Diversity in Engineering Technology: An NSF Project

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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 unless the United States takes more effective action 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 global description of the Diversity in Engineering Technology project, funded by the National Science Foundation through the University of North Carolina at Charlotte, and detail our outreach program to underrepresented groups for engineering and engineering technology.

The project has three goals. The first is to increase the diversity of engineering technology students at the community colleges and ultimately at the university level. We will do this through establishing engineering and engineering technology clubs at twenty high schools in the Charlotte region. Students will participate in fun and engaging hands-on activities and competitions designed to pique their interest in math, physics, engineering and engineering technology.

The second goal is to increase student, parent, teacher and high school counselor awareness of and interest in the career and educational opportunities for students with aptitudes in math, science, engineering and technology. It has been confirmed through high school student interviews that few, if any, know or understand what engineering technology is. By raising the community awareness about engineering and engineering technology, it is believed that more students will enroll in these programs.

The third goal is to better align the curricula between the community colleges' Associate of Applied Science (AAS) degree programs and UNC Charlotte's Bachelor of Science in Engineering Technology (BSET) degree programs. UNC Charlotte currently has a 2+2 program, and is in the process of developing the lower division courses. Through a better alignment of the programs students will have more choices, have fewer problems in transferring classes between institutions, and be better prepared to finish a bachelor's degree program.

Project Rationale

The United States could face a serious shortage of scientists, engineers, technologists, and mathematicians because high school students from underrepresented groups show little interest in these subjects¹. These students are depriving themselves of many technical and scientific career choices, as well as access to high salaried occupations². In 1995, women constituted about 46 percent of the U.S. labor force but only about 22 percent of the scientific and engineering labor force³.

The National Science Foundation (NSF) report “Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000” states that, although some progress has been made at all levels of education and employment, women are still less likely to choose careers in science and engineering. Additionally, the numbers and percentages of minorities in engineering related careers are decreasing⁴. A nationwide shortage of qualified high-tech workers will jeopardize the country’s economic future unless something is done to nurture the intellectual development of these non-traditional students so that the pool of scientists and engineers expands to include more women, minorities, and persons with disabilities⁵.

Figure 1: The Charlotte, North Carolina Region: Colleges and High Schools

The University of North Carolina at Charlotte’s Engineering Technology Department will be working with four community colleges and seven public school systems in the region in a collaborative effort to recruit students from underrepresented groups to participate in several engineering technology activities designed to increase the interest in and awareness of the career opportunities for engineering technology graduates.

The demographic data for the region, the national demographic statistics for ET programs from the American Society of Engineering Educator’s (ASEE’s) “*Profiles of Engineering and Engineering Technology Colleges*”⁶, and for UNC Charlotte’s ET programs is shown below. The University’s data differs somewhat from ASEE’s⁶, but supports the need for action:

<p>Table 1 Demographic Data at UNC Charlotte, the U.S., and in the Region</p>						
	White	African-Amer.	Hispanic³	Asian	Male	Female
UNC Charlotte	76.7%	13.6%	1.3%	4.6%	90.7%	9.3%
National Stats in Eng./Tech¹	69.3%	7.6%	5.7%	6.5	89.3%	10.7%
Regional Population²	74.7%	19.4%	5.0%	2.1%	48.3%	51.7%

¹ from ASEE ² 2000 US Census Bureau ³ Hispanic – any race

The Project: Increasing Diversity

The idea for this project originated when observing a typical class in the Engineering Technology Program at UNC Charlotte. The class consisted of forty students, thirty-nine Caucasian males and one African American male. This seemed to be unusual, so the demographics for the department and the college were inspected. The results are shown in the table above. Although this was somewhat unusual, the demographic statistics of the department and college were alarming.

Clearly this was a problem that needed to be addressed. But, how does one increase the diversity of students at the university?

We began conducting random student interviews at the university. We wanted to discover why students decided to pursue a degree in engineering technology. Three reasons became the most prevalent:

1. Students had enrolled in community college programs to quickly retrain for a better career. The community colleges offered an associate's degree in engineering technology, not engineering, and the university offered a 2+2 program in engineering technology, so they "ended up" with us.
2. The math requirements for an engineering degree program were above the level at which these students felt comfortable, but they were interested in engineering, so they decided to try engineering technology.
3. A friend or family member had advised the student to consider the engineering technology program.

When these students were asked why they didn't consider engineering technology while they were in high school, all students responded with one of two answers: 1) They didn't know about engineering technology in high school, or 2) No one told them about engineering technology while they were in high school.

Clearly we had to work more closely with high school teachers, career counselors, parents, and the female and minority students. We realized that we had to develop significant workshops and technical experiences for teachers, provide tools and workshops for the career counselors, and informational seminars for parents, but we believed that we had to concentrate our efforts on developing meaningful interventions with the female and minority students.

Research indicated⁷ that to attract students typically underrepresented in engineering and engineering technology we had to create fun, engaging, hands-on activities that were related to everyday life. We did not want to attempt making changes to the high school curricula, so we decided to develop after school activities that met our criteria, and supported and reinforced the

curricula in the high schools. We examined the extra-curricular activities currently in place in the high schools and discovered that no high schools in this region had clubs devoted to engineering or engineering technology. The high schools had physics clubs, math clubs, and science clubs, but these clubs' objectives were much different from ours. We chose to develop, implement, and support engineering technology clubs at the high schools and create competitions, to be hosted at the community colleges and the university, in which club members could participate.

Engineering Technology Clubs

The Engineering Technology Clubs are at the heart of this project. Eighteen (18) high schools in this region have started engineering technology clubs, supporting over 400 high school students. The club members have participated in several activities that could be considered mini-competitions, but have concentrated on preparing for several countywide and regional competitions hosted by the community colleges and the university.

For example, students participated in a tower building contest at one high school. The goal was to build the highest tower using plastic straws, paper clips, and rubber bands that would support the most amount of weight. The score was determined by multiplying the height of a tower in inches by the supported weight, measured in ounces. The activity was to last one hour.

Students stayed for more than two hours. If one group received a higher score, the other teams would go back to work to try to build a taller or more stable tower. We observed many things during this activity. The students:

1. Clearly enjoyed the activity
2. Were willing to keep working until they had developed the best tower
3. Were researching information about building a better tower
4. Were asking about the next meeting: when, what, and how long?
5. Told their friends about it, recruiting more students.

We also observed that the girls were more competitive during this activity and won the mini-competition. We believe this was because the girls were confident with their abilities⁷ during this exercise.

Robots, Bridges, Trebuchets, and JETS

Students are preparing for several countywide and regional competitions. They enjoy the competitive nature of club activities between friends and classmates, but the students really get excited about the possibility of winning a competition against a rival school.

The university and community colleges are hosting several different types of competitions in which the clubs may participate:

1. Robotics
2. Bridge building
3. Trebuchet building
4. Math and science tests (JETS' TEAM+S)
5. Writing and public speaking

There are several objectives in the competitions. We want the high school students to:

1. Discover and practice engineering principles while preparing for the competitions
2. Work in collaborative, team environments
3. Visit the community colleges and university campuses
4. Apply what they have learned in their physics and math classes

The competitions are detailed in another paper (*Diversity in Engineering Technology: The Competitions*), so they will not be detailed here, but the importance of the competitions and the impact they have on the students should be noted. The competitions provide a reason for the students to become thoroughly involved in the projects, to research and apply engineering principles, and to experiment with different strategies proposed by other members of their teams.

The website developed for this project provides resources for the students to help them prepare for the competitions. For example, materials were placed on the website to help students prepare for the TEAM+S competition. The TEAM+S Test, developed by Jets (The Junior Engineering Technical Society), is a very difficult math and science test and one of the competitions being hosted by the university for this project. Each club was provided with the 1998 TEAM+S test materials and the answer sheet to help them prepare for the 2004 test, but it was not enough. They were still having some difficulties with the math involved in solving the problems.

To help, university professors worked out each of the problems in detail and placed their work on the website. Occasionally the high school students will request some additional assistance. When they do, a university or community college professor visits the school and answers their questions or provides a problem solving session – making another important connection with high school students.

Summer Camps

During the summer the university is hosting two weeklong summer camps in which students will engage in a number of engineering related activities. They will take classes in engineering principles, participate in hands-on experiments, and conduct some self-directed research. Afterwards they will have some free time to experience other forms of university life: socializing or engaging in sports or in other modes of entertainment.

There are several reasons to host the summer camps. We want to continue promoting engineering and engineering technology, to provide meaningful activities for these students in a non-threatening environment, and to continue the momentum created in the clubs. But, we also want to get these students on our campus because there is a higher probability that they will return as an engineering or engineering technology student if they visit our campus and enjoy the engineering related activities developed for them. We also believe that there is an even higher probability that they will return as an engineering or engineering technology student if they develop a relationship or bond with one of the professors.

Increasing the Diversity of Engineering Technology Students

To get the teachers and high schools involved we chose to provide funding for materials, supplies, and teachers stipends. We made it clear to the teachers who volunteered for this project that they had to recruit female and minority students into the clubs. We were also careful in our

selection of teachers. We wanted teachers to act as role models and mentors for the students but we needed teachers who were very well liked by the students and could recruit the female and minority students into the clubs. Our research showed that if teachers reached out to these students and offered some encouragement, they would join the clubs.

Figure 2: A Comparison of the Club, ET Department, and College of Engineering demographics

Figure 2 shows a comparison of the demographics of the high school clubs, the Engineering Technology Department at UNC Charlotte, and the College of Engineering at UNC Charlotte.

It should be noted that 71.4% of engineering technology students at UNC Charlotte are Caucasian males and in the clubs there are 42% Caucasian males. This is a promising trend because it indicates that the remaining club members are of other race and gender groups. In fact, there is a significant percentage increase in all other race and gender groups participating in the clubs over those enrolled in the Engineering Technology Department or in the College of Engineering at UNC Charlotte.

Figure 3 is a graph comparing the gender differences of members of the clubs and the students at UNC Charlotte.

Figure 3: Gender Comparison of Clubs, ET Department, and the College of Engineering

Twenty-eight percent of the students involved in the clubs are female. This is a significant increase in girls that are taking an interest in engineering related activities. The Engineering Technology Department at UNC Charlotte is made up of only nine percent women and the College of Engineering has only twelve percent.

Figure 4: Ethnic Comparison of Clubs, ET Department, and the College of Engineering

Figure 4 compares ethnicity of the students in the clubs, the Engineering Technology Department, and the College of Engineering at UNC Charlotte. There are significantly more minorities participating in the engineering technology clubs at the high schools than are currently enrolled at UNC Charlotte. Nearly half (44%) of the students participating in the clubs are minority students. Other significant statistics are that four percent of the students are Hispanic, twenty-one percent are African American, eleven percent are Asian, and seven percent are categorized as “other” (as submitted by the teachers supplying the data). This is a significant increase in minority high school students showing an interest in engineering and engineering technology.

Clearly there is a significant improvement in the percentages of non-traditional engineering students participating in the high school clubs. We feel we could do a better job. This year we were concentrating on creating the clubs, activities, and competitions. Next year (year two of the three year project) we will try to increase the number of female and minority student participation in the clubs, as well as increase the number of clubs.

Increasing Awareness of the Opportunities in ET

As each club was started we met with students and asked a few questions. There were a total of 368 students interviewed in a group setting. Some of the questions are shown below:

Table 2 Questions Asked Of High School Club Members During An Interview		
<i>Questions</i>	Yes	No/Not Sure
Are you planning to go to college?	341	27
Are you planning to enroll in engineering or engineering technology?	3	365
Do you know the difference between engineering and engineering technology?	3	365
Did you know that you could get an AAS degree in ET at the local community college?	0	368
Are you planning to go to the local community college?	0	368
Did you know that you could transfer to UNC Charlotte’s Engineering Technology program after completing an AAS degree at the community college?	0	368
Do you know how much money can you make as an entry-level engineer?	0	368
Do you know what the entrance requirements are for the college you want to go to?	0	368
Do you know how many different disciplines there are in engineering and related fields?	0	368

As indicated by the student responses before the clubs got started, high school students were either unaware or not interested in engineering or engineering technology. Many students had plans to go to college, but few were considering engineering or related programs and all of the students seemed completely unaware of the community colleges. At this point we knew we were engaged in a much-needed project.

We suspect that the club activities and competitions will create an interest in engineering and engineering technology, but we also believe that the students need to see the types of careers they may get once they finish an associate degree program in engineering technology or a baccalaureate degree program in engineering or engineering technology. There are several ways to do this. One of the actions we are taking is to place job descriptions of alumni on the project website. Using the Internet as a dissemination tool is a good way to increase awareness, but if

that was all that needed to be done then we wouldn't have a diversity problem in engineering and engineering technology programs across the nation.

So, we are also hosting the following activities:

1. Writing Competitions
2. Public Speaking Competitions
3. Community Seminars for parents
4. Workshops for teachers and career counselors

The writing and speaking competitions encourage high school students to research engineering and engineering technology careers, educational programs, and salaries. To encourage the high school students to participate in these contests we provide prize money. We also want those who are not involved in the writing, speaking, and research to learn more about engineering and engineering technology, so we have the students present their papers to the other club members. Teachers will then submit the papers to professors at the university for assessment. The authors of the seven best papers will be invited to the university to present their papers. In this way, many more students will hear speeches by their peers – one of the groups they listen to when deciding what kind of career they will pursue⁸.

According to Campbell, et. Al⁸, parents are one of the sources to which students will listen when trying to make career and college decisions. So, we are organizing and conducting community seminars for parents. If parents can see the benefits of engineering and engineering technology careers, they may encourage their children.

Teachers are also a source of information for students, so we are holding workshops for teachers and career counselors. In talking with teachers and career counselors, we found that while some are aware of opportunities in engineering, very few are aware of the educational and career opportunities in engineering technology for their students. It can be very time consuming to research this information, so we do it for the teachers and career counselors, and present it in a one-day workshop, through brochures, and on the website developed for this project.

Aligning Curricula Between Community Colleges and Universities

We want to ensure that students can transfer easily from the community colleges to the university. UNC Charlotte is one of two universities in the state of North Carolina that offers a 2 + 2 program in Engineering Technology. Currently, every student enrolled in the Bachelor of Science in Engineering Technology (BSET) programs at UNC Charlotte has transferred from a community college. In the Fall semester of 2004, UNC Charlotte will begin offering the freshman and sophomore level courses in the Engineering Technology Program. We expect transfers to and from community colleges. For both of these reasons it is very important for the curricula to align properly. UNC Charlotte and the local community colleges have worked very hard over the last several years to ensure that students transfer with little or no deficiencies, but now we must also ensure that courses will transfer between institutions.

The mission of the community colleges is to train students to enter the workforce with an associate degree, not to transfer to a university. But now, with the addition of the freshman and

sophomore courses at the university, it becomes very important to the students that courses are transferable between the institutions.

There are many things we do to align the curricula. First, with respect to the 2+2 aspect of the BSET program, we can encourage community college administrators to allow courses needed at the university to count for credit towards their students' degree. As an example: a calculus course is not required for an associate's degree, but is required for a BSET degree at the university. If students do not take this course at the community college, they enter the university with a deficiency. If the community colleges were to allow a calculus course to count as an elective, then students transferring to the university could take a calculus course that counts towards their degree, and enter the BSET degree program without this deficiency. This has been done at many community colleges in our region.

Over the next two years of this project the community college and university faculty will be working towards creating articulation agreements. This will be a very important step for the students, but also for the community colleges and the university.

Course "maps" will be provided through the project website so that students will be sure to enroll in the proper courses, based on their educational goals and know which course will transfer between institutions. The website will also be used by counselors and faculty advisors in the high schools, the community colleges and the university.

Progress Made

As shown in figures 2, 3, and 4 we believe that we have made significant progress. There has been a significant increase in students, typically underrepresented in engineering and engineering technology, showing an interest in these topics. We believe this will translate into more female and minority students enrolling in engineering and engineering technology programs at the local community colleges and at UNC Charlotte.

Recently, a countywide competition was held at one of the community colleges participating in this project. Twenty-four students, from three high schools competed. Of these students, one had indicated that he was going to enroll in an engineering program in college when the club was started at his school (see Questions in the section titled "**Increasing Awareness of the Opportunities in ET**"). So, less than six months ago, one of these students (one of twenty-four: 3.1%) had indicated that they were going to enroll in an engineering college program.

On the day of the competition, seven students made it a point to inform me that they had made a decision to enroll in an engineering program at UNC Charlotte after they graduated from high school. Six months ago 3.1% of these students (one of the twenty-four) had chosen a career in engineering. Since then, 33.3% of these students had made the decision to enroll in engineering programs. We have every reason to believe that this trend will continue over the life of the project and longer if we continue these efforts.

The seven students all indicated they would enroll at UNC Charlotte. We believe this is because they had developed a relationship with one of the faculty members at UNC Charlotte. I had visited these schools on more than one occasion and held problem sessions at one of the schools

to help them prepare for this competition. In fact, all of these students called me by name – my first name – something I had always insisted on.

Summary

Originally we asked the question: How can one increase the diversity of the students in the community colleges and the university? We believe that all of the steps we are taking in this project are necessary. High school students must first be “turned on” to engineering and engineering technology. They need to get involved in fun and engaging engineering related hands-on activities that relate to their everyday lives while still in high school and they need to compete to see that they can measure up to their peers. Their parents need to be able to advise them and possibly even encourage them to do their personal best in math and science so they can pursue a degree in engineering or engineering technology.

The career counselors, teachers, and peers of high school students also need to know as much as possible about the career and education opportunities in engineering and engineering technology in the region. High school students turn to all of these people for advice. What’s more, high school students need to be familiar with the resources available to them so that they can find the answers to their own questions. Our website will provide this for them.

High school students need to be familiar with their local community colleges and university so that they are aware of the programs available to them. If high school students visit the community college and university campuses while participating in a competition, during summer camps, or while engaged in other activities it is very likely that they will return as a student.

In a recent survey students responded with several encouraging responses (Tables 3 and 4). This survey was conducted after the regional competition and after the students had been involved in the clubs for six months.

Table 3 Results of Student Survey			
Statement:	Agreed	Not Sure	Disagreed
I am enjoying the Jets Club	94.4%	5.6%	0.0%
I have enjoyed working with the robot	95.6%	3.3%	1.1%
I have enjoyed preparing for the TEAM+S Competition	44.4%	36.7%	18.9%
I'm looking forward to the trebuchets	77.8%	22.2%	0.0%
I plan to enter the writing/speaking competition	13.3%	32.2%	54.4%
I will be in the club next year ¹	82.5%	15.9%	1.6%

¹ Responses from Freshman, Sophomore, and Juniors only

Ninety-four percent of the club members have enjoyed being a part of the club. This indicates that there are high school students that are looking for this type of activity in which to be involved. Ninety-five percent of the club members have enjoyed working with the robots. Only forty-four percent enjoyed preparing for the TEAM+S competition (97 students participated in the competition). It may be more significant to note that only nineteen percent (18.9%) indicated that they did not enjoy preparing for the competition. This is not surprising. The TEAM+S Test is a very difficult test. What is significant is that ninety-seven students participated in the TEAM+S Test.

Approximately seventy-eight percent of the students indicate that they are looking forward to the trebuchets. High school teachers assured us that this statistic would increase once the trebuchets are built and tested and students have a better understanding of what the trebuchets will do. Only thirteen percent suggest that they are interested in the writing and speaking competition. This does not surprise us. In fact, a large number of students competing in this contest is not our goal, nor our expectation. We are using this contest, in part, to increase the awareness of engineering and engineering technology careers and education programs in our region and to get students involved in researching information about engineering and engineering technology.

The most encouraging statistics are shown below, in Table 4.

Table 4 Percentage Of Each Group Reporting That They Agreed With The Statement							
Statements: Because of the club:	Female	Male	African-Am.	Asian	Hispanic	White	Other
I have been working harder in math	55.6%	65.1%	83.3%	42.9%	85.7%	61.8%	53.3%
I have been working harder in science	48.1%	58.7%	66.7%	28.6%	85.7%	56.4%	46.7%
I have more interest in science	66.7%	57.1%	50.0%	28.6%	71.4%	60.0%	73.3%
I have more interest in math	55.6%	66.7%	50.0%	28.6%	42.9%	69.1%	73.3%
I know more about the university and community college programs	48.1%	47.6%	50.0%	14.3%	57.1%	50.9%	46.7%
I plan to go to a CC for an ET degree	3.7%	28.6%	16.7%	0.0%	0.0%	27.3%	20.0%
I plan to go to UNC Charlotte	11.1%	31.7%	16.7%	0.0%	42.9%	27.3%	26.7%
I plan to get an engineering degree	11.1%	65.1%	66.7%	28.6%	71.4%	47.3%	46.7%
I plan to get an ET degree	7.4%	41.3%	33.3%	14.3%	28.6%	34.5%	26.7%

Many students are working harder in math and science and have more interest in math and science. Fifty-five percent of the female, eighty-three percent of the African-American, forty-three percent of the Asian, and eighty-six percent of the Hispanic students indicated that they were working harder in math because of the clubs. Similar percentages of the students indicated they were working harder in science. Another encouraging statistic is the numbers and percentages of students that are indicating an increased interest in math and science because of the clubs. The students also tell us that they know more about the community college and university programs, plan to go to their local community colleges or UNC Charlotte, and plan to go to another college for degrees in engineering or engineering technology.

So we believe we can increase the diversity at community colleges and universities by supporting the female and minority students in high schools through clubs, activities, and camps. We must also ensure that the people advising the high school students have accurate and current information. Providing good role models and mentors is another important aspect in recruiting underrepresented students into engineering and engineering technology programs. In other words: the community college and university faculty must get involved with the high schools – to the point where high school teachers, counselors, and students know them by name. Then we can increase the diversity of the students in our programs, and thereby increase our enrollment and the number of college graduates entering science, technology, engineering, and math careers.

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Biographical Information

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 20 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.