2006-530: SUMMER CAMPS IN ENGINEERING TECHNOLOGY: LESSONS LEARNED

Stephen Kuyath, University of North Carolina-Charlotte

Stephen Kuyath is an Assistant Professor of Engineering Technology at the University of North Carolina at Charlotte. He has taught engineering technology courses at the college level for over 22 years. He has a strong interest in and dedication to improving both traditional and distance engineering education and to encouraging those students typically underrepresented in STEM fields to consider engineering technology as a career.

Deborah Sharer, University of North Carolina-Charlotte

Deborah Sharer is an Assistant Professor in the Engineering Technology Department at UNC Charlotte. She was the first woman PhD graduate from the Lee College of Engineering, with a research emphasis in microelectronic devices and solid state materials. She has served in numerous mentoring and educational roles for undergraduates, high school and middle school students.

Summer Camps in Engineering Technology: Lessons Learned

Abstract
There is mounting evidence that a nationwide shortage of qualified high-tech workers will jeopardize the economic future of the United States. It is also well established that a more proactive approach must be taken to nurture the intellectual development of underrepresented groups so that the pool of scientists and engineers expands to include more women, minorities, and persons with disabilities.

This paper will provide a summary of the concepts, strategies, implementation and lessons learned from the first two years of the high school summer camps that are a component of the NSF funded *Diversity in Engineering Technology* project[1, 2]. These camps, which incorporate instruction and hands-on activities for each of the disciplines housed in the Engineering Technology Department (Civil, Electrical, Fire Safety and Mechanical), involve high school students in an intensive week-long program on the UNC Charlotte campus and show them that engineering and engineering technology can be fun and rewarding. Significant participation by traditionally underrepresented groups in engineering and engineering technology has been targeted and successfully achieved. Throughout the camp and afterwards, students provide candid feedback about each of the activities, what they liked and disliked, and what they thought we could do better. The camps have been very well received during the first two years, with many students returning, the word-of-mouth advertising by student participants telling their friends of the program overwhelming available space, and last year's campers returning as counselors.

In addition to anecdotal evidence, exit surveys will be utilized to explain what works and what could be improved with respect to student participation in a technically oriented camp-like atmosphere. We will offer a dynamic discussion of the lessons learned to date from this experience, a description of the changes we will establish for future offerings, and how the summer camps are an integral part of the highly successful *Diversity in Engineering Technology* project.

Introduction

White female, African American, 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[3]. Although they do not realize it, these students are depriving themselves of many technical and scientific career choices, as well as access to high salaried occupations[4].

In 1995, women made up about 46 percent of the U.S. labor force but only about 9 percent of the engineering labor force[5]. Although women currently comprise 52 percent of high school graduates who enroll in four-year colleges in the United States, they consist of only 17 percent of college freshmen that choose engineering as an academic major[6]. African Americans make up

5.4 percent of undergraduate engineering enrollment, Hispanic Americans make up 5.5 percent, and other ethnic groups (including Native Americans, Alaskan Natives, Pacific Islanders, and bi-racial people) make up 7.3 percent[5].

If America is to remain competitive in the world today, it must increase the number and quality of persons with technical expertise and the diversity of the STEM (Science, Technology, Engineering and Mathematics) workforce[1]. The business community not only wishes to increase the diversity of their workforce as an ethical responsibility, but has also come to understand the value of employing a diverse workforce and is embracing the concept as a business necessity. Diverse groups are known to combine their unique perspectives to devise exceptionally creative solutions to the problems they encounter[7]. The different perspectives and frames of reference of a diverse team offers competitive advantages in teamwork, service, product quality and work output because a workforce that mirrors a company's customers is more likely to understand the needs of its customers[8].

The Camps: A General Description

The Engineering Technology (ET) Department at the University of North Carolina at Charlotte (UNC Charlotte) hosted two summer camps in July of 2004, for high school students who are members of their school's engineering club as part of the *Diversity in Engineering Technology*[1] project, funded by the National Science Foundation (NSF award #0302801). This is the second year of the camps. As we describe the camps, we will explain where we made changes based on a survey given to the campers on the final day of the camp.

The *Diversity in Engineering Technology*[1] project's goal is to increase the number and diversity of qualified engineers and engineering technologists. The strategy is to engage high school students in engineering activities through engineering and engineering technology clubs (called JETS clubs) in the nine-county region around Charlotte[1] (the clubs were established during the first year of the project). As members of the club, students participate in fun and engaging hands-on activities and competitions designed to pique their interest engineering and engineering technology. Each school opens membership in the club to all high school students, but teachers participating in the project are encouraged to ensure that at least 50 percent of their members are from underrepresented groups (females, African American, Native Americans, and Hispanic Americans). Throughout the academic year, UNC Charlotte faculty visit participating schools and a number of competitions/exhibitions are held that emphasize different aspects of technical professions.

The summer camps are an extension of the high school clubs. Last year's camp consisted of mostly white males, so this year we strongly encouraged female and underrepresented minority club members to attend the summer camp. The camp is a one-week intensive experience focusing on the four engineering technology disciplines within the Engineering Technology Department at UNC Charlotte: Civil Engineering Technology, Electrical Engineering Technology, Fire Safety Engineering Technology, and Mechanical Engineering Technology. Faculty from each of the disciplines developed the daily activities. Another lesson learned from last year encouraged us to keep the lecture part of each day short, and allow more hands-on activities. Consequently, each topic began with a short introduction to the theoretical principles regarding the hands-on activities. Campers then participated in an educational, fun, and engaging, hands-on activity in the discipline under discussion that day.

The University's Summer Programs Office provides evening activities, personal time, and some social time for the campers. The students were encouraged to use the exercise facilities, the swimming pool, or the basketball, racquetball or tennis courts and to interact with the counselors (university students). One of the most rewarding evenings for the campers was the evening in which they met with university students for the expressed reason of discussing life as a university student. This aspect of the camps was also considered of significant value, since high school students had an opportunity to interact with college students and get a feel for life on a university campus.

The college students were extremely candid about life in the dorms, attending class, the amount of time required for studying, expectations of their professors, etc. For most high school students this event produces a revelation in college life. Most high school students believe that college life consists of hours of free time, without supervision, in which they can revel in their newfound freedom. After an evening with college students, the high school students suddenly realize that college life requires a lot of responsibility and dedication.

Participants:
Forty-five students participated in the camp, whereas last year we had thirty-six. Of the campers, 47 percent were rising sophomores (i.e., students who had just successfully completed their freshman year in high school), 22 percent were rising juniors (successfully completed their sophomore year), and 22 percent were rising seniors (successfully completed their junior year). During the first year of the camps we found that middle school age campers and high school age campers did not mix well. However, we allowed two rising ninth graders to join the camp because of the maturity and friendship with some of the other campers.

Our targeting strategy was successful in that we increased female participation this year to 29 percent (last year we had 17 percent female). This strategy also increased our African American participation from 17 percent last year to 27 percent this year, and Latino participation from 3 percent last year to 7 percent this year.

The Camps: The Week's Agenda
We introduced each of the disciplines of the Engineering Technology Department to the high school students participating in the camps. We began with a discussion of theoretical background of the topic of the day and then followed up with the hands-on activity. The students were encouraged to fully participate and to perform their best in the activities through daily team-based competitions. Each team was awarded points for their performance in the daily activities and team membership was rotated on a daily basis, ensuring that no one participated in the same group on any activity. At the end of the week, the camper with the highest points was the first to select a camp reward from the "prize table". The prizes ranged from an ETrex handheld GPS device (cost about $100) to T-shirts (cost about $12).

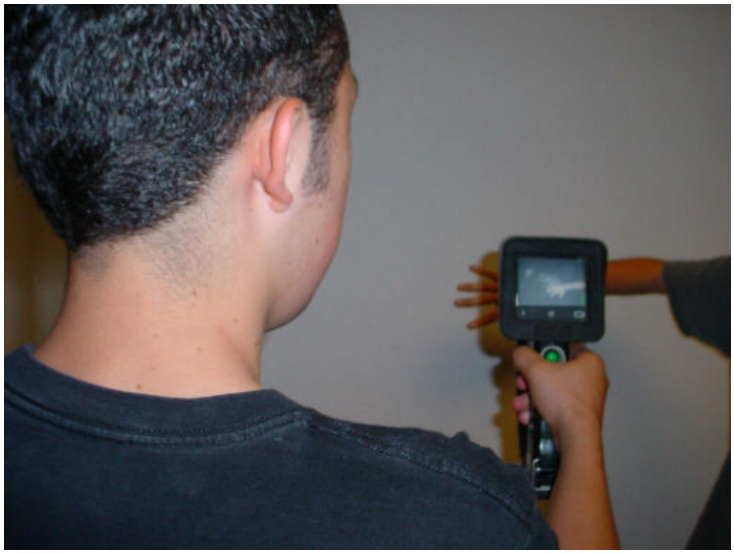

Figure 1: Fire Safety Activity

Day 1: Fire Safety Engineering Technology

The first day began with a short movie showing how fast a fire can burn through a room, as an introduction to fire safety The primary intent of the movie was to increase awareness and expose these young students to the increasing need for qualified engineers to address critical fire protection technology requirements necessary for protecting people, homes, workplaces and the environment. The campers then participated in an activity using a hand held infrared viewer that allowed them to find someone in a completely dark room, demonstrating how firefighters find people in a burning building who may still be alive, but who are suffering from smoke inhalation.

The afternoon session consisted of a field trip to the fire department communications center located at Charlotte Fire Department Station 1. This was not an average fire department tour; modern advances, fostered by innovative engineering concepts, were alluded to throughout the visit. Each student was given access to secure areas and witnessed actual emergency calls dispatched in their presence. Communications staff demonstrated the latest GPS/AVL (Global Positioning System/Automatic Vehicle Location) technology that enables them to dispatch the closest unit in an emergency situation.

Day 2: Mechanical and Civil Engineering Technology

The second day of the camp was devoted to construction in mechanical and civil engineering related projects. To introduce civil engineering, several approaches to bridge construction were presented. Students were provided with the materials and specifications for the hands-on activity in which they designed and constructed a bridge from balsa wood and glue.

Figure 2: Designing & Building Bridges

The second half of the day was an introduction to mechanical engineering through trebuchets. A trebuchet is a medieval military engine, similar to a catapult, and designed for hurling heavy missiles. The primary differences between trebuchets and catapults are: 1) the trebuchet uses counterweights instead of tension to power the machine, and 2) the trebuchet uses a sling to extend the length of the arm. There are a number of physics and mechanical engineering related decisions to be made in fine-tuning a trebuchet for its best performance.

Figure 3: Students Building a Trebuchet

Students were first introduced to the scientific principles involved in trebuchets, and then put to work constructing one of their own. The wood was pre-cut so that students spent their time in construction and fine-tuning. Because female students usually have less confidence in using power tools, we insisted that they use the tools while constructing the trebuchets. The females

soon understood that with just a little practice using power tools was not very hard, increasing their confidence.

Students were not expected to complete either of their second day projects in the time allotted but sufficient time during the remainder of the week was allocated to finish and fine-tune the bridges and trebuchets before final competitions.

Day 3: Civil and Electrical Engineering Technology: GPS

The GPS day was intended to be a more relaxed and fun day. We began by introducing GPS and satellite technology to the students and proceeded through the use of GPS devices to navigate in unknown territory. We then gave the students a hands-on lesson in using the Garmin ETrex hand-held GPS devices and began the treasure hunt (a Geocache) on the UNC Charlotte campus grounds.

This was a multi-level geocache. The coordinates (and hints) for locating the next clue in their treasure hunt were provided by the instructor. The students set out looking for the location of the second clue. There were three sets of clues leading to their final destination – the cache. The first students to arrive at the cache were to remove a piece of paper (that could only be found inside the cache) and a treasure of their choice. The first to return to the starting location received the highest points for the day.

Day 4: Electrical Engineering Technology

We started the day with an introduction to semiconductor principles. We then focused on solar cells and fuel cells. The students participated in several activities with solar cells, i.e., measuring voltage and current with varying intensities of light and using the solar cell to generate current through salt water to separate hydrogen and oxygen. They then constructed a car, powered by the solar cell, and went outside to race their cars. The remainder of the day was spent in powering those cars with fuel cells so that the students could observe the differences between solar and fuel cell powered cars.

Figure 4: Solar Cells and Fuel Cell Cars

Day 5: Mechanical and Civil Engineering Technology

The final day consisted of testing the bridges to destruction and hurling water balloons with the trebuchets.

Figure 5: Testing Bridges to Destruction

Each bridge was setup on the table shown in Figure 5. A bucket was suspended from the bridge. The bucket was slowly filled with water until the bridge collapsed. As shown in Figure 5, the students enjoyed this test. The bridge that weighed the least, but held the most water was considered the winner of this competition.

Figure 6: Testing Trebuchets

We then tested the trebuchets. We used water balloons as the projectiles. The teams competed to see whose trebuchet could toss a water balloon the furthest.

Destroying their bridges was a highlight for the students even though they had spent so much time in the construction. Hurling water balloons with trebuchets was just as much fun. By the end of this camp had introduced students to four engineering disciplines through fun, engaging hands-on projects.

Results

We surveyed the campers on the final day of the camp to see how we did this year as compared to last year. The results are shown in Table 1 with this year's results shown in bold and last

year's results shown in parentheses. The scale ranges from SA=5 (Strongly Agree) to SD=1 (Strongly Disagree):

Table 1: Results of Formal Questionnaire

Questions	Mean Scores	Numbers below are expressed in percentages				
		SA=5	A = 4	N = 3	D=2	SD=1
The JETS camp was, overall, a very good experience	**4.7** (4.7)	**67** (73)	**33** (21)	**0** (6)	**0** (0)	**0** (0)
The JETS camp broadened my educational horizons	**4.7** (4.4)	**78** (48)	**17** (42)	**6** (6)	**0** (3)	**0** (0)
Classroom instruction was very educational	**4.7** (4.3)	**72** (55)	**22** (27)	**6** (15)	**6** (0)	**0** (3)
Classroom instruction was fun	**4.6** (4.1)	**67** (45)	**28** (30)	**0** (12)	**0** (9)	**0** (3)
Class "hands-on" activities were fun	**4.7** (4.8)	**78** (85)	**11** (12)	**11** (3)	**0** (0)	**0** (0)
Class "hands-on" activities were educational	**4.7** (4.6)	**67** (67)	**33** (30)	**0** (3)	**0** (0)	**0** (0)
Camp "downtime" was kept to a minimum	**4.8** (4.2)	**83** (45)	**17** (27)	**0** (24)	**0** (3)	**0** (0)
Instructor concern for my welfare was very obvious	**4.4** (4.4)	**61** (61)	**22** (24)	**17** (12)	**0** (3)	**0** (0)
I will consider UNC Charlotte as a place to go to college	**4.4** (3.7)	**61** (33)	**17** (18)	**22** (36)	**0** (9)	**0** (3)
I would definitely recommend the JETS camp to my friends	**4.4** (4.3)	**61** (55)	**17** (27)	**22** (15)	**0** (3)	**0** (0)

A significant percentage of the campers thought the camps were a good experience and that the camps broadened their educational horizons. Ninety-four percent thought the camps were educational (82 percent last year) and 95 percent thought the "instruction" was fun (75 percent last year). All of the campers thought the activities were educational, but only 89 percent found them as fun.

The statement: "I will consider UNC Charlotte as a place to go to college" increased significantly over last year. However, the goal of the project is to increase the diversity of engineers, engineering technologists, or related scientists in this region, whether they plan to attend UNC Charlotte or not.

The most unexpected development (and opportunity) occurring during the camp was how the campers wanted to spend their free time. The campers were allowed unstructured free time from 4:30 pm until 6:00 pm every day. During this time, they could workout, walk around campus, sit and talk with friends, read, listen to music, etc. But, most students asked to stay in the engineering building, so they could work on their bridges or trebuchets and talk with the project director. They asked questions around several topics, such as:

- College classes
- The difference between engineering and engineering technology
- Careers in engineering and engineering technology
- The level of difficulty of courses in engineering and engineering technology

- What classes should they concentrate on in high school
- Should they go to a community college first and then transfer to the university

This was an opportunity too good to pass up. The project director, being an assistant professor in Electrical Engineering Technology and having taught for many years at the local community college, was conscious of the fact that his opinions may have been slightly biased towards engineering technology in general and the electrical discipline in particular and made this clear in all discussions with students. Although questions were answered as candidly and as honestly as possible, a list of unbiased Internet references (such as the ASEE website) was provided so that the students could research the answers to these questions for themselves.

The goal of the *Diversity in Engineering Technology* project is to increase the diversity of the engineering, engineering technology, or related science professions. Table 2 shows how the campers responded to three questions related to the overall project.

Table 2: Percentage of Each Group Responding Positively

Question	Female	African American	Hispanic
A career in engineering can be enjoyable	83%	90%	100%
I plan to pursue a career in engineering	42%	40%	33%
I plan to pursue a career in science	42%	25%	0%

A vast majority of students have the female and African American students indicated that they plan to pursue a degree in engineering, engineering technology, or other science related disciplines. The project personnel consider this a significant achievement – whether or not students come to UNC Charlotte – if they are entering a STEM profession, the *Diversity in Engineering Technology* project will be an unqualified success.

Conclusions and Future Work

Although the summer camps are having an impact on female and underrepresented minority high school students' decision about entering engineering, engineering technology or a related science career, it is not enough. There are many careers, activities, music, sports, etc. that are competing for these students' attention. Having the clubs and year-round activities to keep the students attention is extremely important.

At the time of these camps we were completing the second year of a three-year project. We have accomplished our goals of increasing engineering career awareness in this region and in working closer with our community college partners in aligning our curricula, but it is still too early to tell if the overall goal of increasing the diversity of the engineering workforce in this region has been accomplished. Many of these students are still in high school and it will still be a few years before we see how many of them actually enter the engineering programs at UNC Charlotte, one of the community colleges, or other universities. However, the trends we have seen as we continue this project have been very encouraging.

Acknowledgments

Funding for this work was provided by the National Science Foundation Award #0302801.

Bibliography

[1] Kuyath, S.J., "Diversity in Engineering Technology: An NSF Project," *Proceedings of the 2004 American Society of Engineering Educators Annual Conference and Exposition*, 2004, Salt Lake City, UT

[2] Kuyath, S.J., Murphy, D.L., and Sharer, D.L., "Summer Camps in Engineering Technology," *Proceedings of the 2005 American Society of Engineering Educators Annual Conference and Exposition*, 2005, Portland, OR

[3] Clark, J.V., *Minorities in Science and Mathematics: A Challenge for Change,* Virginia Parent Information and Resource Center, 2000

[4] Clark, J. V., *Minorities in Science and Math,* ERIC Clearinghouse for Science Mathematics and Environmental Education, ED433216, May 1999

[5] Milbourne, L. A., *Encouraging Girls in Science and Math,* The ERIC Review, Vol 6, Iss. 2

[6] Takahira, S., Goodings, D., and Byrnes, J., *Retention and Performance of Male and Female Engineering Students: An Examination of Academic and Environmental Variables*, Journal of Engineering Education, 87(3), 1998, pp. 297-304

[7] Swann, W.B. Jr., Kwan, V. S., Polzer, J.T., and Milton, L.P., Capturing the Elusive "Value in Diversity" Effect: Individuation, Self-Verification and Performance in Small Groups, Working Paper, 2004

[8] Smith, D. A., *What is the Bottom-line Impact of Diversity?*, Linkage, Inc. 1999