundred twenty-six of the 929 high school students (99.68%) responded to Question 1: "Were you interested in engineering before this presentation?" Of these, 496 (55.56%) were male, and 430 (46.44%) were female.

Instruments

PowerPoint Presentation. The Microsoft PowerPoint slideshow (17 slides) presented to the high school students focused on engineering disciplines, possible careers with an engineering degree, and information on the College of Engineering at UIUC. One slide, for example, focused on the variety of career paths available to those who hold a degree in engineering. Another slide listed the 13 different engineering majors available at the university, and another displayed a bar graph illustrating the starting salaries of people in each of the engineering disciplines. Other slides emphasized the high ranking of several university engineering programs in *US News and World Report*, the wide variety of programs offered by the College of Engineering to support students, the various student organizations tied to engineering, and a few of the new facilities housing prestigious research programs. Several slides took a more personal focus on the students themselves by discussing engineering student myths, the courses to expect during a typical freshman year, and what courses to take while in high school.

One slide took a special focus on women in engineering. It featured a large picture of "Rosie the Riveter" proclaiming "We can do it!" Bold-faced statements asserted that almost a quarter of all engineering students in the U.S. are women, and that there is a high demand for women engineers. There was also a statement from the Dean of the College of Engineering at UIUC attesting to the benefits the college can provide to women students.

Evaluation Form. The evaluation form consisted of three sections. The first section contained demographic questions such as gender, school, and expected graduation date. The second section contained three interdependent yes/no questions that measure the students' interest in engineering careers before and after the presentation. And the third section contained four open-ended questions about the presentation itself (see Appendix for the complete evaluation form).

The second section of the form containing the yes/no questions is of primary interest to this study, and was as follows:

(1) Were you interested in engineering as a career before this presentation? ____ Yes ____ No

(a) If yes, did the presentation strengthen your interest in engineering? ____ Yes ____ No

(b) If no, are you now more interested in engineering? ____ Yes ____ No

Procedure

In the 2003-2004 school year, the students made their presentations during Thanksgiving Break (one week in November 2003), Winter Break (December 2003 to January 2004), or Spring Break (one week in March 2004). The students were responsible for making their own appointments at the schools if they volunteered to return to their former schools. Students usually used a personal connection, such as a former math or science teacher. If an alumnus of a high school could not be found for a "targeted" school or a school that had independently requested a visit, then the Director of Special Programs helped make the contact.

All presenters were encouraged to attend a meeting before their presentation where they viewed a mock EA presentation by one of the EA officers. Presenters were encouraged to share with the high schoolers information about their own engineering disciplines, their experiences as an engineering student (such as internship and study abroad experiences), and their career goals. Presenters were supplied with a portfolio which contained the Power Point presentation, “talking points” for each of the slides, handouts on how to contact schools and making a good presentation to high school students, and brochures on various programs at UIUC. In addition, the teacher was supplied with a folder containing information on all engineering departments and scholarships.

Advocate presentations were generally one-class period (50 minutes) in duration. At the beginning of each presentation, the Engineering Advocate handed out evaluation forms to all the high school students in attendance. The teacher or administrator who was sponsoring the presentation also filled out an evaluation (a different form), as did the presenter (also a different form). Advocates were encouraged to leave approximately 10 to 15 minutes at the conclusion of their presentation for questions and answers and to collect the evaluation forms. At the end of the school year, when all the evaluation forms had been turned in, the data were coded and entered into Excel spreadsheets.

Results

Responses to Questions 1, 1a, and 1b, were broken by gender and tabulated into one 2X2 contingency table for each question. For each table, the following statistical tests were conducted: (a) $?^2$ test of independence, (b) the phi coefficient, (c) the difference in proportions of males and females responding “Yes,” (d) the relative risk of females responding “No,” (e) and the odds ratio of females responding “Yes” to males responding “Yes.” Also, a possible confounding variable, presenter gender, was examined in a three-way contingency table. An alpha level of .05 was used for all statistical tests, and 95% confidence intervals (*CIs*) were computed.

Question 1

On Question 1, students were asked, “Were you interested in engineering before this presentation?” The 926 student responses are summarized in Table 1 by gender.

Table 1: *Frequencies of Student Answers to Question 1 by Gender*

Gender	Yes	No	Total
Male	270	226	496
Female	95	335	430
Total	365	561	926

The $?^2$ test of independence for this table was significant ($?^2 = 100.89$, $df = 1$, $p < .001$), indicating a dependent relationship between gender and response to Question 1. The phi coefficient for this table was -.330, and was statistically significant ($p < .001$), indicating a moderate inverse relationship between the proportion of males answering “Yes” and the proportion of females answering “Yes.”

The proportion of males answering “Yes” was .544, and the proportion of females was .221. The difference in proportions was .323 with a 95% *CI* of (.264, .382). Because the confidence interval does not contain zero, it is clear evidence that the proportions differ. This is equivalent to performing a hypothesis test at the .05 level of significance.

Also, the relative risk of answering “No” given that the student was female was 1.71 with a 95% *CI* of (1.53, 1.90). Because the 95% *CI* does not contain 1.00, it is evidence that response to Question 1 depends on gender, or that a female student is 1.71 times likelier to answer “No” than a male.

The odds of a male student answering “Yes” are approximately 6:5, but the odds of a female student answering “Yes” are approximately 1:3.5, a large reversal. Another way of describing this is with the odds ratio of females answering “Yes” to males answering “Yes”, which was .237 with a 95% *CI* of (.178, .317). Because the interval does not include one, it is evidence that there is a dependent relationship between a student’s gender and how that student answered the question. The odds of a male student answering “Yes” to this question are 4.21 times greater than the odds of a female student answering “Yes.”

Taken together, this is ample evidence that female students were less likely than male students to indicate having an interest in engineering before the presentation.

Question 1a

On Question 1a, students were asked, “If yes, did the presentation strengthen your interests in engineering?” The 350 student responses are summarized in Table 2 by gender.

Table 2: *Frequencies of Student Answers to Question 1a by Gender*

Gender	Yes	No	Total
Male	223	37	260
Female	80	10	90
Total	303	47	350

Both the $?^2$ test of independence and the phi coefficient for the table were statistically insignificant, indicating that gender was statistically independent of student response to Question 1a. This seems to indicate that there was no difference between male and female students already interested in engineering on whether the presentation strengthened their interest.

Question 1b

On Question 1b, students were asked, “If no, are you now more interested in engineering?” The 534 student responses are summarized in Table 3 by gender.

Table 3: *Frequencies of Student Answers to Question 1b by Gender*

Gender	Yes	No	Total
Male	142	77	219
Female	193	122	315
Total	335	199	534

Again, both the $?^2$ test of independence and the phi coefficient for the table were statistically insignificant, indicating that gender was statistically independent of student response to Question 1b. This seems to indicate that there was no difference between male and female students uninterested in engineering on whether the presentation increased their interest.

Effect of Presenter Gender on Question 1b

A possible confound of the aforementioned results was the gender of the college students making the Powerpoint presentations. The students responses to Question 1b were summarized in a 2 X 2 X 2 table—response X gender X presenter gender—which is replicated in Table 4. Of the 533 student responses (there was one student for whom presenter information was not available), 198 were "Yes" and 335 were "No."

Table 4: *Students Responses to Question 1b by Gender and Presenter Gender*

		Response		
Presenter Gender	Student Gender	Yes	No	Total
Male	Male	25	53	78
	Female	46	68	114
Female	Male	52	89	141
	Female	75	125	200
Total	Male	77	142	219
	Female	121	193	314

Cochran's Mantel-Haenszel Test of Conditional Independence was performed at the .05 alpha level, and was insignificant, indicating that presenter gender was independent of student gender on responses to Question 1b. This is evidence that presenter gender played no role differentiating responses between male and female students.

Discussion

There was a statistically significant difference between the proportion of boys who said they were interested in engineering before the presentation and the proportion of girls who said the same. The difference was large, 54.4% of boys versus 22.1% of girls, and was illustrated by the relative risk: a girl was 1.71 times as likely as a boy to report having no interest in engineering before the presentation. Aside from the size of the difference between the proportions themselves, the relative risk and the odds ratio between boys and girls confirmed that the difference is of practical as well as statistical significance. The odds ratio, 4.21, said that the odds of a boy reporting having been interested in engineering before the presentation were more than four times higher than the odds of a girl reporting having been interested. This result seemed to fall in line with conventional wisdom, which says boys are more likely to be interested in engineering than girls.

However, the results of the two follow-up questions to Question 1, Questions 1a and 1b, provided hope that we can change that state. On Question 1a, students who answered “Yes” to Question 1 were asked, “Did the presentation strengthen your interest in engineering?” The difference in proportions between boys and girls answering “yes” all but disappeared, reducing to just 3.1% in favor of girls. Having one’s interest in engineering strengthened after the presentation was independent of one’s gender.

Yet more powerful were the results of Question 1b, where students with no interest in engineering before the presentation were asked, “Are you now more interested in engineering?” Again, the difference in the proportions of boys and girls answering “Yes” was quite small, 3.5% in favor of boys, and statistically insignificant. There was no difference between the likelihood of a boy and that of a girl becoming interested in engineering after the presentation when initially being uninterested.

The fact that gender differences disappeared after the presentation becomes more meaningful when another fact is considered: of the 315 girls who said they were not interested in engineering before the presentation, 193 (61.2%) said they were more interested after the presentation. These two facts support the argument that the EA presentations bridged the gender gap of interest in engineering as a career, and that the strategy of targeting female high school students by presenting them with engineering career information, evidence of female success in engineering, and specifically encouraging females to major in engineering at an institutional level, was extremely effective.

However, this analysis does not account for the ancillary grouping of individuals by school, individual presenter, or teacher. Investigation of differences in attitudinal change based on the gender of the presenters turned up no evidence. The initial difference in gender on Question 1 overall may disappear when such groupings are accounted for in the parsing of measurement error. Further statistical analysis, such as hierarchical linear modeling or the analysis of three-way contingency tables, is needed before any definitive conclusions can be drawn.

During the EA presentations, students were offered the opportunity to sign up to receive mailings from the College of Engineering about events and programs for high schoolers interested in engineering. Approximately 200 students signed up in 2003-2004, and were entered into a tracking database maintained by the Office of Special Programs. Unfortunately, it was not known at the writing of this article whether any of the students who graduated in 2004—427 of the 929 (46.0%) students expected to graduate in 2004—attended UIUC in the fall semester. In any event, the relevance of such data is dubious because of the highly selective admissions criteria applied by the College. It is not known if the EA presentations were any more or less effective with students who would have qualified for admission than students who would not have qualified.

References

American Association of University Women (AAUW). (1992). *How schools short-change girls*. Washington, DC: AAUW.

American Association of University Women (AAUW). (1998). *Gender gaps: Where schools still fail our children*. Washington, DC: AAUW.

Atwater, M. M., Colson, J. J., & Simpson, R. D. (1999). Influences of a university summer residential program on high school students' commitment to the sciences and higher education. *Journal of Women and Minorities in Science and Engineering, 5*(2), 155-173.

Gilligan, C. (1982). *In a different voice.* Cambridge, MA: Harvard University Press.

Goodman, I., Cunningham, C., Lachapelle, C., Thompson, M., Bittinger, K., Brennan, R., et al. (2002). *Final report of the Women's Experiences in College Engineering Project.* Cambridge, UK: Goodman Research Group.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing.* Cambridge, MA: Massachusetts Institute of Technology Press.

Takahira, S., Goodings, D. J., & Byrnes, J. P. (1998). Retention and performance of male and female engineering students: An examination of academic and environmental variables. *Journal of Engineering Education, 87*(3), 297-304.

Yauch, C. A. (1999). Majoring in engineering: A study of gender differences. *Journal of Women and Minorities in Science and Engineering, 5*(2), 183-205.

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Appendix

Presentation Evaluation Form

ENGINEERING ADVOCATES
University of Illinois @ Urbana-Champaign

Student Evaluation

School: ____________________________________ Date: _____/_____/______

Male: ______ Female: ________ Expected Year of Graduation: ____________

(1) Were you interested in engineering as a career before this presentation? ____ Yes ____ No

(a) If yes, did the presentation strengthen your interest in engineering? ____ Yes ____ No

(b) If no, are you now more interested in engineering? ____ Yes ____ No

(2) What did you like best about the presentation?

(3) Name three things you learned about engineering

(1) ____

____

(2) ____

____

(3) ____

____

(4) Name at least two things that you think should be included in future presentations

(1) ____

____

(2) ____

____

(5) Additional Comments: (use back of sheet if necessary)