Teaching Engineering to High School Students in a Summer Camp

Kendrick Aung
Mechanical Engineering Department
Lamar University

Ryan Underdown
Industrial Engineering Department
Lamar University

Abstract

This past summer, Lamar University at Beaumont, Texas hosted a one-week summer camp called gO W.E.S.T (gO Women for Engineering Science and Technology) for female high school students under the sponsorship of Texas Higher Education Certification Board and Lamar College of Education and Human Development and College of Engineering. The summer camp is intended to promote science, technology, engineering and mathematics (STEM) related topics and increased awareness of STEM-related careers to the female students who are under-represented in these disciplines in colleges and universities. Two of the faculty members from College of Engineering took part in the summer camp, teaching robotics, engineering, and other STEM related topics to the students. This paper describes the experience of the faculty members in conducting these classes as well as lessons learned from these camps that might be useful to other faculty members and engineering education community.

Introduction

It is well established that the enrollment of female students in science, technology, engineering and mathematics (STEM) related disciplines are much smaller than that of their mal counterparts1-5. According to Clark6, White female, African Americans, Latino, and Native American high school students traditionally have had little encouragement or have exhibited little interest in pursuing careers related to engineering or engineering technology. According to Milbourne7, women made up of only 9 percent of the engineering work force. Even with increasing enrollment of students, both male and female, in STEM disciplines in colleges and universities, female students are underrepresented especially in engineering schools. For example, female students represented 19.3% (125 students) of the total enrollment in Fall 1998 semester but only 15.8% (198 students) in Fall 2007 semester in the College of Engineering at Lamar University. Similar trends have been noticed in small and large schools nationwide5-8. As a result, attracting and retaining female students in STEM disciplines receive widespread attention among university administration, faculty members and education community across United States. One important way to increase representation of female students in engineering is to expose them early in their K-12 studies to science, mathematics and engineering related activities in order to provide enthusiasm and interests in these disciplines. In this respect, Lamar University at Beaumont, Texas hosted a one-week summer camp called gO W.E.S.T (gO

Women for Engineering Science and Technology) for female high school students under the sponsorship of Texas Higher Education Certification Board and Lamar College of Education and Human Development and College of Engineering. The camp was offered to provide the following goals:

(a) To persuade young women to enroll in math and science throughout high school.
(b) To expose young women to engineering related concepts, material, and knowledge.
(c) To demonstrate how engineering relates to everyday life.
(d) To motivate interest in the process of leading engineering.
(e) To collect data to understand the impact of this kind of program on participants.

The ultimate goal of the camp is to inspire, recruit and retain a new generation of female students and engineers in the southeast Texas region where Lamar University is situated. Two of the faculty members from College of Engineering took part in the summer camp, teaching robotics, engineering, and other STEM related topics to the students. This paper describes the experience of these faculty members in conducting these classes as well as lessons learned from these camps that might be useful to other faculty members and engineering education community.

gO WEST Camp

The gOWEST camp is a one-week camp limited to highly promising high school female students and is free of charge to participating students. The selection criteria for the participants are as follows:

a) Females students from 9^{th} to 12^{th} grades
b) Students with grade point average of B or above
c) Students who show interests in STEM disciplines
d) Students who are traditionally underrepresented
e) Students with recommendation for the gOWEST camp from teachers
f) Students are required to submit an essay why they should be chosen
g) Students undergo personal interview with the camp manager Dr. Urbina

Activities related to recruiting and selecting students were started in early January and completed in April. 50 students from 8 school districts were chosen among the applicants for the camp. The diversity of participants can be seen from the composition of final participants: there are 8 Hispanics, 34 African Americans, 2 Indians, 5 Caucasians and 1 Native American. The duration of the camp is one week and the students underwent many different activities such as computer and technology, engineering design activities, science, mathematics and a field trip to NASA Johnson Space Center (JSC).

Engineering Related Activities

The curriculum of the go W.E.S.T. Academy was designed to spark interest in engineering through a series of captivating speakers, hands-on activities and engaging research. The main goal for engineering related activities conducted during the camp was to provide design experiences through a series of lab activities and sessions exposing students to a number of

"building block" skills purposely designed in relation to engineering professions. The curriculum was based on the theme "Engineering: An Everyday Part of Living" and includes topics on

a) **Bicycle of Yesterday and Today Lab**
b) **Umbrella Open up New Ideas on Recycling Lab**
c) **Robotics into the 21st Century Lab**
d) **Women in Engineering Careers Seminar**
e) **Technology outreach teleconferencing**

One of the authors, Dr. Kendrick Aung, was responsible for topics (a) and (b) and the other author, Dr. Ryan Underdown, for topics (c) through (e). The activities involves one- to two hour lab sessions where the participants perform hands-on activities, calculations, programming as well as seminars and talks by female engineers and professionals. Female guest speakers from local industries such as ExxonMobil, Schlumberger, and Jacobs Engineering described their daily activities, their reasons why they chose engineering as a career and their challenges as females in a male dominated field. Each engineering discipline at Lamar was represented by a speaker: Civil, Chemical, Electrical, Industrial, and Mechanical. All speakers were female representing Hispanic, Caucasian, African American ethnic groups. Our diverse group of speakers provided viewpoints from new, as well as very experienced engineers. By providing a diverse group of speakers, campers had a greater chance of identifying themselves with an engineering presenter and being inspired by a female role model.

Through closed circuit television, go W.E.S.T. campers interacted with female guest speakers from Louisiana State University (LSU) and Penn State University (PSU). Researchers at LSU discussed how students learn and learning styles in an effort to encourage campers to recognize their learning style. Campers participated in interactive demonstrations to gain insight to how students learn. Researchers at PSU discussed their innovative research in engineering. Campers asked probing questions and generated a stimulating discussion on a wide variety of topics including nano-technology and how science integrates with engineering. Some detailed discussions of topics used in the camp were described below.

Bicycle of Yesterday and Today Lab

In this lab session, the main purpose is to provide some engineering knowledge and hands-on activities related to design and analysis of a bicycle. The students were already exposed to topics such as simple machines, and the lab provided further knowledge relating simple machines to different parts of the bicycle. As an example, students were asked to relate the drive train or the chain and sprocket of the bicycle and the concept of the simple machines. The students also learned how to identify the function of each part of the bicycle as well as the contribution of each part to the design of the bicycle such as safety, ease of assembly, and functionality. For example, a Powerpoint presentation was given to show why the frame of the bicycle was designed as such and what materials were used in the construction of the frame. In addition, the students were asked to take measurements of different parts of frame from a given bicycle (Fig. 1) and produce a sketch of the frame as shown in Fig. 2. This activity provides students the importance of measurement and visual representation of their measurement in engineering design process. The analysis part of the lab involves determining the gear ratios of the bicycle using measurements and calculations. In this lab, materials from

Dissecting the Bicycle from Stanford University[9] were used extensively.

Figure 1. A photo of a bicycle frame

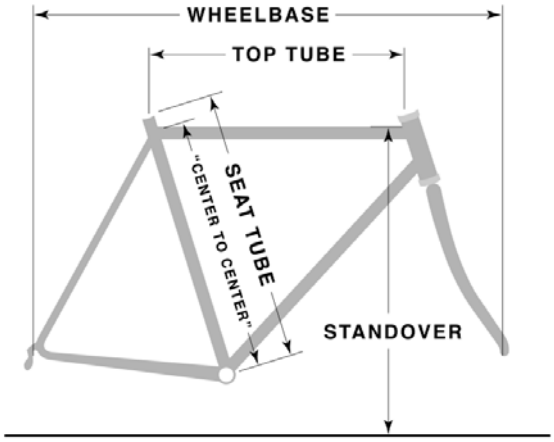

Figure 2 A sketch of a bicycle frame

Umbrella Open up New Ideas on Recycling Lab

In this lab session, the main purpose is to provide some knowledge on waste recycling using an umbrella as an example. Umbrellas provide protection from rain and sun shine but are easily damaged. Once damaged, most of us would discard the umbrella and buy a new one. However, by carefully examining an umbrella there are many parts (look at Figure 3) that can be reused from the discarded one.

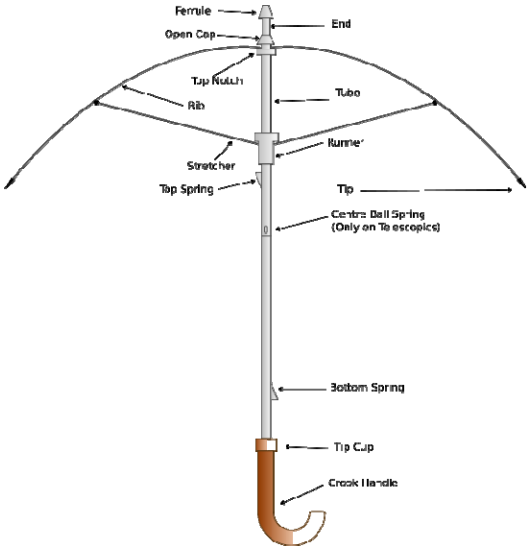

Figure 3 An anatomy of an umbrella

In this lab session, each student was given an umbrella and asked to create or make a new product out of the umbrella. The students were given other necessary supplies such as scissors, tapes, staplers, duct tapes and other decorative items. The exercise promotes students their imagination and creative ideas as well as awareness of recycling. The final products range from a handbag to a puppet to a toy parachute (see Figure 4). The three most innovative and decorative products were chosen and prizes were awarded to the students who made them.

Figure 4 Students and their products

Robotics into the 21st Century Lab

In this lab session, the main purpose is to provide some engineering knowledge and hands-on activities related to robotics using LEGOS. The Robotics Into the 21st Century activity introduced campers to the basic functionality of robots and how they are programmed to perform a wide variety of activities. Campers constructed a robot from LEGOS and programmed them to perform simple tasks. This activity demonstrated how mechanical and electrical engineering disciplines combine to solve problems. The Lean manufacturing simulation was a hands-on assembly line that demonstrated the benefits of lean manufacturing and exposed campers to fundamental concepts in Industrial Engineering.

Lessons Learned

The main lessons learned from conducting the summer camp can be summarized as follows:

a) **Hands-on activities stimulate the interests and capture attention of the campers the most.**
b) **Providing role models and their experiences in engineering careers excite and aspire the campers about careers in science, mathematics and engineering.**
c) **Developing learning materials early and discussing the types and forms of delivery of the materials with support staff ensure a successful camp.**

One of the most important lessons is how much the students prefer hands-on activities to the presentation and lecture. One of the authors has prepared a long presentation on how different components of a bicycle can be considered as simple machines and gave some examples of simple machines. Once the presentation has been given, the author realized that only some slides are really necessary for the hands-on activity that follows and the students prefer to work on the bicycle directly rather than listen to the long presentation. The students are more inclined to learn and enjoy hands-on activities rather than learning about the history, background and other information on bikes. As a result, the presentation on umbrellas was cut short before it was given and more time was devoted to hands-on activities related to umbrellas for students which help stimulates their innovative ideas as well as captures their attention and increases their learning process.

Another important lesson to be learned is how the role models (female engineers and engineering students) plays a very important and essential role in providing excitement and aspiration to these young female high school students. During the camp, practicing female engineers from nearby industries such as Exxon Mobil and DuPont as well as current female engineering students gave a series of presentations related to career opportunities, responsibilities, working experiences, and rewards for female engineers, and educational preparation, surviving and succeeding in engineering studies. These talks provided high school students with increased awareness of their academic preparation prior to joining STEM disciplines, as well as excitement and aspiration about pursuing careers in STEM disciplines. Students were very receptive to these talks which resulted in many exciting question and answer session in each talk.

The last lesson to be learned is the importance of early preparation for the camp. The instructors and lead director of the camp started meeting in early February to start the preparation of the camp schedule, study materials, hands-on activities, and recruitment of support staffs. The director of the camp began the recruitment process in March and completed in early May. The collection of resources, booking of campus buildings and dining options, and other recreational activities such as tours had been planned in advance as early as March. These early preparations ensured the successful camp in our experience.

Evaluation and Success Stories

The evaluation of the camp was done in a series of questionnaires and surveys from the participating students. Table 1 below shows the interests of students in STEM disciplines which

range from 2 and below before the camp to 4 after the camp in the scale of 1 (lowest) to 5 (highest). After the camp, 75% of the participants responded that they would like to pursue engineering as their career. Many of the remaining campers identified science and teaching careers. All campers left the go W.E.S.T. Academy with a greater understanding of engineering in general and of the specific engineering disciplines.

Table 1 Response Rating before and after the Camp

Intervention	Before	After	Gain	Rating
Presentations	1.8	4.0	+2.2	Outstanding
Activities	1.6	4.0	+2.4	Outstanding
Research Teams	2.0	4.0	+2.0	Outstanding

Two campers enrolled in the Lamar University course "INEN 1101 Introduction to Engineering" with Dr. Underdown for the Fall 2008 semester. To date, both students are doing very well in this course as well as their other freshman courses. Both students are active in class discussion and demonstrate a measure of leadership not normally exhibited by freshman. Based on the results presented above, the camp has been a resounding success to promote and excite female students about STEM disciplines.

Summary and Conclusions

In summary, this paper describes the experience of the faculty members in conducting a one-week summer camp called gOWEST and the lessons learned from their participation in the camp. The engineering topics used in the camp were included in some details as well as the qualitative evaluation of the activities by the participating students. It is our opinion that providing early exposure of engineering activities to K-12 students will significantly enhance recruitment and retention of under-represented female students to engineering disciplines.

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KENDRICK AUNG
Dr. Kendrick Aung is an Associate Professor in the Department of Mechanical Engineering at Lamar University. He received his Ph.D. degree in Aerospace Engineering from the University of Michigan in 1996. He has published over 80 technical papers and presented them in numerous national and international conferences.

RYAN UNDERDOWN
Dr. Underdown is an Associate Professor in the Industrial Engineering department at Lamar University in Beaumont, Texas. His research interests include six sigma, facility layout and lean manufacturing. Dr. Underdown is the faculty advisor of the Institute of Industrial Engineers (IIE) student chapter and the Industrial Technology academic program at Lamar. He has been a member of Tau Beta Pi and the Institute of Industrial Engineers since 1996. Dr. Underdown consults small businesses in the Southeast Texas region in the areas of process improvement and six sigma.