

## Summer Camps in Engineering Technology

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### Abstract

There is mounting evidence that a nationwide shortage of qualified high-tech workers will jeopardize the country's economic future. 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 description of the two one-week Summer Camps offered by the University of North Carolina at Charlotte's (UNC Charlotte) Engineering Technology Department as a part of its *Diversity in Engineering Technology* project, funded by the National Science Foundation. The purpose of the camps was to involve high school students in an intensive week-long program and show them that engineering and engineering technology could be fun and rewarding.

The Engineering Technology Department at UNC Charlotte has four disciplines: Electrical Engineering Technology, Mechanical Engineering Technology, Civil Engineering Technology, and Fire Safety Engineering Technology. Faculty from each of the disciplines developed an educational, but engaging, hands-on activity designed to pique the interest of the campers. The students were encouraged through daily competitions (and a point system) to participate fully in the activities and score the highest number of points. Each student took home prizes at the end of the week, with the higher points allowing an earlier selection off the prize table.

In this paper, we describe in detail the objectives and activities developed for each of the four disciplines. Students participated in fire safety activities, bridge building (with a test to destruction), a GPS treasure hunt (geocaching), solar and fuel cell driven model cars with a test of performance, and a trebuchet building day that included testing of accuracy and distance. Throughout the camp and afterwards, students provided candid feedback about each of the activities, what they liked and disliked, and what they thought we could do better. The camps were very well received and the students overwhelmingly indicated that they would like to participate again next year. We will offer a discussion of the lessons learned by this experience, a description of the changes we will establish for next year, and how the summer camps are an integral part of the *Diversity in Engineering Technology* project.

## Introduction

The United States is facing a shortage of engineers because 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 these subjects<sup>1</sup>. 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<sup>2</sup>.

In 1995, women made up about 46 percent of the U.S. labor force but only about 9 percent of the engineering labor force<sup>3</sup>. If more women and minorities can be persuaded to pursue a degree in engineering the imminent shortage can be averted. 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<sup>4</sup>. 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<sup>3</sup>.

We not only need to increase the number of persons with technical expertise in America, but the diversity of the STEM (Science, Technology, Engineering and Mathematics) workforce in America<sup>5</sup>. 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<sup>6</sup>. 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<sup>7</sup>.

## The Camps: A General Description

As part of the *Diversity in Engineering Technology*<sup>5</sup> project, funded by the National Science Foundation (NSF award #0302801) through the University of North Carolina at Charlotte, we hosted two summer camps in July of 2004, for high school students who are members of their school's engineering club<sup>5</sup>.

The *Diversity in Engineering Technology*<sup>5</sup> project is a three-year project whose main goal is to increase the diversity of engineering and engineering technology students at the community colleges and university level. The strategy is to engage students in STEM activities through the establishment of engineering and engineering technology clubs at high schools in the Charlotte region<sup>5</sup>. As members of the club, students participate in fun and engaging hands-on activities and competitions designed to pique their interest in math, physics, 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, project personnel 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 (for a more detailed description of the project see “Kuyath, S.J., *Diversity in Engineering Technology: An NSF Project*”<sup>5</sup>). Club members were invited to attend a one week intensive summer camp 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. Each day (or topic) began with a lecture providing the theoretical principles regarding the hands-on activities. Campers then participated in an educational, fun, and engaging, hands-on activity designed to pique the interest in the discipline under discussion that day.

The University’s Summer Programs Office provided 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:**

Eighteen students participated in each week of the camp. Of the campers, 36 percent were rising sophomores, 39 percent were rising juniors, 17 percent were rising seniors, and the remainder had graduated the previous June (8 percent). The participants were mostly male (83 percent) and Caucasian (75 percent). Seventeen percent (17 percent) of the participants were African American, 3 percent Hispanic Americans, and 5 percent were either Asian or American Indian. The racial demographics of the camp closely match the racial demographics of the region, but the gender demographics did not<sup>8</sup>. For this reason, next year we will target more female high school students to participate in the camp.

### **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 competitions. Each student was awarded points for their performance in the daily activities and then, 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).

#### Day 1: Fire Safety Engineering Technology

The first day began with an introduction to fire safety through a classroom lecture entitled “Fire Protection in the 21<sup>st</sup> Century.” The PowerPoint and video assisted lecture emphasized the importance of technology within the United States fire service. The primary intent of the lecture 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 presentation included a general overview of fire and products of combustion and explained how fires originate and spread, but more importantly, how fire can be detected, controlled, and extinguished. Typical fire protection engineering related careers with salary expectations were also discussed at length in an interactive session following the formal presentation.

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.

Students also toured living quarters while firefighters entertained many questions regarding professional qualifications necessary to become a Charlotte firefighter. The tour culminated in an in-depth look at different types of apparatus and related emergency equipment. Several students actually operated the “jaws of life,” wore a self-contained breathing apparatus, or positioned the raised 100-foot aerial ladder.

At the end of the day, students were prompted to expound on what they had perceived as the most interesting fact they had learned. Many students expressed that they had not realized how technical the fire service had become and how technology has influenced, and will continue to influence, its ultimate direction.

#### 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 1: 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 2: 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. A kit was used so that the students didn't spend all of their time measuring and cutting wood, but rather spent their time in construction and fine-tuning. 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, as well as how these devices were used in surveying and mapping. The use of this technology was demonstrated at the fire department communications center on Day 1, so students were familiar with some of its uses. We then gave the students a hands-on lesson in using the Garmin ETrex hand-held GPS devices. In the afternoon, the students went on a treasure hunt (a Geocache) on the UNC Charlotte campus grounds.

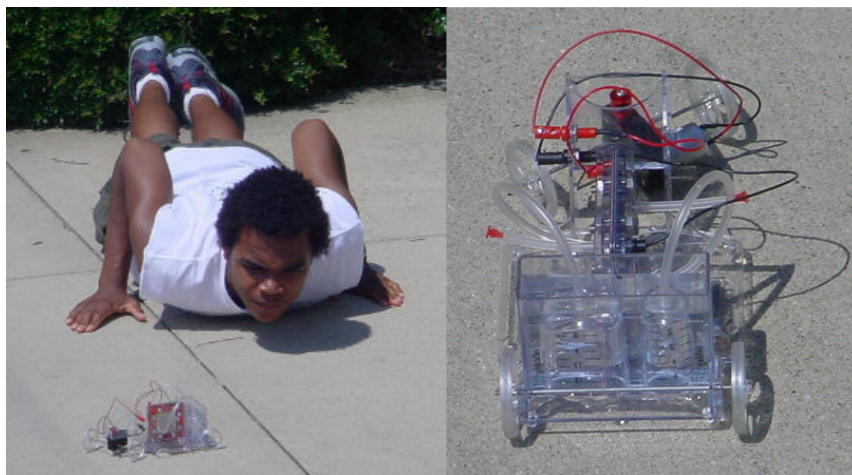
This was a multi-level geocache. The coordinates (and hints) for locating the next clue in their treasure hunt were provided by the instructor. The students set out looking for the location of the second clue. There were three sets of clues leading to their final destination – the cache. The first students 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.

The students thoroughly enjoyed this activity. We spent several hours treasure hunting (we had two caches set up). The remainder of the day was spent in working on the bridges and trebuchets started on the previous day.

### Day 4: Electrical Engineering Technology

We started this day with an introduction to alternate methods for generating electricity. The students were introduced to solar, wind, geothermal, tidal, biomass, and hydrogen fuel cell technologies. We then focused on solar energy 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 3: 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 4: Testing Bridges to Destruction**

Each bridge was setup on the table shown in Figure 4. A bucket was suspended from the bridge. The bucket was slowly filled with water until the bridge collapsed. As shown in figure 4, the students enjoyed this test.



**Figure 5: Testing Trebuchets**

We then headed outside to test 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, students had been introduced to four engineering disciplines through fun hands-on projects.

### Wrapping Up

We wrapped up the week by tallying the scores for each activity and announced the winner. The winner was allowed first choice of prizes from the prize table. There were some very nice gifts for the students, but almost all of the students viewed the Garmin ETrex as the “grand prize”. They knew that this was the most expensive prize but after the treasure hunting of Day 3, they all were doing their best to win this prize to be able to continue this activity on their own.

### **Survey Results**

A number of questions were asked of the students in both a formal and informal setting. The results of the questionnaire (the formal survey) are shown below:

<b>Table 1: Results of Formal Questionnaire</b>						
<b>Questions</b>	<b>Mean</b>	<b>SA=5</b>	<b>A = 4</b>	<b>N = 3</b>	<b>D=2</b>	<b>SD=1</b>
The JETS camp was, overall, a very good experience	4.7	73%	21%	6%	0%	0%
The JETS camp broadened my educational horizons	4.4	48%	42%	6%	3%	0%
Classroom instruction was very educational	4.3	55%	27%	15%	0%	3%
Classroom instruction was fun	4.1	45%	30%	12%	9%	3%
Class "hands-on" activities were fun	4.8	85%	12%	3%	0%	0%
Class "hands-on" activities were educational	4.6	67%	30%	3%	0%	0%
Camp "downtime" was kept to a minimum	4.2	45%	27%	24%	3%	0%
Instructor concern for my welfare was very obvious	4.4	61%	24%	12%	3%	0%
I will consider UNC Charlotte as a place to go to college	3.7	33%	18%	36%	9%	3%
I would definitely recommend the JETS camp to my friends	4.3	55%	27%	15%	3%	0%

A significant percentage of the campers thought the camps were a good experience and that the camps broadened their educational horizons. 79 percent thought the camps were educational, 75 percent thought the “instruction” was fun. Almost all of the campers (97 percent in both cases) thought that the hands-on activities were educational and fun and 82 percent indicated they would recommend the camp to their friends.

The statement: “I will consider UNC Charlotte as a place to go to college” had a low mark compared to the others, but still close to, on average, a 4 (agreement). We believe there were several possible explanations for this. The first is that some of the students (the ones that disagreed or strongly disagreed) had already made up their minds to go to another university. A second explanation (indicated by the high neutral indication – 36 percent) is that these students had made no decisions regarding a university at this time. A third explanation was that many of these students were from the same county in which the university resides. Many students hope to “go away” to college, and any university in their “backyard” is automatically not considered. However, the vast majority of students have indicated in other surveys that they are considering, or have decided on, studying an engineering or engineering technology related discipline. 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.



We also asked several open-ended questions. When asked what they enjoyed most about the camp, most students enjoyed the hands-on activities best, and were evenly divided between the separate disciplines. When asked what they would change in the camp, the three most common responses were: 1) make the camp longer (a two-week camp) and 2) allow more free time, and 3) make the morning presentations shorter. When asked what they liked least about the camps, the most consistent answer was to shorten the morning lectures.

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 Computer 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 computer 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.

## **Conclusions and Future Work**

Considering that this was the first time that we have sponsored a summer camp, we were pleased with the results. Nevertheless, results of the questionnaire and informal discussions, as well as several observations made by instructors, indicate that significant improvements could be made for next year.

As the camps were being planned, the project director asked several faculty to develop a full day of activities for the campers. The project director suggested that each day contain some theoretical information as well as several hands-on activities. The faculty developers did a great job, as evidenced by the results of the questionnaires, but lectured too long on several days. Because we want the campers to enjoy the week, next year the lectures will be shortened and spaced better throughout the day. However, we feel that it is vitally important that relevant material be presented to expose students to some of the rigors involved in the profession.

An unexpected lesson developed as a parent insisted that his rising eighth grade son participate in the camp. At the time, we decided to allow him to enroll in the camp. As the week progressed

we found that an eighth grade student was too immature to be able to interact with campers of high school age. There is not a significant age difference between rising eighth and rising tenth grade students, but there is a significant difference in experience. Next year, we will restrict enrollment to only high school students. Plans are currently underway to expand the project into the middle schools. At some point, it may be feasible to offer a restricted form of the summer camps to middle school students.

### ***Diversity in Engineering Technology Project***

The main goal of the *Diversity in Engineering Technology* project is to increase the diversity of students in engineering and engineering technology programs at community colleges and universities. The camps allow high school students to work with a diverse group of students, in a team environment, while engaging in activities that should pique their interest in areas of engineering and engineering technology. The camp environment also encouraged the campers to put aside their rivalries with students from other schools and learn to work together. In this, the camps were very successful.

The *Diversity in Engineering Technology* project initiated nearly twenty high school engineering and technology clubs in several surrounding counties. During the academic year, the university and the community colleges sponsor competitions and engineering related events. Although nothing serious has occurred, the rivalries between schools were obvious. The camps helped counter some of this, because friendships were established during the camps, and have continued to this day.

The campers also developed a level of trust with the university professors and the project director. Email correspondences between the former campers and the project director are frequent even six months later. We believe that the trust was one of the most beneficial developments during the week of the camps. As the project director visits the clubs or classrooms at the high schools, many students are more accepting and willing to interact with him. The first step to meaningful communication is trust, and through this trust, the project director is able to work more effectively with these students.

### **Acknowledgments**

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## **Biographical Information**

### **STEPHEN KUYATH**

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.

### **DAVID MURPHY**

Dave Murphy retired as Assistant Chief of the Richmond (KY) fire department and currently serves as an Assistant Professor in the Engineering Technology department at UNC Charlotte. He has industrial experience as a Safety Director for AFG Industries. Dave was recently recognized by the National Fire Protection Association as a Certified Fire Protection Specialist and currently serves as a principal member on NFPA Technical Committee 610.

### **DEBORAH SHARER**

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.