Reaching Engineering and Architecture Career Heights: A Pre-College Program To Interest Young Women in Engineering, Architecture and Technology

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Abstract

There is a need to encourage more young people to consider careers in the technical fields of Engineering, Architecture or Technology. Specifically, an increase in women choosing careers in these fields could help curb the predicted shortfall in the professional workplace. To address this need, three summer academies were held at Oklahoma State University. The primary goal of these academies was to introduce young women to the possibilities available to them within the professional fields of Engineering, Architecture and Technology.

Needs Addressed and Project Objectives

The United States faces a shortfall in the number of engineers available to meet the needs of our ever increasing technological society in the 21st century. Atkinson observes that the employment rate for scientists and engineers is increasing faster than total U.S. employment[1]. Pool states that the number of jobs for scientists and engineers should grow at a rate of two times the rate of the rest of the economy[2]. To stay competitive with other advanced societies, the United States must find other sources of professionals to serve as engineers, rather than the traditional white male. It is estimated that 85 percent of those entering the workforce in the year 2000 will be minorities and women[3]. As women make up over 50 percent of the population, they are one of the best sources of available talent to draw upon to fill future needs in fields based upon the application of technology.

Young women are not choosing to enter technical careers at the same rate as young men, however. The drop-off in the study of technical careers among young women is extremely steep from high school through college[4]. Although many reasons are debated as to why this drop-off occurs, there is no dispute that it exists[5]. Programs that support and encourage young women to choose technical careers must be pursued. Engineering and architecture provide challenging career options for women where many of their talents can be drawn upon. The fields of engineering and architecture can only become more diverse and broadly based as relatively untapped populations are involved.

Women are seriously underrepresented in the ranks of scientists and engineers[6]. Women earn more than half of all bachelor's degrees awarded at U.S. colleges and universities. However, in science and engineering disciplines they receive only 30 percent of the bachelor's degrees conferred[7]. Since this figure includes the traditionally "female" field of psychology, the situation is actually more alarming.

Within the field of engineering, an increase in bachelor's degrees conferred to females has been seen over the last few decades. In 1952, 0.17 percent of all bachelor's degrees in engineering were awarded to women, in 1960, 0.38 percent, in 1970, 0.83 percent, in 1975, 2.3 percent, and in 1981, 15 percent[8]. The percentage of women engineering and architecture students has remained at levels of 15 to 20 percent into the late 1990's.

Statistics at Oklahoma State University (OSU) are similar. Women comprise 46 percent of the student population, yet only 16 percent of the population in the College of Engineering, Architecture and Technology are women. It is obvious, and this data supports the fact, that young women are not choosing to pursue careers with a focus in technology and science at the same rate as young men. The drop-off in the study of science among women is extremely steep from high school forward.

Moreover, demographic statistics point to an alarming shortfall of engineers and architects in the 21st century. The number of technically educated persons must increase to meet future industrial, governmental, and academic needs. Underrepresented populations must be exposed to career possibilities in the technical fields of engineering, architecture, and technology. Women make up only ten percent of the engineering work force, and the number is only slowly rising[9]. The number of minority women in engineering in school and in the workplace is even lower.

To acquaint women at the high school level with engineering and architecture, they must be provided with an environment where they can be introduced to the field and where they can witness female role models. They must also be made aware of what being an engineering or architecture student means, what it is like to work on team projects, and the qualities that are necessary to be a successful professional.

In an effort to increase the number of females entering these fields, and address the growing need for additional technical personnel, three summer residential academies for female high school juniors and seniors were held at the College of Engineering, Architecture and Technology (CEAT) at OSU. The Reaching Engineering and Architectural Career Heights (REACH) academies were held during the summers of 1996, 1997 and 1998. The success of these academies is evidenced by the fact that over seventy percent of the REACH 96/97 participants who entered college in 1997 and 1998 have chosen to major in engineering, architecture, or technology.

Recent contact with participants from these academies revealed the students felt the program had an enormous impact on their decision to pursue studies in engineering or architecture:

"I was amazed at the variety of opportunities I was given. We were not tracked or persuaded to one specific area, but instead were enabled to experience all sorts of interesting things. I like how creativity and originality were stressed." *REACH 96 participant*

"I liked the opportunity I had to learn about myself and my interests. I enjoyed the hands-on things we did and loved the modules." *REACH 97 participant*

"I enjoyed getting to know exactly what each type of engineer does. I also enjoyed the projects we got to create without being told exactly what to do." *REACH 98 participant*

The primary objective of the REACH academies was to provide factual, experiential information to participants in order to help them make good individual career decisions. To achieve this goal, the academies were focused on academic modules in six engineering disciplines, architecture and technology, all of which provided participants with a basic understanding of the issues that professionals in these fields face in terms of ethics, environment, energy conservation, safety, and societal concerns.

In addition to increasing the high school students' awareness of engineering and related disciplines, the academies provided hands-on laboratory, problem-solving and teamwork experiences as well an exposure to college life. A career guidance module designed to help the young women understand the professional opportunities available in the fields of architecture, engineering, and technology was offered to help them make informed career decisions. Computer, technical, and communication skills were also addressed. Furthermore, the students had several opportunities to discuss many topics with female college students and practicing professional role models. Female engineers and architects from multiple engineering and architectural firms within the state of Oklahoma were recruited to serve as mentors and role models for the REACH participants, thus providing an additional "real world" view of the professions.

The academies were an example of the ideal partnership between government, industry, and academia. The REACH academies received funding from the Oklahoma State Regents for Higher Education, Phillips Petroleum Company, the National Aeronautics and Space Administration, and the College of Engineering, Architecture and Technology at Oklahoma State University. Phillips Petroleum Company provided female mentors and facility tour opportunities, as well as generous financial support. NASA provided financial support and a female guest speaker who addressed the participants on the role of an engineer in the Space Shuttle program. Oklahoma State University provided facilities, technical support, and faculty release time. The academies were offered at no cost to participants.

Methodology

Administration, Recruitment and Selection

In an effort to meet the objective of increasing the number of women choosing technical careers, the REACH academies were structured to expose the participants to a broad spectrum of technical disciplines. Each respective department in the College of Engineering, Architecture and Technology at Oklahoma State University participated. Faculty from the departments of Architecture, Biosystems and Agricultural Engineering, Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering, Industrial Engineering and Management, Mechanical and Aerospace Engineering, and Technology taught the academic modules in their respective disciplines. Laboratory and research facilities associated with each department were incorporated into the learning experience. Two female faculty members from Architecture and Industrial Engineering served as co-directors of the academies.

The primary tools for recruitment were personal contact with potential participants and direct mailings to Oklahoma high school women and high school math/science teachers. These direct mailings included a colorful poster and brochure, along with an application packet. The elements of the application packet included a compilation of the student's academic record as well as a short answer segment and an essay portion, which the applicant completed on a separate page. Confidential recommendations from the student's math or science teacher were also required.

The selection process was centered on the identification of academically strong individuals who had a sincere desire to attend the academy. The first screening was based on performance criteria, including ACT scores and GPA, and the level of math and science courses completed in high school. The short answer section of the application form was also very critical to the selection process. This section included questions on topics such as their future plans, what interested them about engineering or architecture, and what female role model they admired and why. The longer essay was also a determining factor; this essay asked them to describe why they wanted to attend the academy, and how they felt it would affect their future.

Introductory activities

The academies were carefully organized with a balance of academic, career guidance and social activities. Initial academy activities were devoted to fostering the group cohesiveness necessary for a successful academy. This was accomplished through the use of small group introduction activities the first evening, and participation in a ROPES course the first full day of the academy. The ROPES course fostered teamwork and trust within the group. Special team building activities were utilized to allow the students to get to know each other, and what they could achieve individually, and in a group setting.

An introduction to engineering, architecture and technology was held on the second day of the academy. The department head of Chemical Engineering gave an introductory talk on the role of the engineer and how engineers, architects and technologists work together to design and improve systems. Two faculty members in Civil Engineering led an interactive game in which each of the participants represented an entity such as an industry, a government agency, or a private citizen with an interest in, or significant effect upon, the water quality in the Grand Lake

Basin in Northeast Oklahoma. This lively exercise provoked animated discussion among participants. It demonstrated some of the additional factors involved in engineering decision making including economic limitations, cost-benefit analysis, and engineering ethics, which the participants may not have considered previously.

Career Guidance

The career guidance activities included three sessions. First, the Director and the principal student advisors of CEAT Student Services at OSU provided general college enrollment and scholarship information. Next, an OSU graduate student in speech communication presented an evening session on effective oral communication. Finally, the REACH participants shared an evening meal and additional personal discussions with nine female mentors. The mentors were accomplished professionals in Oklahoma, as all are practicing architects or engineers.

Academic Modules

Architecture

To begin understanding the aspects of the career of an architect, students were asked to design an artist's display module for a park in downtown Oklahoma City. The students were challenged to rethink their conventional notions of what an artist's display module could be; they were asked to consider the problem as "functional sculpture". Issues of public circulation, image, and display of the pottery items were addressed individually by the students, and critiqued by three Architecture faculty members. In addition, an informal evening session was held where information on the profession and the exciting work that an architect or architectural engineer performs was discussed.

Biosystems and Agricultural Engineering

The Biosystems and Agricultural Engineering module introduced participants to food bioprocessing. Pigmentation and enzyme experiments were conducted in addition to food processing and canning testing activities. The importance of accurate testing procedures for food safety was illustrated. The second Biosystems and Agricultural Engineering module focused on Global Positioning System (GPS) and its uses. After learning about the GPS hand held units, the participants used the GPS units to locate popular campus landmarks.

Civil and Environmental Engineering

The Civil and Environmental Engineering module focused on the development of a bridge, which would meet certain criteria for weight, loading capability, and material usage. The young women designed and constructed these bridges in teams, and recorded the hours of labor as well as the amount of materials used in the construction process. Each bridge was then tested for its maximum loading and efficiency.

Chemical Engineering

Participants in the Chemical Engineering module received a brief overview of the profession of Chemical Engineering, participated in a laboratory experience, and were introduced to two computer software packages (EXCEL, and CHEMCAD) necessary for successful practice in Chemical Engineering.

Electrical and Computer Engineering

The Electrical Engineering faculty organized tours of five different Electrical Engineering laboratories (Automatic Controls, Ultrafast-Tetrahertz-Optoelectronic, Electrical Machines, Oklahoma Imaging Laboratory, and Computer-based System Design). The students participated in two hands-on Electrical Engineering teaching modules, using power system dispatcher training software and assembly of a stroboscope. The stroboscope was tested and used to "stop motion" of a rotating machine and water droplets in a water fountain, illustrating fundamental Electrical Engineering concepts.

Industrial Engineering and Management

The Industrial Engineering and Management module introduced the REACH participants to the integrated world of the industrial engineer. Faculty members provided an explanation of the profession of industrial engineering and led the participants in a production/assembly exercise. Issues that affect any manufacturing enterprise, such as facility layout, production planning, quality control, and management, were discussed.

The concept of computer simulation was introduced using the ARENA© simulation software package. Participants completed an exercise using the software. The students learned about the concept of modeling and simulation as decision-making tools, and were introduced to concepts of randomness and variation, considering their effects on a system's performance. Finally, the faculty led the students in a participatory exercise about quality control, introducing the concepts of common and special cause variation, and management's impact on the quality of a product.

Mechanical and Aerospace Engineering

In the Mechanical and Aerospace Engineering module, the women designed a solution to a problem which required them to send food supplies to space explorers via rocket payloads. Each team had a different challenge, as each rocket had a unique required food payload weight and height goal. The students utilized a special computer program to help them calculate the placement of fins, payload and fuselage to achieve a stable rocket. Upon the completion of the construction process, the rockets were put to the test - all were successfully launched, and all of them met their design goals.

Technology

Technology faculty introduced the students to a mechanical and power technology problem that involved the application of the Ideal Gas Laws. Working in teams, the participants demonstrated their understanding of these scientific principles using a pneumatic cylinder and a pressure gauge. In addition, they were challenged to assemble a variety of pneumatic cylinder circuits, which provided continuous sequential reciprocation of two cylinders.

Other Academic Experiences

Academy participants, directors and staff were invited to a special tour of the Phillips Research Facility in Bartlesville, Oklahoma. Practicing Phillips engineers and scientists led the students on a tour of the plastics pilot factory, a simulated oil refinery, and world class research laboratories where interactive exhibits were on display.

Following their engineering experience at the Phillips Research Facility, a guided tour of the Price Tower, designed by renowned architect Frank Lloyd Wright, was arranged. At the Price Tower, the women were introduced to the life work of this prestigious architect, and then given a personalized tour of all the important spaces within the design of the tower. Among the locations visited were Mr. Price's penthouse office, one of the guest apartments for visitors of the Price Company, the company cafeteria, and a typical office floor. The Price Tower was one of Wright's few commercial projects to have been fully realized, and is now a designated National Historic Landmark.

Final Presentation

The academies were completed with a final presentation to parents and faculty, led by the REACH participants. The students displayed their work and described the challenges and successes they had experienced during the academies. The students were each responsible for a portion of the final presentation. Each prepared a brief oral presentation about their topic and designed an informational poster for the poster display. Each individual participant had an architecture module on display and the bridges developed by teams of participants during the civil engineering module were tested and evaluated.

Each young woman delivered an oral presentation on an aspect of the academy, utilizing the presentation skills developed earlier in the academy. Scrapbook and web pages documenting the academies were prepared using the text written by participants for the final presentation. The websites can be viewed at http://master.ceat.okstate.edu/REACH/REACH.html.

Objective Evaluation and Evidence of Project Impact

The primary objective of the REACH academies was to increase the participants' awareness of engineering, architecture and technology as potential careers. In order to assess the effectiveness of the academy as measured against the objective, five different surveys were administered in each academy. One survey was administered at the end of each academy to monitor satisfaction levels with particular academic modules and activities. Three additional surveys, one administered prior to the academy, one at the end of the academy, and one a month after the academy (post-academy), were used to assess the participants' knowledge of the various disciplines, and how appealing each discipline appeared to them before the academy, at the end of the academy, and post-academy. Finally, input from parents was obtained in a post academy survey to assess the parents' reactions.

Results pertinent to the success of the academies with respect to the primary objective are contained in Tables 1, 2 and 3. The results indicate a significant increase in understanding of the career opportunities in each discipline as a result of the academies.

How would you characterize your understanding of the career opportunities in the following disciplines?

	Pre-academy	End of academy	Post-academy
Architecture	2.53	4.00	4.07
Architectural Engineering	2.30	3.52	3.67
Biosystems & Agricultural Engineering	1.63	2.30	2.47
Chemical Engineering	2.33	3.37	3.60
Civil & Environmental Engineering	2.30	4.19	4.13
Electrical & Computer Engineering	2.52	2.48	2.93
Industrial Engineering & Management	1.97	3.37	3.47
Mechanical & Aerospace Engineering	2.27	3.26	3.60
Engineering Technology	1.76	3.26	3.20

Evaluation scale of 1-5:
1=Have no knowledge, 3=Some, 5=Know a lot

What is your overall reaction to REACH 96?

End of academy	**4.64**
Post-academy	**4.60**

Evaluation scale of 1-5:
1=Not at all valuable, 3=Neutral, 5=Very valuable

Table 1: REACH 96 - Survey Results

How would you characterize your understanding of the career opportunities in the following disciplines?

	Pre-academy	End of academy	Post-academy
Architecture	2.67	5.89	5.93
Architectural Engineering	2.04	4.86	5.31
Biosystems & Agricultural Engineering	1.80	4.41	4.08
Chemical Engineering	2.57	5.30	4.93
Civil & Environmental Engineering	2.64	5.37	5.47
Electrical & Computer Engineering	2.14	4.82	5.08
Industrial Engineering & Management	2.44	5.74	5.77
Mechanical & Aerospace Engineering	2.30	5.52	6.23
Engineering Technology	2.10	5.08	4.70

Evaluation scale of 1-7:
1=Have no knowledge, 4=Some, 7=Know a lot

What is your overall reaction to REACH 97?

End of academy	**6.89**
Post-academy	**7.00**

Evaluation scale of 1-7:
1=Not at all valuable, 4=Neutral, 7=Very valuable

Table 2: REACH 97 - Survey Results

How would you characterize your understanding of the career opportunities in the following disciplines?

	Pre-academy	End of academy	Post-academy
Architecture	3.76	4.96	5.13
Architectural Engineering	2.90	4.83	4.33
Biosystems & Agricultural Engineering	2.00	4.33	4.73
Chemical Engineering	2.93	4.16	4.46
Civil & Environmental Engineering	2.83	5.16	4.80
Electrical & Computer Engineering	2.83	4.70	4.60
Industrial Engineering & Management	2.23	5.43	5.93
Mechanical & Aerospace Engineering	2.50	5.00	5.06
Engineering Technology	2.26	4.90	4.26

Evaluation scale of 1-7:
1=Have no knowledge, 4=Some, 7=Know a lot

What is your overall reaction to REACH 98?

End of academy	**6.16**
Post-academy	**6.73**

Evaluation scale of 1-7:
1=Not at all valuable, 4=Neutral, 7=Very valuable

Table 3: REACH 98 - Survey Results

The young women were asked at the end of the academy, and post-academy whether REACH 98 was a valuable experience for them. The reaction from participants and parents was overwhelmingly positive. These results indicate the academy achieved its primary objective of increasing awareness of engineering, architecture and technology as viable career choices. Finally, qualitative comments were solicited regarding what the women liked best about the academy. A selected group of comments from participants are shown below. The women, themselves, speak more eloquently about the impact the academy had on them. These comments are truly the "voice of the customer", and speak to the importance of programs such as REACH for young women.

Comments from REACH participants:

"I'm really glad that I came to REACH because it helped me in the career decision process. Before I came, I didn't know much about engineering."

"I liked the modules because the instructors tried to incorporate their particular area into a fun project."

"I liked meeting other people with the same interests, the information given to us to help decide on a career, and the mentors dinner helped a lot."

"I enjoyed getting to know exactly what each type of engineer does. I also enjoyed the projects that we got to create without being told exactly what to do."

Conclusion

REACH was a successful and enjoyable experience for participants, staff, and the administrators. The academies have had a positive impact on nearly one hundred young women in the state of Oklahoma. If we hope to meet the demands for qualified professionals in the technical fields in the 21st century, programs like the REACH academies can help encourage women to consider their opportunities in these fields. The participants of the REACH academies at OSU left with a real sense of accomplishment, and hopefully, the inspiration to pursue a successful career in Engineering, Architecture, or Technology.

Bibliography

1. Atkinson, R. C. (1990), "Supply and Demand for Engineers, A National Crisis in the Making," Presidential Address, AAAS National Meeting, New Orleans, LA, February 18, 1990.
2. Pool, R. (1990). "Who Will Do Science in the 1990's?" *News and Comment*, 27: 433-435.
3. Robinson G. M., D. Drummey, and S. Myers (1989), "Women Engineers, A Very Rare Breed," *Design News*, August 7, 1989, p. 62.
4. National Science Foundation (1990). *Women and Minorities in Science and Engineering*. Washington, D.C.: NSF.
5. Seymour, E. and N. Hewitt (1994). *Talking About Leaving*. University of Colorado: Boulder.
6. Alper, J. (1993). "The Pipeline is Leaking Women All the Way Along," *Science*, April 1993, p. 409.
7. Ibid
8. Grenga, H. E. (1982), "We Can't Stop Now," *Graduating Engineer*, February 1982, p. 45.
9. Burton, L., L. Parker and W. LeBold (1998). "U.S. Engineering Career Trends," ASEE *Prism*, May-June 1998.

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