AWE: ATTRACTING WOMEN INTO ENGINEERING

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Abstract — *AWE: Attracting Women into Engineering is a weeklong free of cost summer workshop held at the College of Engineering at Rowan University. The workshop participants are young school girls entering the 7th and the 8th grades from four neighboring county schools. The workshop involves the girls in hands-on experiments demonstrated by various engineering disciplines at the College of Engineering. Female faculty and engineering students are active mentors for the participants. All of the hands on activities, field trips and projects are fun and cost effective so that schools and other programs can easily adopt them. This week long workshop involves activities from tower building to rocket launching. Field trips to local industries and team competitions are an integral component of the workshop. Teachers are also invited to participate alongside the students. All these components of the workshop make engineering come alive as a career option for these young girls. Assessment of the workshop indicates that it is highly successful and has a great impact on the participants and their parents.*

Index Terms — Women, Engineering, Workshop, Outreach

AWE WORKSHOP

The AWE workshop at Rowan University is funded by local foundations/industries and the university. The workshop exposes female students from the 7th and 8th grades to the challenges and excitement of engineering careers. Middle school girls are targeted for a number of reasons. During the middle school years, girls show a loss in math and science confidence and achievement. In one classic study [1], the girls' decline in confidence preceded their lowered achievement. Therefore it is important to offer mentoring programs for girls at a young age. The exposure to challenging careers in science, engineering and technology should be started much earlier than the high school years to keep girls motivated in their science and math classes. A review of research literature tends to show that mentoring also has a tremendous positive impact upon the academic life of students. Most girls currently enrolled in science and engineering programs indicate that that they were strongly influenced either by a parent/guardian/siblings/friend/ teacher or counselor [2]. Therefore the AWE workshop focuses on exposing engineering careers to local middle school girls. The program consists of on-campus sessions at Rowan University. The details of the AWE workshop have been well documented [2]-[6]. The AWE workshop is typically a one-week workshop free of cost to the participants. Funding is obtained from local industries, non-profit foundations and the university. Faculty and students from engineering conduct the workshop. The workshop targets middle school girls from four neighboring counties Gloucester, Salem, Cumberland and Camden near Rowan University. The workshop has hands-on experiments from various engineering disciplines. Seminars on engineering careers, scholarships for women in science and engineering, history of women in science and engineering and gender sensitivity are also a part of the workshop. Speakers are sought from local industries to inform participants about engineering careers. Field trips include a nearby Sony CD manufacturing facility and the local water treatment plant. These trips help break the monotony of being indoors all the time and also provide the participants a first hand look at the practice of engineering. Snacks and three lunches are provided for the participants. The workshop ends with a formal luncheon and a keynote speaker for the AWE participants and their parents. The participants in teams also present a project in poster format on the final day of the workshop. The project focuses on a specific engineering design or process or product. Teams also have to identify and prepare an article on a famous woman in science and engineering.

This paper focuses on implementation, activities and impact of the workshop.

OBJECTIVES OF THE PROJECT

The overall objectives of the AWE workshop are to:

1. Recruit middle school female (minorities are strongly encouraged to apply) students for a two week summer workshop at Rowan University,
2. Expose selected students to laboratory and field experiences directly related to the practice and profession of engineering,
3. Provide direction, motivation, support and encouragement for students to pursue carriers in science and engineering,

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4. Address issues such as gender sensitivity, sexual harassment, professional ethics that will affect students directly as future professionals in the 21st century,
5. Create an atmosphere of intellectual growth, self-esteem and empowerment,
6. Prepare students for a successful completion of their high school program, and
7. *Provide a model workshop that is easily adaptable by other institutions.*

PROJECT LOCATION

The Rowan University College of Engineering has a brand new engineering building, including state-of-the-art equipment and computer resources, and a dedicated and extremely competent faculty. Facilities such as seminar and lecture rooms, laboratories, computer rooms, audiovisual equipment and study hall space are located in Rowan University's state-of the art $28M Henry M. Rowan Hall. This newly constructed home of the college of engineering has a 92,500 sq. ft. space with multifunctional state-of-the-art teaching and research laboratories. Founded in 1923 as Glassboro State Teachers College, Rowan University has evolved into a comprehensive regional state university with six colleges. The College of Engineering was initiated as a result of a major donation in 1992 from the Rowan Foundation [7]. The engineering faculty use innovative methods of teaching and learning to better prepare students for entry into a rapidly changing and highly competitive marketplace. Key program features include: (a) creating inter- and multi-disciplinary experiences through collaborative laboratories and coursework; (b) stressing total quality management (TQM) as the necessary framework for solving complex problems; (c) incorporating state-of-the-art technologies throughout the curricula; (d) and creating continuous opportunities for technical writing and communication. The College has four engineering programs of Chemical, Civil and Environmental, Electrical and Computer and Mechanical Engineering. Faculty from all four disciplines participate in this workshop.

PROJECT ACTIVITIES

A typical workshop activity schedule is presented in Table I. Each discipline offers hands-on cost effective modules for the AWE participants. The participants are divided into four teams of 3-4 girls and are led by an engineering student mentor. The activities are conducted both outside and inside the College of Engineering.

TABLE I
DISCIPLINE SPECIFIC ACTIVITIES

Civil and Environmental Engineering
Teaching Civil Engineering Measurements through Bridges/ Computer Software: The Bridge Builder
Tower Building Using Jenga Blocks
Learning Water Treatment through Portable Water Purification Systems/ The Jar Test/ Water Quality Sampling
Building Sandcastles
Chemical Engineering
Food Processing: Ketchup Manufacturing and Slime Processing/Water Treatment using Membranes
Electrical and Computer Engineering
Electrical Circuits/ Reverse Engineering of Common Appliances
Mechanical Engineering
2L Soda Bottle Rockets for Rocket Launching

Civil and Environmental Engineering Module

The Civil and Environmental Engineering modules include structural, geotechnical and environmental components. The structural module consists of building various types of bridges (arch, suspension, steel girder) using wooden Jenga blocks. These blocks are readily available in most toy and departmental stores. The girls further design a steel truss bridge using the USMA Bridge builder software the BRIDGE BUILDER [8] (http://bridgecontest.usma.edu). This software can be downloaded for free from the mentioned website. This is an extremely user friendly visual software that teaches the intrcicacies of engineering design.

The Geotechnical module introduces the participants to the importance of soil properties and the importance of soils in structural design. The students learn about the failure of the Leaning Tower of Pisa. They watch a video presentation on some of the solutions that have been devised to solve the problem of the leaning tower. The students also come up with suggestions on how the tower could be rectified. In addition, the students also leam about some basic definitions relevant to soil properties. They learn about how soils are formed, the different classifications and the influence that water can have on the strength of soil. Participants perform an experiment to study the strength of different types of soils. They are provided with various types of soil such as silt, loam, sand, clay or gravel. They make a soil mixture of their choice in a clear plastic container and compact the soil. They then place a brick on the soil mixture and let it stand for 15 minutes. The brick is removed and the indentation left on the soil is measured. Water is then added and the experiment is repeated. This exercise helps participants learn about the importance of determining the properties of the foundation material before constructing any structure.

They also learn about the different types of soils that can form the foundation material. In addition, they also learn about the influence of water on the strength of the soil.

The Environmental module introduces students to concepts of treating surface water to make safe drinking water. Students sample the Rowan Pond water for certain conventional water quality parameters such as pH, conductivity, suspended solids and organic matter. They also conduct a jar test experiment to determine the optimum chemical dose for removing colloidal contaminants from water. The experiment, which is very visual, illustrates principles of chemical treatment of water. Participants are encouraged to think about the reactions occurring in the water. They are also encouraged to think about huge water treatment plants and their chemical needs and costs incurred for the chemicals. This helps them obtain an idea about pilot scale and real scale studies.

Electrical and Computer Engineering

In the Electrical Engineering Module at the AWE workshop, we stress three aspects of the electrical world:

- *Electrical power generation.*
- *Delivery of power.*
- *Implementation of an electrical system.*

Electric power generation is demonstrated using some simple materials. All that is required for them to observe this phenomenon is a small kit with one zinc nail, one copper nail, a lemon and a hand-held meter to measure voltage. Lemon juice acts as an acidic conducting medium between the two nails, which are inserted in the lemon - one on either end. The voltage that is developed is small but measurable and from this easy experiment the principle of operation of a common battery is made clear.

Power delivery again is demonstrated via a simple cost-effective experimental setup. A small modular circuit that consists of a Light Emitting Diode (LED), a resistor and a buzzer has been assembled. These three components are separately attached to a small piece of board and not connected to each other. The students can take the wire leads from each of these components, twist them together to make a connected circuit and attached the ends to a battery. The LED lights up and the buzzer buzzes. This is a very clear demonstration that "electricity" must have an unbroken path; if the students disconnect any of the leads the components do not work. All of the components for this circuit can be purchased at a local electronics store very economically.

The final component of the Electrical Module is the most fun, informative and the least expensive. The participants follow the electrical circuit inside a common household appliance such as a toaster, a hair dryer, an electric clock or radio. Participants bring broken objects from their homes or friends. This project has two goals; 1) the participants get to see how a circuit like the one they just built is actually part of an appliance that they use every day, and 2) they get to take something apart! Girls typically shy away from broken appliances with electrical circuits. Few of them know what is actually happening inside of our electrical artifacts. This final project is an extremely valuable exercise for the participants.

Mechanical Engineering Module

The Mechanical Engineering Module stresses basic concepts of rocket propulsion as space research and missions always intrigue children of all ages. The module relates science principles that the students have already learned to an engineering application. Students in teams are given a certain set of supplies to design a rocket that can be launched using pressurized air. The main concept in the rocket is Newton's third law - "For every action there's an equal and opposite reaction". Participants are provided with the following supplies: 2 liter soda-pop bottle, foam board, modeling clay, roll of duct tape and a rocket launcher. Rowan students prior to the workshop build these launchers. Shop air is used to pressurize the soda bottle rocket via the launchers.

Each team has 30 minutes to design and build a rocket that achieves the maximum distance. The students are allowed to launch their rockets before the official launch. The students can test ideas such as using more or less mass (clay), different size or no fins, clay lumped at the front or the back, more or less water, for their rocket design. While there is variability in these experiments, the students make some conclusions from these test launches in order to iterate to the final design. After launching all the rockets, the students and instructors discuss the process used to design the rocket. They focus on aspects such as 1) what forces act on the rocket, 2) specific designs the groups came up with and 3) what aspects make for a good design. A good source for more informatio on this physics principle and rockets is http://www.howstuffworks.com/rocket1.htm.

Chemical Engineering Module

The chemical engineering module focuses on illustrating principles of process design. Participants use different brands of ketchup to determine viscosity and its importance in chemical design involving fluid flow. Students are also provided with chemicals (sodium borate and poly vinyl alcohol solutions) to make slime of a color of their own choice. This exercise reinforces the importance of right proportions of chemicals for a reaction, the importance of mixing speed, the proper reactors etc.

The above-described activities are illustrated in Figure 1 from the AWE workshops held in the summers of 1999 and 2000.

PROJECT STAFF

The workshop is administered through the Department of Civil and Environmental Engineering at Rowan University. However, the workshop involves faculty from the chemical, electrical and mechanical engineering disciplines. All faculty are active members of the Society for Women Engineers. Four undergraduate female engineering students served as mentors and role models for the participants during the course of the workshop. The program format is designed to increase the participating students' confidence by exposure to other college students with similar interests. The experience also serves to encourage engineering students to recognize the importance of mentoring.

INFORMATION DISSEMINATION

A web site dedicated to project AWE has been established at Rowan to facilitate the rapid dissemination of the project [9]. This web page will also be used to communicate with the participants on a routine basis in order that the project staff may be able to provide valuable guidance, assistance and encouragement to the students throughout their high school years. The AWE workshop was also publicized through local newspapers and television. The overall impact of the project on local students, their parents/guardians and the community was extremely positive.

PROJECT ASSESSMENT

It is important to have a means to measure the success and impact of a particular project. The AWE workshop assessment consisted of surveys for both the participants and their parents. Participants were asked to rate the individual components of the workshop on a daily basis. This evaluation was extremely successful in assessing the impact of the project topics. At the conclusion of the workshop the participants were further asked to rate the overall workshop on how the components of the entire project came together. All participants strongly agreed that they had a better understanding of engineering careers. Most participants also agreed that they understood the importance of learning science and mathematics. The Student Evaluation Form is presented in Table 2.

TABLE 2
AWE STUDENT EVALUATION FORM 2000

		Percentages		
	Questions (# of Participants 20)	**Strongly Agree**	**Agree**	**Disagree**
1.	I had fun.	100%	0%	0%
2.	I learned new things.	85%	15%	0%
3.	I learned science and math is more important to me now.	80%	10%	5%
4.	I have a better understanding of what engineers do.	80%	20%	0%
5.	I see the importance of women in science careers.	75%	20%	5%
6.	The student mentors were very helpful with our activities.	85%	15%	0%
7.	The student mentors helped me feel more comfortable.	95%	5%	0%
8.	I understood the lectures.	40%	60%	0%
9.	The field trip was interesting.	95%	5%	0%
10.	I would like to attend similar workshops in the future.	95%	5%	0%
11.	The projects were fun.	90%	10%	0%
12.	I enjoyed working in a group with other girls.	90%	10%	0%
13.	I would recommend this workshop to other girls.	85%	15%	0%
14.	The faculty were very helpful.	85%	15%	0%
15.	I understand the faculty instructions/lectures.	75%	25%	0%

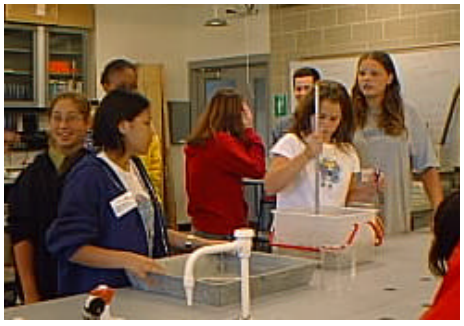
Jenga Tower Building Competition

Soda Bottle Rocket

Jenga Block Bridge Building

Chemical Slime Manufacturing

Water Treatment Using
the Jar Test



Investigating Strength of Soils

Electrical Circuits

FIGURE 1
AWE ACTIVITIES

In addition to the participant feedback, a survey was also given to the parent(s)/guardian of the participants. All questions on the survey received very positive responses. Some responses to two important questions from the survey are presented below:

Survey question: Do you feel that your daughter has benefited from this Workshop?
Survey response: All parents strongly responded by saying YES.

Comments
" I'm glad she had this opportunity to be exposed to the field of engineering. The workshops have inspired her to consider studying engineering and pursue it as a career."

"She has learned to be more independent and to work in a team setting."

Survey question: Did you feel comfortable about the environment your daughter was
exposed to at this workshop?
Survey response: *All parents strongly responded by saying YES.*

Comments
"The instructors were very warm and personable…"

Surveys will also be sent out to the students during their freshman, sophomore, junior and senior years in high school to determine the impact that the program may have had on their career plans. Electronic email is also being used to communicate with the participants on a routine basis in order that the project staff may be able to provide valuable guidance, assistance and encouragement to the students throughout their high school years.

PROJECT IMPACT

Overall the impact of the AWE workshop has been overwhelming. Each year the number of applicants is steadily rising indicating the need for such educational programs for young girls. One of the unique features of the workshop was in having the three-tier mentoring relationship. The engineering students as well as the middle school girls benefited from it. Assigning workshop participants to engineering students closer to their peer group eased student communication. The engineering freshmen students received advice and mentoring on handling middle school participants. There was a perceptible improvement in their handling of the disciplinary problems as well as in the guidance they provided to the middle school. The cost effective modules are also easily adaptable by other schools. AS to whether the participants will pursue carrers in science, engineering or technology remains to be seen. The AWE alumni are surveyed every year to obtain information on their interest in science and engineering. The AWE alumni are also brought back for reunions and reinforcement.

CONCLUSIONS

The impact of project AWE has been extremely positive. There was an overwhelming response during participant recruiting. Parents were extremely grateful for having such a program for their daughters. Many times they mentioned how they never had such opportunities in their times. AWE is designed to allow us to focus our educatio nal efforts on our own individual disciplines. Faculty are given the opportunity to introduce aspects of engineering and science by setting up a simple project that demonstrates how those aspects are applied. As faculty participants of the AWE workshop, there is ample opportunity to serve as a mentor to the engineering freshmen students as well as the workshop participants. Finally the cost-effective nature of the engineering modules is also a huge success. Evaluations indicate that the simple and down to earth nature of the hands on activities is very popular amongst participants, their parents and teachers.

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