AC 2008-788: MENTORING YOUNG GIRLS INTO ENGINEERING AND TECHNOLOGY

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Mentoring Young Girls into Engineering and Technology

Abstract

We continue to see a decrease in percentage of women entering the engineering field, a trend that will continue for the near term according to ASEE. Studies show that a large number of girls outperform boys in science and mathematics in elementary schools. However, by the time these girls are beginning to consider their college and life career, they are less and less interested in math and science.

Low female student enrollment in the College of Engineering and Architecture, North Dakota State University is of particular concern as our numbers lag behind national numbers significantly. In order to increase our female student enrolment numbers we have been working offering an engineering and technology after school program aimed at fourth-through seventh-graders. This is an interactive, 10-week program that brings girls to campus to work with female engineering students. Girls are exposed to engineering and technology through demonstrations, hands-on activities, and interactions with female engineering students. In this paper we discuss the important elements of the outreach program and share both quantitative and qualitative data compiled from participants and their parents/guardians and mentors.

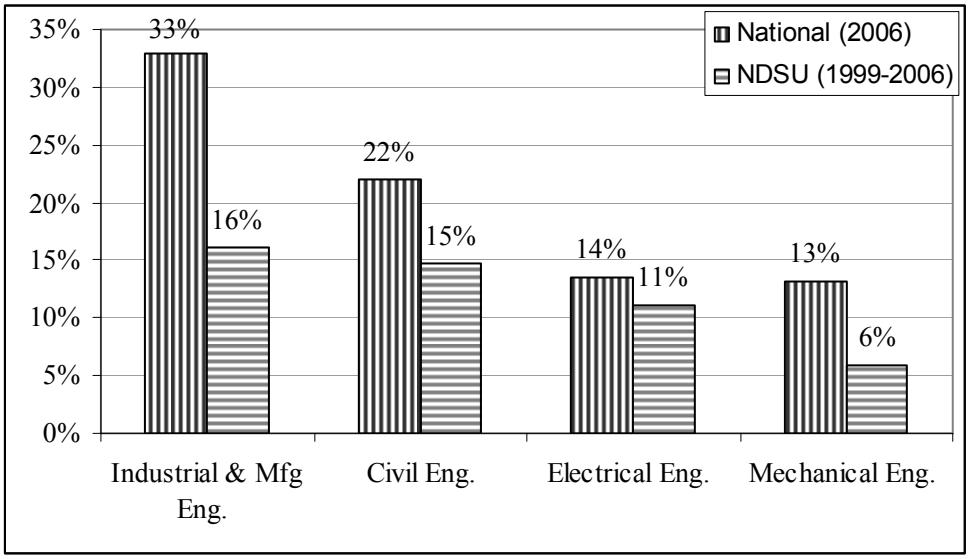
Introduction

In spite of the progress made in the past two decades, women remain a minority in science, technology, engineering, and mathematics professions. Women still enroll and remain in engineering fields in disproportionately smaller numbers than men. Female students tend to avoid mathematics, science or engineering majors in order to maintain their femininity. The reasons cited for not choosing science and engineering majors include social rejection, peer acceptance and loss of appeal to the opposite sex.[1]

Even though women constitute fifty percent of our intellectual resource, engineering is deprived of the valuable talent and diverse thinking, women bring into the profession. This is emphasized by the fact that women form fifty percent of the consumers of products in our society and make over fifty percent of the purchasing decisions.[2] While there has been an increase in the number of students enrolled in undergraduate engineering programs the percentage of women earning bachelor degrees has only been around 20%. According to ASEE from 1999 to 2006, the percent of total engineering bachelor degrees earned by women varied between 19.3% and 21.2%.

Under representation of women in the College of Engineering and Architecture, North Dakota State University (NDSU) is of particular concern as our numbers lag well behind the national statistics (Table 1). Overall, from 1999 to 2006 the percentage of engineering bachelor degrees awarded to women varied between 8.2% and 13.3%. However, percentage of degrees awarded to women varies greatly from major to major as well as from year to year. For instance, in 2001 percentage of mechanical engineering and industrial and manufacturing engineering degrees awarded to women were 4.3 and 19.1, respectively.

Table 1. Comparison of engineering bachelor degrees awarded to women at NDSU and nationally

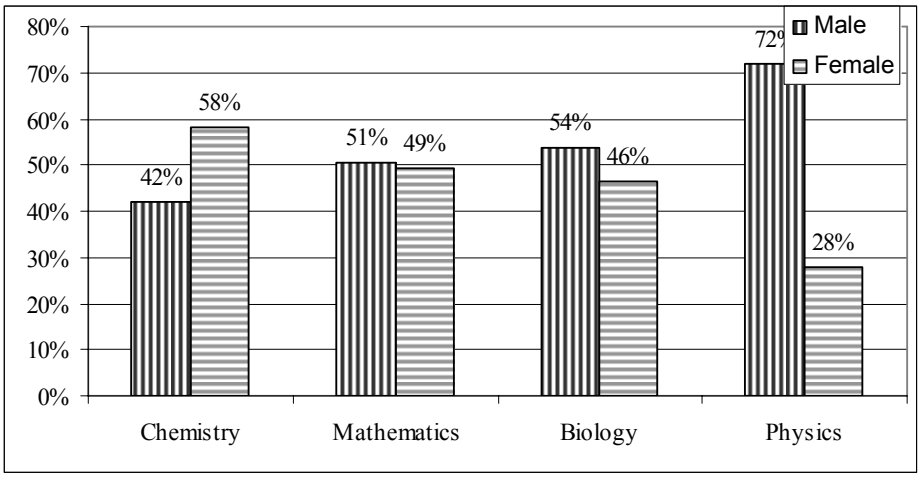


Much work has been done in the nation to identify the needs of girls in science, technology, engineering, and math (STEM) and to develop programs to encourage their progress. Today girls tend to, more than in the past, take advanced elective math and science courses necessary to begin a STEM major in college. A recent survey of area high schools show that, with the exception of physics, the number of female students is comparable to or higher than the number of male students taking elective advanced math and science courses (Table 2). Research indicates that taking science and math courses in high school has a substantial effect on success and persistence in STEM.[3,4] Clearly, female students in area high schools have as strong backgrounds in math and science as male students. Furthermore, female college students are represented in science and math fields, with the exception of physics, at much higher rates than their representation in engineering (Table 3). Percentages of degrees awarded to women in mathematics, biological sciences, and chemistry at NDSU are comparable to national statistics.

Modeling and mentoring are essential impetus for encouraging women to go into engineering.[5] A role model is usually a person who serves as an inspirational figure, generally resembling the person they serve in terms of gender, race, and other personal characteristics.[6] Research indicates that role models influence career choice[7] and especially attitudes towards non-traditional careers.[8] In fact role models and mentors starting from early grades impact girls' attitudes towards math and science courses and STEM professions in general.[9,10,11,12]

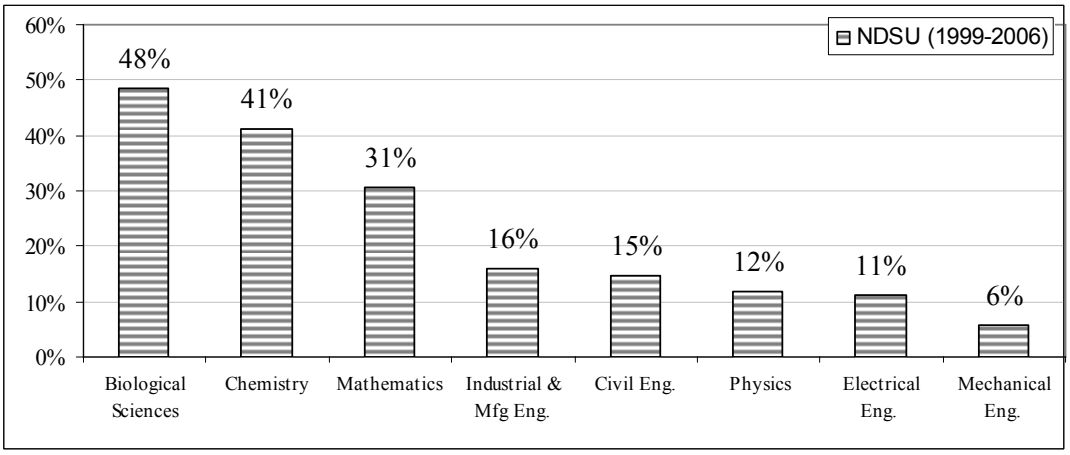
Lack of role models and mentors[9,13,14] and lack of interaction with other women[15] in STEM fields contribute to gender discrepancies in education. In fact, female students perceive role models to be especially important for women who want to pursue non-traditional careers.[16] Lack of female role models and mentors in nontraditional female occupations hinders the recruitment and retention of female students as well as the occupational choice in STEM fields.[17,9,18] Hence researchers recommend positive female role models for encouraging the recruitment and retention of women in engineering.[19]

Table 2. Enrollment rates by gender in elective science and math courses in area high schools



Additionally, encouragement from the family is important in the decision of women students to pursue engineering.[20,21] Unfortunately, not all girls receive encouragement from their parents/guardians to do well in science and engineering. Parents and significant others may actually discourage young women from studying engineering.[22]

Table 3. STEM bachelor degrees awarded to women at NDSU between the years 1999 and 2006



Engineering and Technology after School Program for Girls

In order to increase the number of female engineering students, since 2002 NDSU has been offering an engineering and technology after school program aimed at fourth-through seventh-graders. The program is a joint effort with the local YWCA's Empowerment of Girls program and targets girls aged 9 to 12 as support and intervention programs prove to be most effective during middle school years. Starting with the middle school years girls' interest in math and science decline mainly due to a perception that these subjects are boring, a disconnect with the relevance of these fields, and a decline in girls' confidence in their abilities with respect to these subjects.[23] Gender differences in performance are related to gender stereotyping about these subjects and contribute to girls' interest, attitudes, and achievement. Therefore, early interventions around middle school years are critical.[24,25,26]

Around the age of nine to 12, girls start to develop and explore their interests. In addition, for girls in these age brackets role playing and observing women around them plays a significant role in developing their identities and shaping their interests. Thus, this is a crucial time to provide opportunities for girls, especially those from underprivileged communities without immediate role models in engineering and technology, to interact and develop relationships with women in engineering and technology fields.

The goals of the program are to:

1. generate and increase the participants' interest, confidence and competence in the area of technology,
2. help the participants use this confidence and skill in their math and science courses,
3. provide participants with role models from engineering fields,
4. help the participants imagine themselves going into engineering and technology related careers,
5. enhance the understanding of engineering among the guardians of the participants, and
6. help the guardians of the participants to be aware of the critical role their encouragement plays in the decision of the participants to pursue an engineering degree.

This engineering and technology after-school program brings girls to the NDSU campus for two hours per week for 10 weeks. Girls are exposed to engineering and technology through demonstrations, hands-on activities, and interactions with female engineering students. The program strives to broaden young girls' interest in technology, while also introducing them to female mentors as role models and instructors in technical fields. The female engineering students are from the NDSU chapter of Society of Women Engineers (SWE).

The by-girls-for-girls structure of the program is intentional as girls are more likely to thrive in single-sex learning environments.[27] Inaddition; women mentors have more positive influence on female students than male mentors.[28] Mentoring is not an obvious or natural activity and good mentoring is enhanced through training.[29,30] Therefore, prior to the start of the program the mentors and the instructors go through a brief training program.

A new group of students are served each academic semester. The program serves 15 to 30 participants every semester and is staffed with two instructors and three to six mentors. The program gives priority to girls from low-income families as girls from low-income families are less likely to have engineering and technology exposure and women mentors from technical fields. The program charges a nominal fee of $20. Requesting participants receive scholarships due to low income status.

The curriculum consists of hands-on engineering activities, exploration of many technologies, and field trips. Once a week girls are introduced to computer animation, engineering, and robotics. The participants are exposed to several computer programs. They use Microworlds, a computer animation program, to make a calendar and a weather themed picture that is shown on 5:00 pm local weather news. The girls practice robotics by programming a vehicle they build with Legos to follow a path. They also use software on the internet to design a bridge. In one of the hands-on activities, girls use a computer to design their own pendants and watch them actually being made by a Computer Numerical Control machine in NDSU's manufacturing

processes lab. The pendants serve as a reminder to the participants as to what they learned with the hope that it will have an influence on them in the future as they start making plans for their own careers. In one of the field trips, the participants tour a local manufacturing company to see how engineering translates into manufacturing. They get exposure to business side of engineering by managing their own paper airplane company (Figures 1-3).

The highlight of the 10-week session is a social event in which the participants show parents/guardians their calendars, pictures, and Lego robotic vehicles. The social event is an important opportunity for parents/guardians to learn about engineering and technology related careers, low representation of females in these fields, and the important role family, especially parents, plays in the decision of women students to pursue engineering.

The hands-on exposure to technology and engineering is only part of the program. An important element of the program is the interaction with the college age mentors and instructors, who are female engineering students. The duration of the program allows the participants to build meaningful relationships with their mentors. This is also a good time for the NDSU female engineering students. The mentors and instructors enjoy the experience as much as the girls.

Program Evaluation

So far ten groups of students have gone through the program. Since its inception, interest in the program has been high. Usually, most of the participants are fourth and fifth graders followed by sixth and seventh graders. However, participant age varies significantly in each offering. The most recent offering had about 80% of the participants in fourth grade.

Program evaluation involves pre- and post-surveys of participants and their parents/guardians. To assess the long term impact of the program, phone interviews are conducted with participants and their parents/guardians three years after participation in the program. Participant, parent/guardian, as well as mentor feedback is used to improve the program after each offering.

Pre-Survey. On the first day of the program, the participants fill out a pre-survey. In addition to help assess the effectiveness of the engineering and technology program, the pre-survey contains detailed information about participants' job interests, attitudes towards and confidence in math, science, engineering and technology.

Out of the 13 jobs that were listed in the pre-survey, majority of the participants were not sure whether they would be interested in becoming an *engineer.* While *architect* was the top job choice, the participants were also in interested in nurse, medical doctor and computer technician jobs. The participants were not interested at all in electrician, auto mechanic, and welder jobs.

Most of the participants (62.5%) somewhat or strongly agreed that a degree in engineering would allow them to obtain a well paying job and a similarly high percentage (58.3%) also somewhat agree and strongly agree that engineering interests them because they like to think about solving technical problem. However, almost as many (45.8%) of the participants were not sure whether engineering skills would allow them to better the society. Although, the participants were more

confident of their abilities in science than in math, their interest in careers in math and science was comparable. Furthermore, most of participants indicated that they perceive their performance to be very well in science and not as well in mathematics.

Figure 1. Girls are programming and testing their lego robot vehicles.

Figure 2. CNC machined pendants and learning about TV cameras.

Figure 3. Local TV station and manufacturing facility tours.

Post-Survey. About half of the participants indicated that the program helped them a lot in increasing confidence in their abilities in math and science. Similarly, about half of the participants indicated that the program increased a lot their interests in math and science. The program also increased about half of the participants' confidence in their abilities in technology and even more importantly increased about 83% of the participants' interest in engineering and technology.

Participant parents/guardians confirmed that the program increased their daughters' interest and confidence in math, science, engineering, and technology (94.5%). Almost 80% of the parents/guardians thought as a result of the program their daughters are interested a lot in engineering and technology related careers. In addition, 87.4 % of the parents/guardians rated their general feelings about the program 8 or higher (out of 10 points). Sample comments from the parents/guardians include:

> *"She looked forward every Monday to go to this class. We would like to do something like this again".*
> *"We were very pleased that Katie was exposed to engineering and engineers! We expect this program to pay dividends for a long time".*
> *"Great mixed of instruction, hands on application, and field trip. Not having the distraction of unruly boy behavior a definite plus. Great ratio of students to mentors. Nurturing and low pressure achievement environment fosters confidence and risk taking without frustration".*
> *"Before attending this program, Sarah was embarrassed to say that she was good at or liked math. This program really showed her it was OK to be good at these skills."*

Almost all parents/guardians and about half of the participants consider the female mentors/instructors to be an important element of the program. Most parents/guardians had some interaction with mentors/instructors and 87.5% rated them as good and excellent in helping the girls. Parents commented that:

> **"***These women who volunteered their time to the girls were friendly, outgoing, nurturing and positive role models. They are an example of what (or who) I'd choose for my daughter to model herself after".*
> *"I like the "all girls" environment with technology emphasis. Having the opportunity to work with women as role model was great".*

LegoRobotics, computer animation (Microworlds), local TV station and manufacturing company tours, and mentors are the top four things that the participants most enjoyed in the program. They learned the most in LegoRobotics. Participants had these to say on the activity they enjoyed the most:

> **"***The Robot car because we have a lot of teamwork"*
> *"KVLY, learning about news weather, meeting news people for TV that you see everyday"*
> *"I liked the robot and it really helped me understand more about what engineers do"*
> *"Learning about different engineering things. Building bridges and robots."*
> *"Robolab because you fixed your mistakes."*

Phone Interviews. Phone interviews consist of questions selected from the post-survey to assess the long term effect of the program on the participants' attitudes towards engineering and technology as well as math and science. Participants and their parents/guardians are contacted three years after having participated in the program.

About three years after their daughter's participation, a relatively high percentage of parents/guardians (77.4%) thought that the program helped increase their daughter's interest and confidence in science, technology, engineering and math. The percentage that thought that the program increased interest in engineering and technology related careers remained about the same. Still, most parents/guardians considered (90.3%) female mentors to have been the most important element of program.

Participants' view of the program's impact on their math and science confidence and interest dropped about 10 percentage points from the time they first participated in the program: interest, 41.2% versus 50.0%; confidence, 38.2% versus 50.0%. While a similar drop rate is reported for technology confidence (41% versus 50.0%), unfortunately, the participants' interest in engineering and technology decreased about half (44.1% versus 83.3%).

Looking back, a higher percentage of participants (67.7%) consider female mentors/instructors from engineering to be a very important element of the program. Three years after participating in the program, 44.1% of the participants are still unsure of the job they are interested in pursuing.

Mentor/Instructor Surveys. Most mentors and instructors view the program to be a rewarding experience. The mentors and instructors enjoyed working with young girls and seeing their reactions when the girls accomplished building their bridges and programming Lego robotic cars.

Mentors consider being a role model to be an irreplaceable experience. The mentors also regard the program to be a challenging experience at times. Through the program, the mentors learned that patience and effective communication are important when working with others. Although a few of the mentors expressed interest in staying in touch with the participants, interactions beyond the duration of the program were not facilitated or evaluated.

Mentors also valued the opportunity to work with other female engineering students and form/enlarge their peer networks. Support provided by the peer network is crucial for the academic success of female students and their persistence. Although not assessed, the program may have indirectly helped with the attrition rate of the female engineering students who participated in the program as mentors and instructors.

Conclusion

The engineering and technology for girls after school program has benefited young girls as well as female engineering students. Industry, University, YWCA, and SWE support are keys to success of this program.

The after-school program described in this paper can be easily implemented in other schools. The hands-on exposure to engineering and technology can involve many different activities designed to emphasize various aspects of engineering. All girls learning environment, female role models/mentors, and engaging parents/guardians are crucial elements of the program. Offering a program on the university campus as opposed to at a local elementary/middle school may pose challenges for some parents/guardians. However, seeing the university campus and spending time in the engineering laboratories are exciting for young girls. Offering the program on campus also makes it easier to find female engineering students who would volunteer to be mentors and instructors for the program.

In its sixth year, the demand for the program continues to be strong. It is too early to assess the impact of the program in increasing female student enrollment at NDSU. Articles and programs that appeared in local print and broadcast media communicate effectively to the broader community the importance of engineering and technology and the need to encourage more girls to pursue related fields. Indirectly, the program helped increase the visibility of the NDSU Engineering College as well as enhance the image of engineering in the area.

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